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PROCEEDING

THE 11th AISTSSE 2024

The Annual International Seminar on Trends in Science and Science Education

Theme : Implementing of Applied Science Research as Outcome Based Education Result for Supporting of Industrial Innovation

November 5th, 2024
Medan, North Sumatra, Indonesia

FACULTY OF MATHEMATICS AND NATURAL SCIENCES
UNIVERSITAS NEGERI MEDAN

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Medan, Indonesia

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Preface: Proceedings of the 11th Annual International Seminar on Trends in Science and Science Education (AISTSSE) 2024

The application of natural science research in the current decade in the industrial world is also a serious concern as a form of the contribution of the world of science in the industrial field. Incorporating material from research results as a learning resource and producing learning products that provide ideas for research development into learning targets based on Outcome Based Education (OBE) curriculum. The exit learning outcomes that students should demonstrate at the end of a program or course influence all curriculum, assessment, and instruction decisions.

The theme of this year exciting forum is '***Implementing of Applied Science Research as Outcome Based Education Research to Supporting of Industrial Innovation***", which embraces six main topics, including:

1. Fundamental and applied research in mathematics including basic mathematics, applied mathematics and statistic
2. Fundamental and applied research in physics including theoretical physics and computation, geophysics, material science and technology
3. Fundamental and applied research in biology including fundamental biology, applied biology and biotechnology
4. Fundamental and applied research in chemistry including instrumentation, basic chemistry, and applied chemistry
5. Science education
6. Computer science

AISTSSE 2024 is conducted to provide a forum for researcher, academicians, teachers, school principals, government agencies, consultants to share their insights related to the Trends In Science and Science Education. The committee are really honored to have attention from approximately 104 speakers and participants from five different countries. They come from United State of America (USA), Australia, Japan, Malaysia, and of course Indonesia. About 10 universities from all over Indonesia and others country participate in this event. It is expected that those who participate in the seminar will afterwards be familiar and able to interact with their international counterparts in their scientific area. This is in line with the vision of Universitas Negeri Medan to become a world class and character-building university.

The committee received more than 100 seminar abstracts and full papers from science education, biology, chemistry, physics, and mathematics sciences. Most of the abstract have been edited and bound into an abstract collection book which is a part of the seminar kit. The seminar full papers are now in editing stage by the committee before publish in seminar proceeding that will be available in both printed and on-line forms.

For this year conference, we invited six plenary speakers with solid expertise from different countries and regions. We are extremely grateful to:

1. Prof. Dr. Syawal Gultom, M.Pd
   Senat Chairman of Universitas Negeri Medan, INDONESIA
2. Prof. Peter Charles Taylor (Science Education)
   Transformative Education of Murdoch University, AUSTRALIA
3. Prof. Yashwant Pathak (Biotechnology)
   Taneja College of Pharmacy, University of South Florida, USA

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4. Prof. Masaru Watanabe (Applied Chemistry/Physics)
   Chemical Engineering Department, Faculty of Engineering, Tohoku University, Sendai Miyagi, JAPAN
5. Prof. Madya Dr. Nazlina Bt. Ibrahim (Science and Technology)
   Faculty of Sciences and Technology, Universiti Kebangsaan, MALAYSIA
6. Dr. Saibah Siregar (Education Science)
   UNISEL Virtual School, Universiti Selangor, MALAYSIA

We believe that we can learn plenty of things from different presenters. This year's conference is attended by participants coming from different counties and regions in and beyond Indonesia. Selected papers will be published in indexed journal. The conference is not able to come into a reality without whole hearted support from many parties. Therefore, on behave of the committee, I would like to take this opportunity to extend my appreciation to the Rector of Medan State University, the Dean of the Faculty Mathematics and Natural Sciences, the invited plenary speakers, paper presenters, delegates and guests, and participants that have supported us to host this conference. In addition, my sincere thanks go to my organizing team and student volunteers for un-tiring efforts to make this conference as a memorable one. Last but not least, it is a pleasure to inform you that we are going to make this AISTSSE into annual international conference, proudly hosted by the Faculty of Mathematics and Natural Sciences, Medan State University. So, I do hope we will meet again in next year conference.

Moondra Zubir, Ph.D
Committee Chairman AISTSSE 2024

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Supercritical technology and its application to lithium-ion battery-related technologies

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Abstract. *To understand the supercritical state is to correctly understand the state of matter at different temperatures and pressures. In other words, it is to know whether the system under investigation is a homogeneous or heterogeneous phase at that temperature and pressure, and if it is a mixture system, how much of the substance under investigation is present in each phase. These are the amounts of components per effective unit volume of the system under investigation, and they are the indicators for correctly knowing the changes in the physical and chemical state of the system. From this perspective, supercritical technology is not essentially about whether or not the critical point is exceeded, but about determining the operating conditions by understanding all the conditions of the fluid acting as a solvent, including the temperature and pressure leading up to that point.*

Recycling technology is essential to the formation of a recycling-oriented society, and the process must also be recycling-oriented. We are examining how supercritical technology can be used to create the desired process with as little burden on the work and global environment as possible. Here, we would like to deepen our understanding of the usefulness of supercritical fluid technology by reviewing lithium-ion battery recycling technology as an example.

Keywords: Supercritical technology, phase diagram, equilibrium, kinetics, lithium-ion battery, recycle

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Introduction

Hydrothermal Water

Water, one of the green solvents, is the most important solvent in industry as well as in people's daily lives as the one and only solvent due to its chemical stability and its special properties due to hydrogen bonding, not to mention its environmental friendliness. In atmospheric pressure processes, water is often used under conditions that do not exceed its boiling point of 100°C. Water at room temperature is called water, and up to ~100°C, it is called hot water or boiling water. 100°C water at 1 atm is usually in a boiling state and will boil. In this state, water dissipates into the environment as steam, emitting bubbles from within. Water boils at 100°C because the vapor pressure of water becomes equal to 1 atm at 100°C, and water, which has been held down by air at 1 atm, gains kinetic energy to overcome the pressure and becomes completely gaseous water (water vapor). If water at a temperature above the normal boiling point is to be obtained, if the same pressure as the vapor pressure is secured as the in-vessel pressure in a pressure vessel that can withstand that vapor pressure, the critical temperature of water is 374°C and the critical pressure is 218 atm, so liquid water at the desired temperature can be obtained even at 200°C or 300°C. Such liquid water above 100°C is traditionally called hydrothermal conditions.

Hydrothermal Water for reactions

The first advantage of hydrothermal conditions is the high kinetic energy due to the high temperature, which accelerates chemical reactions. Second, changes in the physical properties of water at high temperatures result in changes in solubility and reactivity. Naturally, hydrothermal technology is a green solvent technology based on the 12 principles of Green Chemistry: “Use as few solvents, separators, and other reaction aids as possible,” or “If used, they are harmless.
Hydrothermal technology is a green solvent technology. In the 1980s, the development of supercritical hydrothermal technology was vigorously promoted in the U.S., and as a spillover effect, basic research and demonstration research based on this technology were conducted in many countries around the world. The area where demonstration and practical application are currently being most vigorously pursued is probably the development of high-temperature, high-pressure water technology for biomass conversion, which, in addition to being a green solvent, is an important technology for achieving a major shift to renewable resources for decarbonization. In other words, since cellulose hydrolysis proceeds without the use of acid catalysts, basic research [1],[2] as well as practical application studies are being conducted with the aim of biomass refinery. In addition, the usefulness of high-temperature, high-pressure water for degradation of hemicellulose and lignin has been confirmed [3],[4]. In addition to the conversion of carbon resources (plastics, heavy oil, and biomass), the author has been studying the recycling of waste LIB battery materials, which is the subject of this series of articles, from basic research to process demonstration in order to understand the characteristics of this technology, expand its range of application, and promote its widespread use.

Lithium Ion Battery recycle

As mobility and home energy supplies are shifted into on-demand electricity, the secondary battery is crucial [5]. Due to high stability, light weight, and high electric power capacity, lithium-ion battery (LIB) is currently the best choice in the secondary batterie, with a

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remarkably increasing demand and a growing market size [6]. Typical LIB cathode materials are oxides of transition metals, such as $LiCoO_2$, $LiMn_2O_4$ (LMO), and $LiCo_xNi_yMn_{1-x-y}O_2$. The cathode of an LIB is composed of rare metals such as Li, Co, and Ni, and thus it is desirable and beneficial to recover these metal components from spent LIBs. Metals used in LIBs (e.g., Co, Li, Ni, and Mn) will be the next economical target [7] because their supply and price are unstable due to the demand and logistic and political reasons. Thus, recycling the cations from discarded LIBs must be developed. In a conventional method, the metal ions in LIB cathode material are leached to water using sulfuric acid and hydrogen peroxide, and then separated by various methods. This leaching process consumes a large amount of chemicals including high-concentration acids and reducing agent (hydrogen peroxide) and requires a long reaction time. H_2O_2 was always added as a reducing agent to improve the leaching efficiency by reducing trivalent Co in $LiCoO_2$ to divalent [8]. In accordance with the concept of green sustainable chemistry, we are conducting research on the development of green chemical engineering processes that actively utilize biomolecules in consideration of their cyclicality and environmental impact [9],[10] . We believe that the following three issues should be solved for acid leaching of cathode active materials for LIBs: (1) use of highly concentrated acid, (2) use of explosive reducing agents, and (3) long processing time. To solve these problems, we focused on hydrothermal technology, which has been under continuous research and development in our laboratory. Based on the concept we proposed a method of hydrothermal leaching. The results revealed that hydrothermal leaching with citric acid at 100 ~ 200 °C did not require H_2O_2 addition for getting 100 % leaching of Li and Co owing to multi-functions of citric acid as proton donor and reducing agent at hydrothermal condition [9].

Here, some explanation of the hydrothermal leaching, as one of supercritical fluid technologies, will be delivered based on the basic knowledge of the solvent and reactants.

Mechanism of Hydrothermal Acid Leaching

Citric acid

Hydrothermal conditions are techniques that utilize water in a liquid state above the boiling point, a condition that increases the ionic product up to around 250°C to 300˚C at a constant pressure like 25 MPa while decreasing the dielectric constant. Increasing the temperature increases the reaction rate and weak acids are more likely to dissociate. As reported in previous studies, various organic acids, including citric acid, are also effective in acid leaching of lithium-ion battery cathode active materials

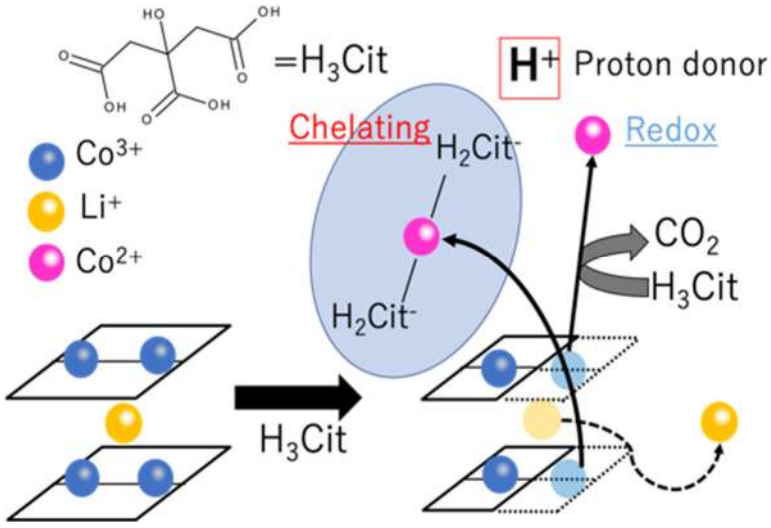

Figure 1 Role of citric acid in acid leaching of $LiCoO_2$ under hydrothermal conditions

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[11 -14]. However, the addition of hydrogen peroxide was essential to significantly recover cathode active material as an aqueous solution below 100°C. Citric acid itself is a reducing substance [15], and if its effectiveness is demonstrated, there is no need to add a reducing agent. Citric acid is also known to form water-soluble complexes with Co^{3+} [16], and if this reaction is induced, acid leaching can be accelerated. Furthermore, hydrothermal conditions promote dissociation of citric acid, thereby enhancing its ability as a proton source (acid). The author considered that hydrothermal conditions are essential to realize the potential functions of citric acid and conducted a study on hydrothermal citric acid leaching. As a result, as shown in **Fig. 1**, citric acid was found to act as a reducing agent to increase the dissolution of Co^{2+} as well as a ligand to dissolve Co^{3+}-citrate complexes under hydrothermal conditions, in addition to being a proton source [9].

Reaction Mechanism

Here, we present the results of a study on the effects of reaction temperature, reaction time, and acid concentration on the leaching of Li and Co in the hydrothermal citric acid leaching of $LiCoO_2$. Furthermore, kinetic analysis using a solid-fluid reaction model focused on elucidating the reaction behavior and active species is also discussed.

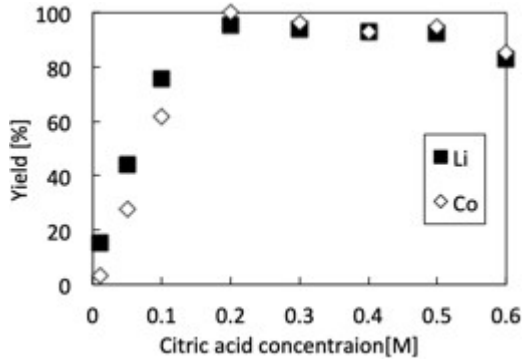

Figure 2 Citric acid concentration dependence in hydrothermal citric acid leaching of $LiCoO_2$ (175°C, 30 min)

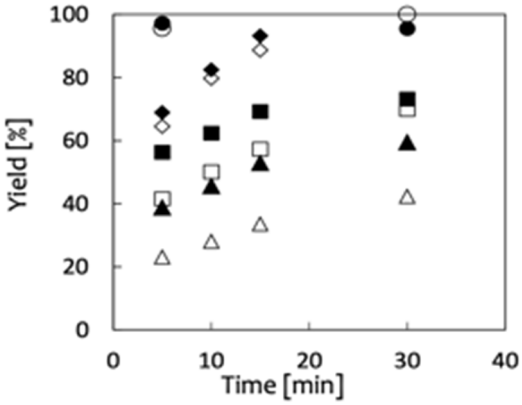

Figure 3 Effect of temperature and time on $LiCoO_2$ hydrothermal citric acid leaching (1 wt% $LiCoO_2$, 0.2 mol/L citric acid)

Fig. 2 shows typical results of the citric acid concentration dependence of the hydrothermal citric acid leaching of 1 wt% (pulp density 10 g/L) $LiCoO_2$ at 175°C for 30 min, with acid leaching (yield in solution) of over 90% for both Li and Co at concentrations above 0.2 mol/L. **Fig. 3** shows the effect of reaction temperature and reaction time on hydrothermal citric acid leaching when $LiCoO_2$ is 1 wt% (pulp density 10 g/L) and citric acid concentration is 0.2 mol/L. For all reaction temperatures, there was a time period in which the leaching yield of Li and Co increased quickly in the early stages of the reaction, and the leaching yield showed a slowing behavior after the reaction time of 5-15 min.

The kinetic study of this reaction was performed over a wide range of citric acid concentrations and reaction temperatures, and it was confirmed that the reaction behavior can be

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well reproduced in the product layer rate-limiting step in the unreacted core model for the leaching of LiCoO2, and that it depends on the 1.2 order proton produced by the dissociation of citric acid [17]. The rate constants over a wide range of temperatures were normalized against the $LiCoO_2$ content, and the results compared in an Arrhenius plot are shown in **Fig. 4**. As shown here, the activation energies differ significantly at 1000/T [K^{-1}] around 2.7. This indicates that the reaction mechanism may have changed significantly. With regard to it, we believe that this is due either to citric acid acting as a reducing agent or to an acceleration of the complex formation reaction. To know which of these is dominant, it is essential to quantify the valence and the amount of complexes of Co recovered in the solution. In the future, it will be necessary to recover the recovered solution as a solid by lyophilization or other means and analyze it by XPS, NMR, etc.

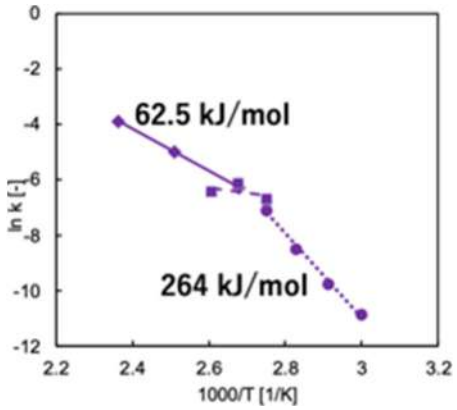

Figure 4 Arrhenius plot of rate constants for hydrothermal citric acid leaching of $LiCoO_2$ (unreacted nuclear model, product layer diffusion rate: 1 wt% $LiCoO_2$, 0.4 mol/L citric acid)

Flow process

Following the results obtained with the batch system apparatus, an attempt was made to convert the system to a continuous system. **Fig. 5** shows a schematic diagram of the distribution-type reactor used in this study. The tubing connecting the feeder tank and slurry pump is made of Teflon, the sedimentation separator is made of SUS304, and the rest of the piping is made of SUS316. The piping tubes were made by GL Sciences, Inc. and the tube fittings were made by Swagelok. Only the sedimentation separator is 1 inch, and all other tubing is 1/8 inch. A slurry pump (PU-2100S, Japan Spectroscopy) was used to pump the slurry. The slurry pump is equipped with a small agitator to suppress slurry separation. In the reaction section, two thermocouples were connected to a thermocouple with a piping tube wrapped around it and covered with insulation. The slurry that passes through the reaction tube is installed so that it flows into the center of the sedimentation separator. The settling separator is heated by a heater and, like the reaction zone, is surrounded by insulation. The solids and liquid are separated by the settling separator, and only the liquid flows out of the top of the settling separator and is cooled by the cooler. At this time, the remaining solids settle at the bottom of the settling separator. The system pressure was controlled using a back pressure valve (JASCO, BP-2080-M). The feeder tank was positioned higher than the recovery section to prevent the accumulation of particles in the slurry. For temperature control, two locations at the outlet of the reaction section were automatically controlled, and the target value for the reactor (sedimentation separator) was varied in detail.

The slurry was prepared by mixing 20 g of the experimental sample with 1980 g of 0.4 mol/L citric acid solution to make a 10 g/L (pulp density) aqueous solution, and was prepared in a feeder tank. Pumping of ultrapure water was started by a pump. The flow rate was set at 30 ml/min. The system pressure was controlled to 20 MPa by a back pressure valve. For safety reasons, the

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pressure was increased in 5 MPa increments. After confirming that the system pressure was maintained and that there was no leakage of liquid from the device, heating was started.

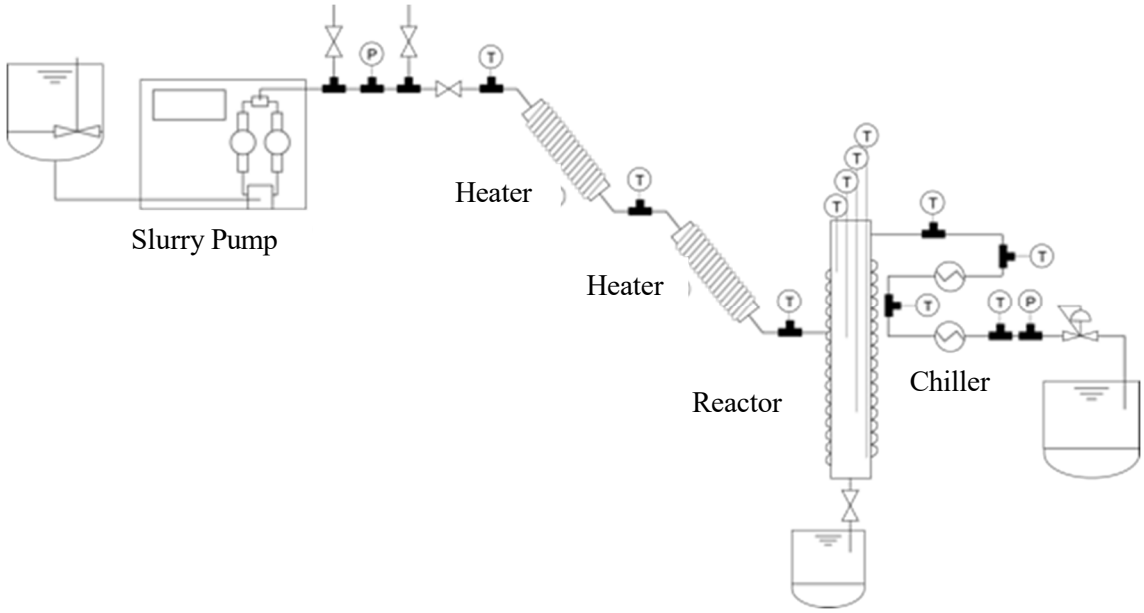

Figure 6 Process for Continuous Treatment of Lithium Ion Cathode Active Materials by Hydrothermal Citric Acid Leaching

Here, the temperature setting of the reactor (sedimentation separator) was set to be lower at the bottom than at the top. This was to prevent a density difference in the liquid due to the difference in temperature, which would cause convection currents in the separator and lower the separation performance. After the temperature reached a certain level, the ultrapure water feed was stopped and a 0.4 mol/L citric acid solution, which was the same as the solvent, was started. The volume and flow rate in the apparatus indicated that displacement in the apparatus would be completed in about 15 min, so the solution was pumped for 15 min. After 15 min, the feeder tank stopped feeding the citric acid solution and started feeding the prepared slurry. During the experiment, the feeder tank was agitated at 600~800 rpm using a stirrer to suppress solid-liquid separation. Sampling of the slurry was also started after 15 min of pumping. Once the reaction temperature (the temperature at the top of the settling machine was set at 200°C) and stabilized, sampling was performed 10~20 times at 5 min intervals.

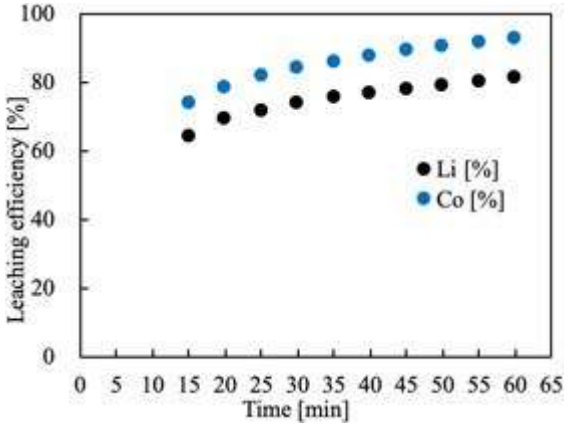

Figure 6 Results of continuous $LiCoO_2$ treatment by hydrothermal citric acid leaching (200°C, 20 MPa, 0.4 mol/L citric acid, slurry flow rate 30 mL/min, 10 g/L $LiCoO_2$)

Fig. 6 shows the effect of continuous process operation time on the leaching rate of Li and Co. Immediately after the start of sampling (15 min after the start of slurry feeding), the leach rates of Li and Co were 64 % and 74 %,

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respectively. The leach rates increased as time elapsed from the start of slurry feeding. Since the leach rates of Li and Co are expected to increase after 60 min, continuous operation of the system can be used to continuously obtain recovered solutions with high leach rates.

Conclusion

With wet refining of lithium-ion battery cathode materials in mind, we focused on acid leaching and attempted to apply the hydrothermal process to solve the problems of conventional methods, such as (1) use of highly concentrated acid, (2) use of explosive reducing agents, and (3) long processing time. We investigated the conditions for recovering Li, Co, Ni, and Mn contained in active materials of ternary lithium-ion battery cathode materials by dissolving them in aqueous solution using hydrothermal acid leaching, and found that only organic acids could be used as leaching agents without adding a separate reducing agent such as hydrogen peroxide. We found conditions under which only organic acids can be recovered completely as a leaching agent without the addition of a separate reducing agent such as hydrogen peroxide. Using this method, we conducted a small-scale demonstration using commercially available cathode materials and actual waste in a small continuous process and confirmed its effectiveness. Furthermore, hydrothermal acid leaching with other organic acids was also investigated, and it was found that Li and Co can be leached without the addition of additional reductants, although the dissolved species and their rate differences are variable. In the future, we plan to conduct a scale-up demonstration and to develop a hydro-metallurgical refining process based on hydrothermal acid leaching, as well as recycling to battery materials.

Acknowledgments

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Coefficient bounds for subclass of alpha-logarithmic of bi-univalent functions involving double zeta function

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Abstract. *In this paper, we introduce a new subclass of bi-univalent functions defined alpha logarithmic involving double zeta function. For functions in each of these bi-univalent function subclasses, we derive estimates for the Taylor–Maclaurin coefficients* $|a_2|$ *and* $|a_3|$ *for functions belonging to this new subclass. The results obtained from this research will improve the theoretical foundation of this field and open new avenues for mathematical inquiry and application..*

Keywords: bi-univalent functions; analytic functions; Alpha logarithmic, coefficients bounds

Introduction

Let S denote the class of functions $f(z)$ that are analytic in the open unit disk $U=\{z:|z|<1\}$ and normalized by the conditions $f(0)=f'(0)-1=0$ and having the form as follow

$$f(z)=z+\sum_{n=2}^{\infty}a_n z^n . \quad (1)$$

The image of U under every univalent function $f(z)\in S$ contains the disk of radius $\frac{1}{4}$ as stated in the Koebe one quarter theorem [14]. Thus, every univalent function f has an inverse f^{-1}, defined by

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$$f^{-1}\left(f(z)\right)=z\,,\qquad \left(z\in U\right)$$

And

$$f\left(f^{-1}(w)\right)=w,\qquad \left(|w|<r_0(f)\geq\frac{1}{4}\right)$$

where

$$g(w)=f^{-1}(w)=w-a_2w^2+\left(2a_2^2-a_3\right)w^3-\left(5a_2^3-5a_2a_3+a_4\right)w^4+\ldots \tag{2}$$

A function $f\in S$ is said to bi-univalent in U if both $f(z)$ and $f^{-1}(z)$ are univalent in U . Let $\sum$ denote the class of bi-univalent in U given by Taylor-Maclaurin series expansion in eqn. (1). For a brief history and examples in the class $\sum$ introduced by [6]. This examples also motivated by [1], [11], [12], and [22].

Lewin in [11] investigated the class $\sum$ of bi-univalent functions and show that $|a_z|\leq 1.51$. Subsequently, [2] conjectured that $|a_2|\leq\sqrt{2}$. Netanyahu [6], on the other hand, showed that $\max_{f\in\Sigma}|a_2|=\frac{4}{3}$. Brannan and Taha in [1] and Taha in [22] introduced certain subclasses of bi-univalent function class $\sum$ similar to the familiar subclasses C, S^* and K, the subclasses of convex, starlike and close-to-convex functions, respectively.

By using Hadamard product or convolution product of generalization Hurwitz-Lerch zeta function given by [17], a function is defined as follows:

$$\Psi_n(y,x,a):=\frac{\Phi(y,x,a+vn)}{\Phi(y,x,a)},(n\in\mathbb{N}\cup\{0\})\,. \tag{3}$$

It is clear that $\Psi_0(y,x,a)=1$. Now, consider the function

$$\Upsilon_\mu(y,x,a)=\sum_{n=0}^{\infty}\frac{\mu_n}{n!}\Psi_n(y,x,a)z^n,$$

implies

$$z\Upsilon_\mu(y,x,a)=z+\sum_{n=2}^{\infty}\frac{\mu_{n-1}}{(n-1)!}\Psi_{n-1}(y,x,a)z^n.$$

Thus,

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$$z\Upsilon_{\mu}(y,x,a)*(z\Upsilon_{\mu}(y,x,a))^{-1}=\frac{z}{(1-z)^{\lambda}},(\lambda>-1)=z+\sum_{n=2}^{\infty}\frac{\lambda_{n-1}}{(n-1)!}z^{n}.$$

So,

$$I_{\mu}^{\lambda}(y,x,a)f(z)=z+\sum_{n=2}^{\infty}\frac{\lambda_{n-1}}{\mu_{n-1}\Psi_{n-1}(y,x,a)}a_{n}z^{n}=z+\sum_{n=2}^{\infty}\Omega_{n}a_{n}z^{n}, \tag{4}$$

where

$$\Omega_{n}=\frac{\lambda_{n-1}}{\mu_{n-1}\Psi_{n-1}(y,x,a)}, \tag{5}$$

$$|y|<1,|z|<1;\mu\in\mathbb{C}\setminus\{0,-1,-2,...\},v\in\mathbb{C}\setminus\{-(m+vn)\},\{n,m\}\in\mathbb{N}\cup\{0\},$$

and Ψ is defined in eqn. (3). It is clear that $I_{\mu}^{\lambda}(y,x,a)f(z)\in A$.

Darus and Thomas in [10] have studied the class M^{α} of α-logarithmic convex functions and they also have solved the Fekete-Szego problem for the class M^{α}. In [10] a function $f\in S$ is said to be α - logarithmically convex denote by M^{α} if the following conditions is satisfied

$$\mathrm{Re}\left\{\left(\frac{zf(z)'}{f(z)}\right)^{1-\alpha}\left(1+\frac{zf''(z)}{f(z)'}\right)^{\alpha}\right\}>0, \tag{6}$$

$(\alpha\geq 0,z\in U)$.

The class $M^{\alpha}(\beta)$ of strongly α-logarithmic convex functions of order β. The class $M^{\alpha}(\beta)$ was introduced by Cho in [12]. In [12] a function $f\in S$ given by eqn. (1) is said to be α-logarithmic quasiconvex of order β if there exists a function $g\in S$ such that

$$\left|\arg\left\{\left(\frac{f'(z)}{g'(z)}\right)^{1-\alpha}\left(\frac{(zf'(z))'}{f'(z)}\right)^{\alpha}\right\}\right|\leq\frac{\beta\pi}{2},\ (\alpha,\beta\geq 0;z\in U). \tag{7}$$

The result of this research also motivated by [3], [4], [8], [11],[15], [19], [20] and [23] in their research about coefficient bounds for subclasses of bi-univalent functions.

The object of the present paper is to introduce new subclass of the functions class $M^{\alpha}(\beta,\Omega)$ involving double zeta functions operator and the estimation of the coefficients $|a_2|$ and $|a_3|$ for this

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new subclass also will be obtained. The techniques of proofing used [6] and [18].

Preliminary Result

Lemma 1. If $S \in P$ then $|p_n| \le 2$ and $|q_n| \le 2$ for $n \in \mathbb{N}$, where the Caratheodory class P is the family of all functions p analytic in U for which $\Re p(z) > 0$ and $\Re q(w) > 0$

$$p(z) = 1 + p_1 z + p_2 z^2 + \dots, \tag{8}$$

$$q(w) = 1 + q_1 w + q_2 w^2 + \dots. \tag{9}$$

for $z \in U$, $w \in U$.

Coefficient bounds for the function class $M^{\alpha}(\beta, \Omega)$

Definition 1. A function $f(z)$ given by eqn. (1) is said to be in the class $M^{\alpha}(\beta, \Omega)$, $(\alpha, \beta \ge 0; z \in U)$, if the following conditions are satisfied

$$f \in \sum \text{ and } \left| \arg\left\{ \left(\frac{z\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'}{I_{\mu}^{\lambda}(y,x,a)f(z)} \right)^{1-\alpha} \left(\frac{\left(z\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'\right)'}{\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'} \right)^{\alpha} \right\} \right| \le \frac{\beta\pi}{2},$$

and

$$\left| \arg\left\{ \left(\frac{w\left(I_{\mu}^{\lambda}(y,x,a)g(w)\right)'}{I_{\mu}^{\lambda}(y,x,a)f(w)} \right)^{1-\alpha} \left(\frac{\left(z\left(I_{\mu}^{\lambda}(y,x,a)g(w)\right)'\right)'}{\left(I_{\mu}^{\lambda}(y,x,a)g(w)\right)'} \right)^{\alpha} \right\} \right| \le \frac{\beta\pi}{2},$$

where the function g is given by eqn. (2).

First state and prove the following result.

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Theorem 1 Let $f \in M^{\alpha}(\beta,\Omega),\ (\alpha,\beta \geq 0; z \in U)$ be given by eqn. (1). Then

$$|a_2| \leq \frac{\beta}{\Omega_2\sqrt{\beta(7\alpha+1)+(1-\alpha)^2}} \text{ and } |a_3| \leq \frac{4\beta^2(\alpha^2+5\alpha+2)}{\Omega_3(\alpha^2+3\alpha+2)(1-\alpha)^2}, \quad (10)$$

where

$$\Omega_2 = \frac{\lambda_1}{\mu_1\Psi_1(y,x,a)}, \quad (11)$$

and

$$\Omega_3 = \frac{\lambda_2}{\mu_2\Psi_2(y,x,a)}. \quad (12)$$

Proof.

Let

$$\left(\frac{z\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'}{I_{\mu}^{\lambda}(y,x,a)f(z)}\right)^{1-\alpha}\left(\frac{\left(z\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'\right)'}{\left(I_{\mu}^{\lambda}(y,x,a)f(z)\right)'}\right) = p^{\beta}(z), \quad (13)$$

where $I_{\mu}^{\lambda}(y,x,a)f(z)$ in eqn. (4) and $p(z)$ in eqn. (8).

The functions $\left[p^{\beta}(z)\right]$ have the forms

$$\left[p^{\beta}(z)\right] = 1+\beta p_1 z + z^2\left(\beta p_2 + \frac{\beta(\beta-1)}{2}p^2\right)+\ldots. \quad (14)$$

From eqn. (13) and eqn. (4), then we obtain

$$\left(\frac{z+2\Omega_2 a_2 z^2+3\Omega_3 a_3 z^3+}{z+\Omega_2 a_2 z^2+\Omega_3 a_3 z^3+}\right)^{1-\alpha}\left(\frac{1+4\Omega_2 a_2 z+9\Omega_3 a_3 z^2+}{1+2\Omega_2 a_2 z+3\Omega_3 a_3 z^2+}\right)^{\alpha} = 1+\beta p_1 z+\left(\beta p_2+\frac{\beta(\beta-1)}{2}p_1^2\right)z^2+\ldots$$

$$\left(1+\Omega_2 a_2 z+\left(2\Omega_3 a_3-\Omega_2^2 a_2^2\right)z^2\right)^{1-\alpha}\left(1+2\Omega_2 a_2 z+\left(3a_3-2\Omega_2^2 a_2^2\right)2z^2\right)^{\alpha}$$

$$=1+\beta p_1 z+\left(\beta p_2+\frac{\beta(\beta-1)}{2}p_1^2\right)$$

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$$1+\Omega_2 a_2(1-\alpha)z+\left(\alpha\left(2\Omega_3 a_3-\Omega_2^2 a_2^2\right)+\frac{\alpha(\alpha+1)}{2}\left(2\Omega_3 a_3-\Omega_2^2 a_2^2\right)-\left(\alpha\Omega_2^2 a_2^2\right)+\left(2\Omega_3 a_3-\Omega_2^2 a_2^2\right)\right)z^2$$

$$=1+\beta p_1 z+\left(\beta p_2+\frac{\beta(\beta-1)}{2}p_1^2\right)z^2. \quad (15)$$

By equality both of side in eqn. (15), can be get the following.

$$a_2=\frac{\beta p_1}{\Omega_2(1-\alpha)}. \quad (16)$$

And

$$2\alpha\Omega_3 a_3+\frac{\alpha(\alpha+1)}{2}2\Omega_3 a_3+2\Omega_3 a_3=\beta p_2+\frac{\beta(\beta-1)}{2}p_1^2+\Omega_2^2 a_2^2\left(2\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)$$

$$.2\Omega_3 a_3\left(\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)=\beta p_2+\frac{\beta(\beta-1)}{2}p_1^2+\Omega_2^2 a_2^2\left(2\alpha+\frac{\alpha(\alpha+1)}{2}+1\right). \quad (17)$$

Next, for $g(w)$,

Let

$$\left(\frac{w\left(I_\mu^\lambda(y,x,a)g(w)\right)'}{I_\mu^\lambda(y,x,a)f(w)}\right)^{1-\alpha}\left(\frac{\left(z\left(I_\mu^\lambda(y,x,a)g(w)\right)'\right)'}{\left(I_\mu^\lambda(y,x,a)g(w)\right)'}\right)^{\alpha}=q^\beta(w), \quad (18)$$

where $I_\mu^\lambda(y,x,a)f(z)$ in eqn. (4) and $q(z)$ in eqn. (9).

The functions $\left[q^\beta(w)\right]$ have the forms

$$\left[q^\beta(w)\right]=1+\beta q_1 w+\left(\beta q_2+\frac{\beta(\beta-1)}{2}q_1^2\right)w^2+\ldots \quad (19)$$

Then we obtain

$$\left(\frac{w-2\Omega_2 a_2 w^2+3\left(2\Omega_2^2 a_2^2-\Omega_3 a_3\right)w^3}{w-\Omega_2 a_2 w^2+\left(2\Omega_2^2 a_2^2-\Omega_3 a_3\right)w^3}\right)^{1-\alpha}\left(\frac{1-4\Omega_2 a_2 w+9\left(2\Omega_2^2 a_2^2-\Omega_3 a_3\right)w^2-16\left(5\Omega_2^3 a_2^3-5\Omega_2\Omega_3 a_2 a_3+\Omega_4 a_4\right)w^3}{1-2\Omega_2 a_2 w+3\left(2\Omega_2^2 a_2^2-\Omega_3 a_3\right)w^2-4\left(5\Omega_2^3 a_2^3-5\Omega_2\Omega_3 a_2 a_3+\Omega_4 a_4\right)w^3}\right)^{\alpha}$$

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$$= 1 + \beta q_1 w + \left(\beta q_2 + \frac{\beta(\beta-1)}{2} q_1^2 \right) w^2 .$$

And

$$\left(1 - \Omega_2 a_2 w + \left(3\Omega_2^2 a_2^2 - 2\Omega_3 a_3\right) w^2\right)^{1-\alpha} \left(1 - 2\Omega_2 a_2 w + 2\left(4\Omega_2^2 a_2^2 - 3a_3\right) w^2\right)^{\alpha}$$

$$= 1 + \beta q_1 w + \left(\beta q_2 + \frac{\beta(\beta-1)}{2} q_1^2 \right) w^2 .$$

Then

$$1 - \Omega_2 a_2 (1-\alpha) w + \left(\alpha\left(3\Omega_2^2 a_2^2 - 2\Omega_3 a_3\right) + \frac{\alpha(\alpha+1)}{2}\left(3\Omega_2^2 a_2^2 - 2\Omega_3 a_3\right) + 3\alpha\Omega_2^2 a_2^2 + \left(3\Omega_2^2 a_2^2 - 2\Omega_3 a_3\right) \right) w^2$$

$$= 1 + \beta q_1 w + \left(\beta q_2 + \frac{\beta(\beta-1)}{2} q_1^2 \right) w^2 \tag{20}$$

By equality both of side in eqn. (20), we obtain the following

$$-a_2 = \frac{\beta}{\Omega_2 (1-\alpha)} q_1, \tag{21}$$

and

$$3\alpha\Omega_2^2 a_2^2 - 2\alpha\Omega_3 a_3 + \frac{\alpha(\alpha+1)}{2} 3\Omega_2^2 a_2^2 - \frac{\alpha(\alpha+1)}{2} 2\Omega_3 a_3 + 3\alpha\Omega_2^2 a_2^2 + 3\Omega_2^2 a_2^2 - 2\Omega_3 a_3$$

$$= \beta q_2 + \frac{\beta(\beta-1)}{2} q_1^2 .$$

Then

$$2\Omega_3 a_3 \left(-\alpha - \frac{\alpha(\alpha+1)}{2} - 1 \right) = \frac{2\beta q_2 + \beta(\beta-1) q_1^2}{2} - 3\Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right) \tag{22}$$

From eqn. (16) and eqn. (21), we get the equation below

$$\frac{\beta p_1}{\Omega_2 (1-\alpha)} = -\frac{\beta q_1}{\Omega_2 (1-\alpha)}$$

$$p_1 = -q_1 \tag{23}$$

and

$$a_2^2 \Omega_2^2 (1-\alpha)^2 + a_2^2 \Omega_2^2 (1-\alpha)^2 - \beta^2 p_1^2 - \beta^2 q_1^2 = 0$$

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$$2\Omega_2^2 a_2^2 (1-\alpha)^2 = \beta^2 (p_1^2 + q_1^2) \tag{24}$$

Also, from eqn. (17) and eqn. (22), we obtain the equation below,

$$2\Omega_3 a_3 \left(-\alpha - \frac{\alpha(\alpha+1)}{2} - 1 \right) = \frac{2\beta q_2 + \beta(\beta-1) q_1^2}{2} - 3\Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right),$$

and

$$-\beta p_2 - \frac{\beta(\beta-1)}{2} p_1^2 - \Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right) = \frac{2\beta q_2 + \beta(\beta-1) q_1^2}{2} - 3\Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right).$$

A rearrangement together with the second identity in eqn. (21) and eqn. (22), then we get as equations below,

$$-\Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right) + 3\Omega_2^2 a_2^2 \left(2\alpha + \frac{\alpha(\alpha+1)}{2} + 1 \right)$$

$$= \beta p_2 + \frac{\beta(\beta-1) p_1^2}{2} + \beta q_2 + \frac{\beta(\beta-1)}{2} q_1^2$$

$$2\Omega_2^2 a_2^2 \left(\alpha^2 + 5\alpha + 2 \right) = 2\beta(p_2 + q_2) + \beta(\beta-1)\left(p_1^2 + q_1^2 \right)$$

$$2\Omega_2^2 a_2^2 \left(\alpha^2 + 5\alpha + 2 \right) = 2\beta(p_2 + q_2) + \beta(\beta-1)\left(\frac{2\Omega_2^2 a_2^2 (1-\alpha)^2}{\beta^2} \right)$$

$$2\beta^2 \Omega_2^2 a_2^2 \left(\alpha^2 + 5\alpha + 2 \right) - \beta(\beta-1)\left(2\Omega_2^2 a_2^2 (1-\alpha)^2 \right) = 2\beta^3 (p_2 + q_2)$$

$$\left(2\beta^2 \Omega_2^2 \left(\alpha^2 + 5\alpha + 2 \right) - 2\Omega_2^2 \beta^2 (1-\alpha)^2 + 2\beta\Omega_2^2 (1-\alpha)^2 \right) a_2^2 = 2\beta^3 (p_2 + q_2)$$

$$\left(\beta^2 \Omega_2^2 \left(\alpha^2 + 5\alpha + 2 - 1 + 2\alpha - \alpha^2 \right) + \beta\Omega_2^2 (1-\alpha)^2 \right) a_2^2 = \beta^3 (p_2 + q_2)$$

$$a_2^2 = \frac{\beta^2 (p_2 + q_2)}{\Omega_2^2 \left(\beta(7\alpha+1) + (1-\alpha)^2 \right)}.$$

According to Lemma 1, $|p_n| \le 2$ and $|q_n| \le 2$. Applying the Lemma 1 for coefficients p_2 and q_2, then we can be obtained,

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$$|a_2| \le \frac{\beta}{\Omega_2 \sqrt{\beta(7\alpha+1)+(1-\alpha)^2}}.$$

Next, in order to find the bound on $|a_3|$, by subtracting eqn. (22) from eqn. (17), we can get,

$$4\Omega_3 a_3\left(\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)-4\Omega_2^2 a_2^2\left(2\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)$$
$$=\beta(p_2-q_2)+\frac{\beta(\beta-1)}{2}\left(p_1^2-q_1^2\right)$$

By substituting the value of a_2^2 from eqn. (24) and observing that $p_1^2=q_1^2$ it follows that.

$$4\Omega_3 a_3\left(\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)-2\left(\frac{\beta^2(p_1^2+q_1^2)}{(1-\alpha)^2}\right)\left(2\alpha+\frac{\alpha(\alpha+1)}{2}+1\right)=\beta(p_2-q_2)$$
$$2\Omega_3 a_3\left(\alpha^2+3\alpha+2\right)=\beta\left(p_2-q_2\right)+\left(\frac{\beta^2\left(p_1^2+q_1^2\right)}{(1-\alpha)^2}\right)\left(\alpha^2+5\alpha+2\right).$$

So,

$$a_3=\frac{\beta\left(p_2-q_2\right)+\left(\frac{\beta^2\left(p_1^2+q_1^2\right)}{(1-\alpha)^2}\right)\left(\alpha^2+5\alpha+2\right)}{2\Omega_3\left(\alpha^2+3\alpha+2\right)}$$

Apply the Lemma 1, for coefficients p_1, q_1, p_2 and q_2 then we can get,

$$|a_3| \le \frac{4\beta^2\left(\alpha^2+5\alpha+2\right)}{\Omega_3\left(\alpha^2+3\alpha+2\right)(1-\alpha)^2}.$$

For $\alpha=0$, we arrive the following corollary.

Corollary 1. Let $f \in M^0(\beta,\Omega)$, $(\beta \ge 0; z \in U)$ be given by eqn. (1). Then

$$|a_2| \le \frac{\sqrt{\beta}}{\Omega_2} \text{ and } |a_3| \le \frac{4\beta^2}{\Omega_3}, \tag{25}$$

where Ω_2 in eqn. (11) and Ω_3 in eqn. (12).

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Transformative STEAM education for sustainable living: ethical valuing

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Abstract. A seemingly endless litany of global crises is threatening the viability of our planetary biosphere and the biocultural and linguistic diversity of humanity. This has created a unique educational challenge for STEM educators given that STEM disciplinary knowledge and skills are often regarded as the panacea for the world's economic and environmental problems. However, this popular view tends to focus narrowly on students' learning scientific, technological, engineering and mathematical disciplinary knowledge about the world *out there*, thereby overlooking the crucial role that education for the 21st century must play in shaping students' attitudes and values – *their inner worlds* - that drive their moral agency for living and working in sustainable ways. It is moral agency that empowers socially and environmentally responsible citizens to willingly tackle global crises in their local communities. Across the world visionary educators in STEM-related fields, working in universities and schools, are embracing transformative learning and Arts education methods to develop and implement *integrated* STE[A]M education programs and practices for preparing young people with special capabilities, including ethical values, with which to contribute actively to ensuring the ongoing sustainable development of our world.

Keywords: *STEAM education, transformative learning, sustainable living, moral agency, ethical values*

Introduction

Since the European industrial revolution, we have increasingly benefitted from the productive power of science and technology to enhance our lifestyles with material splendor, comfort and convenience. But at what cost to the environment? Thanks to recent international scientific research (IPCC, 2023), the world is becoming aware that our vastly powerful industrial revolution has created a new geological era - the Anthropocene - characterized by the harmful impact of our technological footprint on the planet's natural ecosystems - oceans, soils, forests, rivers and atmosphere. Consequencently we are experiencing global crises that must be urgently resolved, including climate change, loss of biocultural diversity, and plastic pollution of our marine environments (OECD, 2022; Ceballos, et al. 2015; Skutnabb-Kanga, et al., 2003; World Economic Forum, 2016).

In the newly emerging interdisciplinary field of STEM education the passionate drive to create curriculum synergies between Science, Technology, Engineering and Mathematics learning areas is being treated as a priority by governments and education systems worldwide. However, this reform agenda tends to focus largely on preparing students for the workforce of the *fourth*

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industrial (digital) revolution (Alper, 2016; Pricewaterhouse-Coopers, 2015). This narrow *economic rationalist* focus is doing little to enable students to recognize and respond proactively to ethical dilemmas associated with global production, consumption and disposal of STEM-related processes and products, especially how they are implicated in actively destroying our planetary life-support system, thus putting in jeopardy the lives of future generations.

To help protect our ecosystems from terminal demise, thereby ensuring humanity's future survival, we need a transformative perspective (i.e., a paradigm shift) that gives rise to *socially responsible* education systems. This can be achieved, in large part, by integrating STEM with the Arts to create interdisciplinary STEAM curricula and pedagogies. The goal is to develop not only students' STEM disciplinary knowledge, skills and objective values but, most importantly, also to awaken their self-consciousness, elevate their moral and spiritual awareness, and enhance their agency to practice environmental justice in their homes, local communities, and places of work (OECD, 2024).

This presentation draws on our recently published book to illustrate how STEAM educators, driven by a moral conscience, are addressing the urgent need to prepare young people with essential *transdisciplinary capabilities* for responding proactively to the global crises of the Anthropocene (Taylor & Taylor, 2022).

Calling Out Unsustainable Development

We are experiencing an unparalleled period in the history of the Earth - the *Anthropocene* - a new geological epoch in which, it is argued, we have largely wrested control over Nature (Crutzen & Stoermer, 2000). This unprecedented era has its genesis in the European industrial revolution (with the invention of the steam engine) and is characterised by our prolonged use of fossil fuels and powerful technologies for exploiting the planet's natural resources. Alarmingly, our largely uncritical and uncaring employment of these technologies for economic gain is dangerously altering the natural systems of the planet, including the atmosphere, oceans, rivers and soils, resulting in fundamental changes to biological and geological systems. The impact of our modern human footprint has become so profound that, for the first time in history, natural ecosystems are at the mercy of human systems.

In the public mind the clearest evidence of our detrimental impact on the planet is human-induced climate change due to release of carbon-based exhaust gases into the atmosphere (National Research Council, 2011). The OECD reports (2022) that we have until 2030 to limit average global temperature increase to 1.5C! Already we read daily reports that we have exceeded this *tipping point*!

Another major impact, one that is not so well embedded in public consciousness, is loss of linguistic, cultural and biological diversity, which taken together are known as *biocultural diversity*. The importance of the intimate (spiritual) inter-relationship between indigenous cultures and the natural world has been documented by UNESCO, The World Wide Fund for Nature and Terralingua (Skutnabb, Maffi, & Harmon, 2003, p. 10):

> In the language of ecology, the strongest ecosystems are those that are the most diverse. That is, diversity is directly related to stability; variety is important for long-term survival. Our success on this planet has been due to an ability to adapt to different kinds of environment over thousands of years (atmospheric as well as cultural). Such ability is born out of diversity. Thus language and cultural diversity maximises chances of human success and adaptability.

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The more we reduce cultural and linguistic diversity, especially the worldviews and languages of indigenous peoples, the more we lose our library of spiritual wisdom about how to live in harmony with Nature. And the more we reduce biological diversity through overharvesting of the ocean, deforestation, soil salination, microplastic pollution of the food chain, and so on, the more we despoil the life-affirming wonders and beauty of the natural world.

Educating for Sustainable Development

Because we have failed to resolve human-induced global crises during the United Nations Decade of Education for Sustainable Development 2005-2014, the UN recently established the *2030 Agenda for Sustainable Development*, with 17 Sustainable Development Goals (United Nations, 2015). Goal 4 is Education, which aims to foster the well-being of self, family, community, nation, and humanity at large, as well as the planet's living systems and other life forms. In setting out the following principles of education for sustainable development, UNESCO (2020) recognises that sustainable development is an ethical challenge as well as a scientific concept. Education for sustainable development (ESD):

- is based on the principles and values that underlie sustainable development
- deals with the well-being of all four dimensions of sustainability – environment, society, culture and economy
- uses a variety of pedagogical techniques that promote participatory learning and higher-order thinking skills
- promotes lifelong learning
- is locally relevant and culturally appropriate
- is based on local needs, perceptions and conditions, but acknowledges that fulfilling local needs often has international effects and consequences
- engages formal, non-formal and informal education
- accommodates the evolving nature of the concept of sustainability
- addresses content, taking into account context, global issues and local priorities
- builds civil capacity for community-based decision-making, social tolerance, environmental stewardship, an adaptable workforce, and a good quality of life
- is interdisciplinary. No single discipline can claim ESD for itself; all disciplines can contribute to ESD

In response to these principles, designing education to address sustainable development incorporates *values education* and *citizenship education*, and embraces *transdisciplinarity*. In addition to developing disciplinary knowledge and skills, a socially responsible STEM education contributes to preparing students as future citizens with crucial transdisciplinary capabilities. The Arts can help with this.

Embracing The Arts

Over the past decade, the Arts have established a strong presence in the social sciences, including education. The Handbook of Arts-Based Research (Leavy, 2018) and the Handbook of Arts in Qualitative Research (Knowles & Cole, 2008) define the field of the Arts as comprising *literary genres*, *performative genres*, *visual arts* and *audiovisual arts*. The significance of these branches of the Arts is that they provide powerful methods – narrative inquiry, visual thinking, critical reflexivity - for developing the subjectivity and character of the learner.

Leading Arts educator, Eliot Eisner (2008), explains that the Arts are concerned with expressiveness, evoking emotion, generating empathic understanding, stimulating imagination

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that disrupts habits of mind and creates open-mindedness, and eliciting emotional awareness. In sum, the Arts enable us to discover our humanity. Such an altruistic goal sits well with educating for sustainability where exploring one's (deeply felt) moral values and reconnecting spiritually with both the natural world and culturally different (especially indigenous) others are of central concern. A succinct account of what the Arts can offer was coined by Arts educators Bucheli, Goldberg and Philips (1991):

> The arts can be, for both students and teachers, forms of expression, communication, creativity, imagination, observation, perception, and thought. They are integral to the development of cognitive skills such as listening, thinking, problem-solving, matching form to function, and decision making. They inspire discipline and dedication. The arts can also open pathways toward understanding the richness of peoples and cultures that inhabit our world, particularly during this period of global change. The arts can nurture a sense of belonging, or community; they can foster a sense of being apart, or of being an individual. By acknowledging the role of the arts in our lives and in education, we acknowledge what makes individuals whole.

But is there a compelling moral philosophy of education that urges STEM educators to reach out into unknown territory, beyond their established disciplinary comfort zones (or disciplinary 'silos'), to embrace their colleagues in Arts education and co-design (and perhaps co-teach) innovative STEAM curricula and pedagogies aimed at developing students' transdisciplinary capabilities for participating as concerned citizens in helping to resolve the global crises of the Anthropocene?

Transformative Learning

Missing from the *Arts + STEM = STEAM* equation is a moral philosophy of education that guides the design of STEAM teaching and learning approaches aimed at developing students' transdisciplinary capabilities for engaging as future citizens in sustainable development debates, decision-making and practices. To address this need we turn to a philosophy of *transformative learning* that has been articulated in various ways for much of the 20th century by leading educational philosophers and psychologists, including Jack Mezirow, John Dewey, Parker Palmer, Carol Gilligan and Abraham Maslow, who call for our subjectivities and lived experiences to be addressed in the curriculum of formal education. This *inner education* perspective resonates with the Ancient Greek maxim of *know thyself*.

Transformative learning involves engaging students in reflecting critically on the presuppositions underpinning their (largely invisible) values and beliefs. Using cognitive, emotional, social and spiritual development methods, students learn to reconceptualise and reshape the relationship between their outer and inner worlds. Transformative learning comprises five interconnected (and interwoven) ways of coming to value, to know, to become, and to act (Taylor 2015; Taylor & Taylor 2022).

1. **Cultural-self knowing** (or self-realisation) involves coming to understand our culturally situated selves, in particular how the (mostly invisible) premises underpinning our (automatic) habits of mind – moral values, beliefs, ideals, emotionality, spirituality – give rise to our cultural identities and govern our habituated ways of making sense of our social and natural worlds.
2. **Relational knowing** (or opening to difference) involves learning to connect empathically and compassionately with our true (nonegoic) selves, our local community, and culturally different others; and to appreciate firsthand the beauty and inspiration of the natural world.

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3. **Critical knowing** (or political astuteness) involves coming to understand how and why (political, institutional, economic) power has structured historically our social realities by creating seemingly natural categories of class, race, gender, vocation, intelligence, etc., and how this mostly invisible power governs (especially distorts) our lifeworlds, our relationships with others, and our relationship with the natural world.
4. **Visionary and ethical knowing** (or 'blue-sky' thinking) involves engaging in creative, inspirational processes of imagining, idealizing, poeticising, romanticising, meditating on and negotiating a collective vision of what a better world *could be* like and, most importantly, what a better world *should be* like.
5. **Knowing in action** (or making a difference) involves consciously developing our agency to help make the world a better place by committing to making a difference and taking action locally while thinking globally.

Taken together, these five dimensions comprise a 21st century philosophy of transformative learning that supports the moral imperative for STEM educators to draw on Arts education methods to develop students' transdisciplinary capabilities for participating as citizens (i.e., key stakeholders) in sustainable development debates, decision-making and social actions.

Transformative STEAM Education

In 1959 the renowned physical chemist and novelist, Charles Snow (1998), argued for a rapprochement of the cultures of Science and the Arts. Today, there is a new and growing wellspring of opinion that combining Science and the Arts in the form of transformative STEAM education is essential for producing a creative, scientifically literate, and ethically astute citizenry and workforce for the 21st century (Boy, 2013; Edwards, 2010; Feldman, 2015; Piro, 2010).

Recognising their limitations in developing students' transdisciplinary capabilities, visionary and ethically astute STEM educators are teaming up with colleagues in Arts learning areas to design innovative transdisciplinary STEAM curricula and teaching approaches (Root-Bernstein, 2008; Sousa & Pilecki, 2013). Already, the USA and Korea have begun producing an array of STEAM curricula for their respective nations (White, 2010). It should be noted, however, that many of these STEAM approaches do not necessarily involve transformative learning for achieving the crucial goal of sustainable development.

Conclusion

In summary:

- Transformative STEAM education is a compelling moral philosophy of education that empowers visionary STEM teachers to engage in community-based, interdisciplinary curriculum development with colleagues in the Arts with a primary focus on education for sustainable development.
- Transformative STEAM learning engages students in developing not only STEM disciplinary knowledge/skills but also the transdisciplinary capabilities of cultural self-knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action.
- Transformative STEAM education is not in opposition to STEM education; instead, it aims to foster development of socially responsible education at the heart of which is a moral commitment to urgently resolving the global crises of the Anthropocene.

As we have seen recently in the media, young people worldwide are deeply concerned about the global crisis of climate change that, in its various modes, is threatening their futures, and they are demonstrating *en masse* around the world to demand urgent action from their national leaders.

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As their teachers, are we not morally obliged to respond authentically to their pleas to provide the means for enabling them to help secure a sustainable future?!

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Chapters 1 and 4 are open access and available to **download free of charge** from the publisher: https://brill.com/display/title/63388?rskey=o5glT2&result=1

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Development of the textbook on plant morfology based on *case methods* and *team base project* to improve student learning outcomes

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Abstract. *This research aims to produce a Plant Morphology textbook based on the case method and team based project that meets feasibility based on material aspects, learning aspects, graphic design and based on responses from lecturers and students as well as to determine the role of the morphology textbook based on the case method and team based project in improving Biology student learning outcomes. The Plant Morphology textbook was developed using the ADDIE development model which consists of the stages of analysis, design, development, implementation and evaluation. The subjects in this research were material expert validators, learning expert validators, lecturers teaching Plant Morphology courses and students participating in Plant Morphology courses. The object of this research is a case method and team based project based morphology textbook. The results of the analysis of the achievement of the 7th Main Performance indicator-PTN (IKU-PTN) and curriculum analysis on learning outcomes at level 6 of the KKNI require the development of case method-based and team-based project textbooks for learning Plant Morphology courses as one of the learning tools that can accommodate learning activities which can ultimately improve student learning outcomes. The main material in plant morphology is the morphology of roots, stems, leaves, plant organs undergoing metamorphosis, flowers, fruit and seeds. According to material experts, learning experts and graphic design experts, Plant Morphology textbooks based on case methods and team based projects are good or suitable for use in learning Plant Morphology courses. Implementation of Plant Morphology textbooks based on case methods and team based projects in learning can improve student learning outcomes.*

Keywords: Textbook, Case Method, Team Base Project, Learning Outcome

Introduction

The Directorate General of Higher Education has 3 (three) main tasks in the field of higher

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education, namely: 1) improving the quality and relevance of higher education; 2) strengthening the quality of lecturers and education personnel; and 3) increasing access to higher education. These three tasks are contained in the Merdeka Belajar Kampus Merdeka policy, the implementation of which is outlined in the Decree of the Minister of Education and Culture No. 3/M/2021 concerning the Main Performance Indicators of State Universities (IKU-PTN). In the Directorate General of Higher Education, it is stated that there are 8 (eight) Main Performance Indicators stipulated in the Decree of the Minister of Education and Culture, including the 7th Main Performance Indicator (IKU), namely collaborative and participatory classes[1]. In the technical explanation of the 7th IKU, there are case-solving methods and team-based projects as methods that must be applied in classroom learning to create collaborative and participatory classes. Meanwhile, the description of Learning Achievement level 6 in the KKNI is being able to apply their field of expertise and utilize science and technology in their field in solving problems and being able to adapt to the situation at hand; mastering theoretical concepts of a particular field of knowledge in general and theoretical concepts of specific parts in that field of knowledge in depth, and being able to formulate procedural problem solving; being able to make the right decisions based on analysis of information and data, and being able to provide guidance in choosing various alternative solutions independently and in groups; being responsible for one's own work and being able to be given responsibility for achieving the organization's work results. From the explanation above, the implementation of the 7th IKU above is assumed to be able to accommodate most of the Learning Outcomes at level 6 of the KKNI.

Textbooks are teaching materials that contain information on learning outcomes., material presentation, learning activities, summaries and exercises/evaluations in accordance with the Semester Learning Plan (RPS). In learning activities, there are tasks that must be done, both theoretical and practical, which refer to the learning outcomes that have been set. Textbooks used in teaching and learning activities can make students active in the teaching and learning process, help students find and develop concepts, train students in finding and proving a material concept[2]. Using textbooks in learning can not only improve skills, but also foster students' creativity in thinking and doing.

Case method is a problem-solving learning method, students are directed to be able to solve a problem[3]. Casemethod is a participatory learning method based on discussion to solve a problem. The application of this method can help students hone and improve critical and creative thinking skills to solve problems, communication skills, collaboration, and creativity. Case method is included in the constructivism learning method because this method provides students with the opportunity to build their own knowledge.

Learning methodsteam base project or it can also be said that project based learning is a learning method that involves students in designing, making and displaying products to solve a problem. This method can trigger the imagination, creativity, and innovation of students. Like the case method, the team base project is also constructivism. The project based learning is a learning method that uses problems as an initial step in collecting and integrating new knowledge based on their experiences in carrying out their activities in real terms[4].

In learning by applying the case method and team-based project, students are led to carry out science process skills such as analyzing, predicting, finding, evaluating, designing, concluding, and collaborating. These science process skills can shape the character of students who are skilled, creative, innovative, cooperative and participatory and will form a collaborative class because learning is carried out in teams or groups.

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Plant Morphology is one of the courses in the Biology Department of FMIPA Uniersitas Negeri Medan both in the Biology Education study program and in the Biology Study Program. Plant Morphology discusses the morphological structure of plants, especially those belonging to Spermatophyta, including the morphology of roots, stems, leaves, flowers, fruits and seeds as well as the metamorphosis organs of the main parts of plants. Root morphology studies include taproot and fibrous root systems, each of which has variations in its morphological characteristics. Stem morphology includes the type, shape, direction of stem growth to stem branching. Leaf morphology includes leaf types/types, leaf structure, variations in tips, bases, leaf edges to phyllotaxis. Flower morphology includes flower components, flower types seen from several aspects to flower formulas. Fruit and seed morphology includes types based on several aspects[5,6,7,8,9,10]. In his learning so far using reference books (not textbooks according to the Semester Learning Plan).

Based on the explanation above about textbooks, case method learning methods and team based projects, it is assumed that textbooks designed according to the characteristics and syntax of the case method and team based projects can be used to improve student learning outcomes and subsequently have an impact on accelerating the achievement of university performance targets.

This study aims to obtain Plant Morphology textbook based on case method and team based project which is feasible based on material aspects, learning aspects, media design and to find out learning outcomes by using the textbook.

This research can contribute to the provision of case method and team-based project-based textbooks in the Plant Morphology course and further contribute to the realization of collaborative and participatory classes as mandated in the Ministry of Education and Culture no. 3/M/2021.

Method

The research was conducted at the Biology Department, FMIPA, Universitas Negeri Medan, Jl. Willem Iskandar Pasar V Medan. The subjects in this study were material expert validators, learning expert validators, lecturers in charge of Plant Morphology courses and students in the Biology Department, FMIPA Universitas Negeri Medan in the odd semester of the 2024-2025 academic year.

The object of this research is the Plant Morphology Textbook based on the case method and team-based project.

This research is a Product Development Research (Research and Development). The product developed is a Plant Morphology Textbook based on case method and team base project. The development design used is the development of the ADDIE (Analysis, Design, Develop, Implementation, Evaluation) model[11]. The scheme can be seen in the following image.

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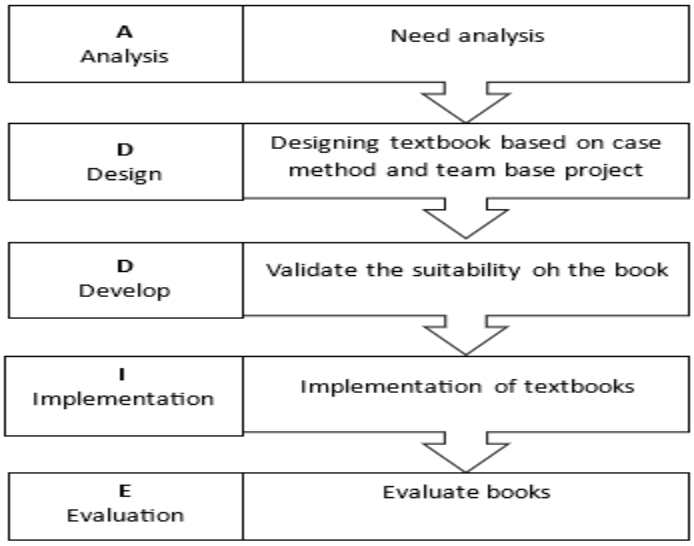

Figure 1. Stages of development model ADDIE[11]

The analysis of the feasibility of the textbook was conducted descriptively quantitatively. Data to determine the feasibility of the textbook was obtained from the results of validation by material experts, media design learning, lecturer and student responses using a score scale of 1 to 4, with the following information: score 1 = not feasible; score 2 = less feasible; score 3 = feasible and score 4 = very feasible. The student response scale with a score scale of 1 to 4 with the following information: score 1 = disagree; score 2 = less agree; score 3 = agree and score 4 = very agree.

To determine the level and criteria for the suitability of textbooks and student responses, use the modified formula and criteria as follows[12]:

$$\text{Percentage score} = \frac{\text{Number of indicators per category}}{\text{Total number of category indicators}} \times 100$$

Table 1. Criteria for The Feasibility of Textbooks

Criteria	Score Level
Not feasible	<65
Less feasible	65 - 74
Feasible	75 - 84
Very feasible	85 - 100

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Table 2. Criteria for Student Responses to Textbooks

Criteria	Score Level
Disagree	<65
Less agree	65- 74
Agree	75 - 84
Very agree	85 - 100

To determine the level of student ability/learning outcomes, use the following formula:

$$\text{Learning outcome score} = \frac{\text{score obtained}}{\text{maximum score}} \times 100$$

The level of student learning ability/outcomes and their criteria are in the following table.

Table 3. Learning Outcome Criteria

Criteria	Score Level
Very Low	<65
Low	65 - 74
High	75 - 84
Very High	85 - 100

Result and Discussion

Analyze

Analysis of IKU-PTN and Curriculum Achievements. There are 8 (eight) Main Performance Indicators of State Universities (IKU-PTN) in the Decree of the Minister of Education and Culture No. 03/M/2021. Among them is the 7th IKU, namely realizing collaborative and participatory classes. In the technical explanation, it is stated thatcase method and team base project are methods that must be applied in classroom learning to create collaborative and participatory classes. The 7th IKU is an embodiment in line with Learning Outcomes at level 6 (Bachelor's degree level) in the Indonesian National Qualification Framework (KKNI) which is a reference in developing/compiling the curriculum in Higher Education.

Description of Level 6 learning outcomes in KKNI are being able to apply their field of expertise and utilize science and technology in solving problems and being able to adapt to the situation at hand. Mastering theoretical concepts of a particular field of knowledge in general and theoretical concepts of specific parts in that field of knowledge in depth, and being able to formulate procedural problem solving. Being able to make the right decisions based on analysis of information and data, and being able to provide guidance in choosing various alternative

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solutions independently and in groups. Being responsible for one's own work and being able to be given responsibility for achieving the organization's work results.

In order to realize the 7th IKU which is meaningful and also to realize Learning Achievements at level 6 of the KKNI, it is necessary to develop a learning tool that accommodates case method and team-based project learning activities..In addition to the Semester Learning Plan (RPS), learning tools that need to be developed for the above objectives are case method and team-based project based textbooks.

Textbook Needs Analysis.Textbooks are learning resources as well as learning media that are very much needed in learning activities to achieve a learning achievement/learning objective. Buku ajar yang berisi materi dan kegiatan-kegiatan sesuai capaian pembelajaran akan sangat membantu menciptakan pembelajaran aktif [13]. As it should be, the textbooks used must be in accordance with the learning design in the RPS, therefore the textbooks must include learning achievements, material presentations, details of learning activities along with student assignments as stated in the RPS. So the textbooks are very much needed in learning. Also, in learning the Plant Morphology course, textbooks are very much needed as learning resources or learning media to realize learning achievements. To realize IKU-7, it is necessary to develop textbooks based on case methods and team-based projects that are integrated with student assignments in learning activities.which includes Critical Book Report (CBR), Critical Journal Review (CJR), Mini Research, Idea Engineering, Project Assignments and Routine Assignments based on case method and/or team based projects.

Design

Plant Morphology textbook developed in accordance with the Plant Morphology course RPS based on case method and team based project. Number of chapters in the textbook according to the number of sub CPMK in the RPS, namely there are 11 book chapters because there are 11 sub CPMK in the RPS. This textbook discusses the morphology of the main organs of plants (roots, stems and leaves), the morphology of metamorphosis organs and the morphology of plant reproductive organs (flowers, fruits and seeds). In each chapter of the book, learning outcomes, material presentations, summaries and exercises / evaluations are presented. At the beginning of the material presentation, a discourse is presented as a trigger to lead to the material according to the learning outcomes. To further improve mastery of the material, in the material presentation section in each chapter of the book there are learning activities that can be carried out using the case method and team-based projects that are integrated with tasks oriented to the KKNI curriculum, namely Critical Book Review (CBR), Critical Journal Review (CJR), Mini Research, Idea Engineering, Project Assignments and various forms of Routine Assignments. The learning activities written in the body of the textbook must be in accordance with those designed in the RPS.

Develop

This stage begins with the validation of the textbook by material experts, learning experts and design. From the validation results, the textbook is revised according to the validator's suggestions, namely in the deepening of the material in several chapters of the book; revising the editorial of learning activities in the material presentation section to suit the objectives and syntax of the established method. case method and or team base project. Validation results on the material aspect are 84 with feasible criteria; validation results on the learning aspect are 86.8 with very feasible criteria; validation results on the textbook design aspect are 82.5 with feasible

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criteria (Figure 1).

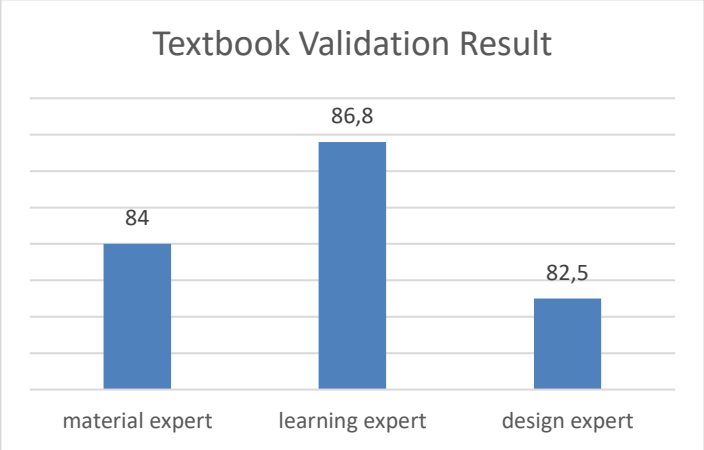

Figure 1. Textbook Validation Results

The result of the validation of the textbook is that this textbook is declared feasible in terms of material and design aspects, while the validation result from the learning aspect is that it is very feasible to be used in learning the Plant Morphology course to improve student learning outcomes. The following explanation is an explanation of why this case method and team-based project-based textbook is declared feasible and very feasible. In each chapter of the textbook, there is a description of most of the material according to the title of the book chapter. This material can be used as a standard reference for the purposes of the assignments contained in the "Learning Activities" section in each chapter of the book. At the beginning of the "Material" section in each chapter of the book, there is a short discourse related to learning outcomes. This discourse is a trigger for students to start learning. In the "Material" section in each chapter of the book, there is a "Learning Activity" according to the "Learning Achievement" listed at the beginning of each chapter of the book. These learning activities are available with 2 activity patterns, namely theoretically reviewing all sub-materials and practically to find, verify and/or prove the morphological characteristics of all parts of the plant.

Implementation and Evaluation

The revised textbook was given to students to be used in learning the Plant Morphology course. From the student responses, 82.9% of students stated that they strongly agreed and 17.1% of students stated that they agreed that the textbook was based on case method and team base project are used in learning because they greatly help students in mastering the concepts of plant morphology material and can improve students' ability in determining the morphological characteristics of plant organs because in the textbook there are learning activities with easy-to-implement procedures. The learning activities contained in the textbook greatly help students in working collaboratively and participatively. The student activity sheets can increase student activeness in learning which has implications for the better understanding of the substance of the material by the students [14], [15]. The evaluation results on plant

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morphology material obtained an average value for all materials of 83.5 (high category). Details of the average value of each sub-material can be seen in Figure 2 below.

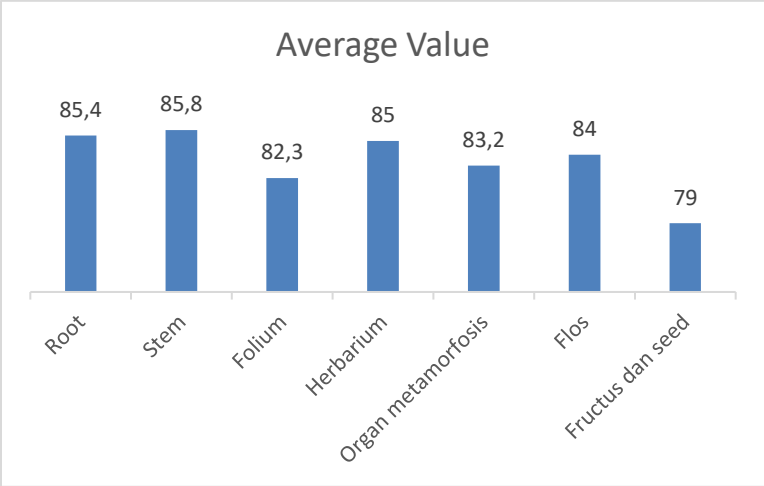

Figure 2. Plant Morphology Learning Outcome Value

The evaluation results for all sub-materials obtained high and very high scores. This is because in each chapter of the textbook (containing certain sub-materials) there are two types of learning activities, namely theoretical learning activities and practical learning activities. So in each sub-material, it is studied twice with different learning activity patterns. Learning outcomes for the sub-materials of roots, stems and herbarium were obtained in the very high category, while the sub-materials of leaves, metamorphic organs, flowers, fruits and seeds obtained results in the high category.

Conclusion

The developed plant morphology textbook based on case method and team-based project is declared suitable for use in learning Plant Morphology courses both in terms of material, learning and design aspects. This textbook is prepared in accordance with the learning design in the Semester Learning Plan (RPS) of the Plant Morphology course based on case method and team-based project. The body of the textbook consists of learning outcomes, material presentations in which learning activities are presented, conclusions and exercises/evaluations. Based on the responses of students as users, they agree that this textbook is used in learning plant morphology courses because it is very helpful for students to master the concept of the material, find a concept through learning activities contained in the textbook. Textbooks based on both methods can create collaborative and participatory classes.The use of Plant Morphology textbooks based on case methods and team-based projects in plant morphology lectures can improve student learning outcomes.

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Development learning equipment of general biology in case based method and project based learning

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Abstract. *This research is a type of development research. The development method applied follows the define, design, and development model. The aim of this study is to produce a valid general biology equipment learning based on case method and project based learning. In this research, the completed general biology equipment learning design was validated by content experts and language experts. Based on the validation results from content experts, the tool achieved a validation percentage of 86.65%, categorized as highly valid. The language experts validated the tool with a percentage of 81.25%, also categorized as highly valid. The results of the practicality test showed a figure of 83,04%, including very high criteria. Therefore, it can be concluded that the developed general biology equipment learning is suitable for testing by instructors of general biology courses.*

Keywords : General Biology, Equipment Learning, Case Method, Project Base Learnin

Introduction

The 21st century currently demands lecture learning that leads to the active participation of not only lecturers but also students. In accordance with the demands in higher education, it must meet the main performance. Ministry of Education and Culture said that the Main Performance

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Indicators in Higher Education that must be met are 8 indicators. One of the indicators that is closely related to the learning process is the seventh indicator, which is an indicator that realizes a collaborative and participatory classroom. [9] The guidance from IKU 7 stimulates lecturers to involve students in the teaching and learning process, by using a case method.[11]

Along with the development of the implementation of the Independent Campus Learning curriculum, campus policies are increasingly developing by implementing Outcome-Based Education Independent Learning Independent Campus based learning[2]. The case method concept is one of the developments of Outcome-Based Education (OBE). In the concept of learning in higher education, the basis of thinking learning outcomes refers to program learning outcomes rather than to curriculum education learning outcomes.[4]

Success in achieving learning objectives is one of them by using the right method in lectures. The case study method has an effect on student learning outcomes both in cognitive and affective aspects. In lectures, it is hoped that students will not only memorize the material but also know the relationship between the material taught and real-world situations. For prospective educators, case studies can broaden their learning horizons and give them a concept of how learning should be done. This case study method encourages problem determination, investigation and persuasion that must be carried out by students. Therefore, one of the important elements of the case study method is to include a collaborative discussion of the issues at hand. That way, students can identify what they need to know with the aim of understanding the case and establishing a problem to investigate. [12]

Project-based learning (PjBL) allows students to focus on achieving the project while achieving the learning objectives or concepts to be achieved. PjBL is able to increase students' creativity in carrying out projects and improve students' ability to utilize technology as a medium to communicate their work, media to create products. PjBL increases student creativity. PjBL is also effective in improving expected learning outcomes.[3]

The PJBL-CM learning model is one of the learning models that uses real problems/cases as a form of description of the real world experienced by students. The PjBL-CM learning model requires the active participation of students to integrate many sources of information in the learning context and be able to solve cases based on previous experience and knowledge and facilitated by lecturers and then students are trained to cooperate or collaborate with their peers to discuss solving problems/case. [1] . To enhance students' abilities, it is not sufficient to merely lecture or explain; efforts are needed to train and practice the skills they possess. One of these efforts includes encouraging students to analyze and seek solutions to problems around them through the case study method. Therefore, in case method learning, students are expected to collaborate in solving assigned projects given by the lecturer. [10]

Biology is a part of Natural Sciences (IPA) that studies living organisms and their environment, exploring the reciprocal relationships between living organisms and their surroundings. In the biology learning process, there are four main elements that students should possess: Curiosity, interest in natural phenomena, Scientific methods to solve problems, Products consisting of facts, principles, theories, and laws, and Implications, applications of scientific methods, and scientific concepts in daily life. [13]

The General Biology course in the Department of Biology FMIPA Unimed is one of the compulsory courses and still uses the KKNI curriculum, but in the future it will use an OBE-based curriculum so that it is necessary to update the learning equipment for the General Biology course. Problem-solving skills are skills that need to be developed in biology learning and biology learning can equip students with positive values.[15] In the General Biology course at the Biology Education

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Study Program of UNIMED, it consists of three credits (SKS), divided into two credits for theory and one credit for practical sessions. The General Biology lectures in the Biology Education program at UNIMED have not yet implemented case method and project-based learning. It is Necessary to Develop General Biology Course Learning Equipment Based on Case Method and Project-Based Learning in Accordance with OBE Curriculum. Based on the background outlined above, the research title could be "Development of General Biology Learning Equipment based on Case Method and Project Based Learning".

Method

This research includes development research. this research product is a case method and team project-based course learning tool in general biology courses that is valid. This development research refers to the 4-D model (four-D model) which consists of four stages, namely the define stage, the design stage, the develop stage, and the dissemination stage. [5] In this research, the focus is on the development stage, following validation of the instructional materials. The definition stage in this study begins with recognizing the General Biology material, student exercises and assignments, learning strategies and models based on case methods and project-based learning, as well as the evaluation of the learning outcomes to be used. The second stage is design. The researcher designed the development of learning equipment for general biology courses consisting of Semester Learning Plans, Student Task Designs, and learning outcome assessment sheets. In the third stage, namely development. The compiled device is validated by four validators. The validation process involves two content experts and two language experts. This study uses a data collection technique using a validation method through the provision of validation sheets to expert validators to determine the validity of the learning equipment developed. The data analysis technique in this study was carried out by calculating and analyzing the average results of the validation score of the learning tool from expert validators. To calculate the percentage of validity results, the following formula is used[14]

$$P\ \% = \frac{Total\ score\ of\ data\ collection\ results}{Total\ Score}\ x\ 100\%$$

Furthermore, to interpret the validity percentage, criteria can be used as presented in Table 1. Learning equipment are said to be good if they have at least valid validation results (percentage > 61%). [6]

Table 1. Validation criteria

No.	Percentage	Validation Criteria
1.	81 ≤ P < 100	Very valid
2.	61 ≤ P < 80	Valid
3.	41 ≤ P < 60	Less valid
4.	21 ≤ P < 40	Valid enough
5.	0 ≤ P < 20	Not valid

Result & Discussion

The development of General Biology Learning Equipment Based on Case-Based Method

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and Project-Based Learning was conducted at the Faculty of Mathematics and Natural Sciences, Department of Biology, Universitas Negeri Medan, following the Syntax of Research And Development (R&D) Method. Based on the Research and Development results that have been carried out, the researchers presented several findings as follows:

The researcher developed/produced a product in the form of the Development of General Biology Learning Equipment Based on Case-Based Method and Project-Based Learning by choosing the Research and Development (R&D) type of research. The development method followed the 4D Development Model, namely Define, Design, Development, and Dissemination. In this study, the development process progressed up to the development stage.

a. Define

In the Define stage, curriculum analysis is conducted. The curriculum used for developing General Biology learning equipment is the OBE Curriculum. The General Biology course consists of three credits, with a distribution of two credits for theory and one credit for practical work. Therefore, in developing General Biology learning equipment based on case method and project, practical activities are equated with mini-research tasks.

b. Design

In the Design stage, General Biology learning equipment that will be developed are planned. The General Biology learning equipment to be developed include Course Contracts, Semester Teaching Plans, Student Worksheets (mini-research and project), and task assessment rubrics. The developed learning equipment are tailored to the current OBE Curriculum, which incorporates case method and projects, thus facilitating their use in the learning process.

c. Development Stage

During the development stage, an evaluation is conducted on the completed general biology learning equipment that have been designed. A good learning tool must meet validity criteria set by expert validato.[8] The developed learning equipment should meet validity requirements, which are achieved by calculating the percentage of achieved scores compared to the ideal score (maximum score) for each aspect assessed, calculating the average percentage of validator score achievements, and then interpreting the data using percentage interpretation based on feasibility achievement criteria. Evaluation by validators is done through discussions about the developed learning equipment. This aims to obtain input from the validator. [7]

The validation results by content experts can be seen in the following Table 2.

Tabel 2. The validation results by content experts

Validator	Percentage	Result
Validator 1	93,3%	Very Valid
Validator 2	80%	Valid

The development of General Biology Learning Equipment Based on Case Based Method and Project Based Learning has currently received validation results both in terms of content and language. The developed learning equipment have been validated by Content Expert first validator, achieving a validation percentage of 93.3%, deemed suitable for field testing with some revisions. Additionally, second validator, provided a validation percentage of 80%, concluding it suitable for

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field testing with revisions including adding assessment criteria F1, F2, F3, and F4 (according to the latest rules), detailing the contract between lecturer and students, adding lecture rules, and specifying the objectives, theory, equipment, and materials in the Student Worksheet. From the validation results of both content experts, the overall validation percentage obtained is 86.65%. This indicates that the General Biology Learning Equipment Based on Case Based Method and Project Based Learning are considered valid for use in the General Biology learning process. The validation results by language experts can be seen in the following Table 3.

Tabel 3. The validation results by language experts

Validator	Percentage	Result
Validator 1	92,5%	Very Valid
Validator 2	70%	Valid

The validation by language experts, first validator, concluded that the tool is suitable for field testing without revisions, achieving a percentage of 92.5%. second validator achieved a percentage of 70%. Therefore, the overall validity from the language experts is 81.25%. This means that the General Biology Learning Equipment Based on Case Based Method and Project Based Learning have been deemed linguistically valid by the validators for use in the General Biology learning process. Based on the validation results from both content and language experts, the development of General Biology Learning Equipment Based on Case Based Method and Project Based Learning is deemed suitable for use by students and lecturers in teaching General Biology courses.

Along with the development of the implementation of the Independent Campus Learning curriculum, campus policies are increasingly developing by implementing Outcome-Based Education Independent Learning Independent Campus based learning.[2] A limited trial was carried out on 6 lecturers teaching general biology courses. The assessment required is on 14 points in Table 3.

Table 3. The Assessment Required

No.		1	2	3	4	5	Total Score
1.	The language used is according to EYD	0	0	0	3	3	27
2.	The presentation of sentences is easy for the lecturer to understand	0	0	0	2	4	28
3.	Clarity of the language used so that it does not give rise to multiple interpretations	0	0	0	2	4	28
4.	Instructions on learning tools make it easier for lecturers to convey the aims and objectives of various learning activities	0	0	0	2	4	28
5.	Lecture contracts and RPS make it easier for lecturers to teach material to students	0	0	0	1	5	29
6.	The steps in the RPS and LKM are in accordance with the time allocation provided	0	0	0	2	4	28
7.	The learning method used is in accordance with the learning material taught	0	0	0	3	3	27
8.	The learning method used is based on the Case Method	0	0	1	1	4	27
9.	The learning method used is project based	0	0	0	2	4	28
10.	Accuracy of the RPS format with the OBE format	0	0	0	4	2	26

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11.	There are assignments and assessments that are in accordance with the Case Method method	0	0	0	4	2	26
12.	The RPS created does not have misconceptions about the concept of the material to be taught	0	0	1	4	1	24
13.	RPS and LKM make it easier for lecturers to attract students' interest in learning	0	0	0	2	4	28
14.	This learning tool can be used as a source of data for assessing the learning process	0	0	0	2	4	28
	Total Score						382
	Percentage of Product Trial Achievement						83.04%

From the results of product trials on 6 lecturers teaching general biology courses, it was found that product success was achieved at 883.04%, which means that the general biology teaching tool developed based on the OBE curriculum was declared very feasible. This means that the RPS can be used for general Biology lectures that use the OBE curriculum. This is in accordance with the demands of lectures at Unimed State University which uses an OBE-based curriculum which will answer the demands of the world of work in the future and is expected to be able to prepare the graduates needed to prepare for the needs of the world of work in the future.

Along with the development of the implementation of the Independent Campus Learning (MBKM) curriculum, campus policies are increasingly developing by implementing Outcome-Based Education Independent Learning Independent Campus (OBE-MBKM) based learning (Annisa et al., 2023).

Conclution

The General Biology learning equipment developed in this study include the syllabus contract, Semester Teaching Plan, Student Worksheet, and Rubric for assessing mini-research tasks and projects. These learning equipment are based on case method and project based learning. The research has progressed to the development stage, and the learning equipment have been validated by subject matter experts and language experts. The validation results indicate that the General Biology learning equipment are valid and can be used in teaching activities.

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Validity and practicality of case-based curriculum study semester lesson plan for biology education students

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Abstract. Abstract. *This research aims to obtain the validity and practicality of the case-based Semester Learning Plan (SLP) for the Curriculum Review course taught to biology education students. Research and development uses the analysis, design, development, implementation and evaluation (ADDIE) model by taking as subjects four curriculum review material experts and biology education experts. This research was carried out at the development stage by producing a product in the form of a case-based SLP. Data was obtained using a questionnaire and analyzed descriptively qualitatively and the scores obtained were analyzed using percentage techniques to determine the criteria for validity and practicality. The results of the research found that the SLP which was prepared based on cases contained in the biology curriculum for middle and high schools in Indonesia was stated by experts at a very valid and very practical level to be applied to the learning process of the Curriculum Review course in Biology Education, FMIPA, Medan State University.*

Keywords: validity, practicality, case based method, curriculum, lesson plan.

Introduction

Biology education students in their preparation to become biology teachers are required to attend Curriculum Review lectures. This Curriculum Review lecture material provides students with an overview of the ins and outs of the existing curriculum in Indonesia, both as it applies to junior high schools and high schools. The substance discussed refers to the structure of the biology

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curriculum. By examining the biology curriculum in Indonesia and comparing it with neighboring countries, biology education students are expected to have adequate cognitive abilities, attitudes and skills.

Lecturers prepare learning plans for the Curriculum Study course together with the teaching team who are members of the biology education professional expertise group. So far, Semester Learning Plans (SLP) have been produced, but with new developments in the context of curriculum changes, revision of the SLP has become a very urgent need. In line with the demands of current developments and in facing the industrial revolution 4.0 and social revolution 5.0, the abilities of biology education students need to be improved so that they have various competencies such as critical thinking abilities, problem solving abilities, collaboration abilities, and creative thinking.

Currently, biology education students are expected to have the ability to think creatively, think critically, collaborate and solve problems[1]. This is in accordance with the demands for skills to be obtained in the 21st century[2]. These 21st century skills should be well planned and presented in the biology learning process[3]. So that the biology learning process can be carried out well, it is necessary to prepare a learning plan which is presented in the Learning Implementation Plan or SLP.

Problem-solving abilities among students can be improved through case-based learning[4,5]. With case-based learning, students will become active and creative learners[6]. Active activities in the learning process will make it easy for students to understand the subject matter presented by the lecturer, and will leave an impression on students' minds for a relatively long time. Learning by doing will bring very significant learning outcomes.

The importance of the case-based learning process is that it is planned and systematic. In the designed SLP, cases about the subject matter are presented, so that the material will become more meaningful, in-depth and more detailed. According to Zendrato[7] that preparing a learning plan is very important to serve as a guide for teaching staff so that they are focused and in accordance with the material that has been planned. In this research, the design and development of SLP was carried out in which there were cases for students to study in order to gain problem-solving abilities and improve student character.

The SLP that is prepared requires continuity that can truly produce the goals to be achieved. Therefore, measuring validity and practicality is very important to see the feasibility of the SLP that has been developed. This article discusses the validity and practicality of the case-based Curriculum Review SLP which will be applied to biology education students as future biology teacher candidates. This is in line with the curriculum demands that are implemented, namely an outcomes-based curriculum. By reviewing the SLP being developed, this will become a means of new innovation in producing SLP that is ready to be implemented in accordance with curriculum demands.

Method

This research uses the research and development method of the ADDIE model with the stages of Analysis, Design, Development, Implementation and Evaluation. According to Trianto[8], this research and development is characterized by the existence of a product. Likewise, according to Gay[9] that research and development is carried out to meet consumer needs and produce products that can be implemented in innovative teaching and learning activities.

This research has gone through the analysis and design stages. This stage is a development stage in which expert validation activities are carried out, namely two material experts and two

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language experts. The test subjects for the validity and practicality of the SLP were carried out on 64 biology education students at Medan State University. The research sample was determined using purposive sampling on the grounds that the sample was attending Curriculum Review lectures. At the research stage, a learning tool was produced in the form of a Semester Learning Plan (SLP) which had been validated. However, at this research stage it can be said to be development research because according to Mulyatiningsih[10] the essence of development research is validation and revision of the learning tools being developed.

Results

The SLP components assessed in this study are listed in Table 1 below.

Table 1: SLP Components

No.	Assessed Components	Validator 1	Validator 2	Average	Creteria
1.	General identity	3.88	3.76	3.82	Very good
2.	Graduate Learning Outcomes	3.02	3.34	3.18	Good
3.	Final ability	3.32	3.40	3.36	Good
4.	Study material	3.16	3.28	3.22	Good
5.	Learning methods	3.88	3.76	3.82	Very good
6.	Time provided	3.90	3.92	3.91	Very good
7.	Student learning experience	3.42	3.38	3.40	Good
8.	Criteria, Indicators and Assessment Weights	3.56	3.52	3.54	Very good
9.	List of references used	3.34	3.28	3.31	Good
10.	All components	3.49	3.51	3.50	Very good

The research results relate to writing SLP according to the grammar used as shown in Table 2 below.

Table 2: Writing SLP

No.	Assessed Components	Validator 1	Validator 2	Average	Creteria
1.	Use of punctuation	3.56	3.62	3.59	Very good
2.	Sentence presentation is easy to understand	3.80	3.75	3.78	Very good
3.	Clarity of language	3.62	3.68	3.65	Very good
4.	Clarity of instructions for use	3.88	3.76	3.82	Very good
5.	Component collapse in SLP	3.82	3.84	3.83	Very good
6.	SLP format accuracy	3.83	3.87	3.86	Very good
7.	Presentation of cases in the SLP	3.56	3.62	3.59	Very good
8.	All aspects	3.72	3.74	3.73	Very good

The research results relating to the validity of the SLP for the Curriculum Review course are in Table 3 below.

Table 3: Validity of SLP Curriculum Review

No.	Assessed Components	Score	Criteria
1.	Suitability of learning outcomes	3.82	very valid
2.	Suitability of learning objectives	3.88	very valid

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3.	Suitability of learning materials	3.82	very valid
4.	Suitability of learning steps	3.78	very valid
5.	Suitability of learning methods	3.64	very valid
6.	Appropriateness of assessment	3.75	very valid
7.	All aspects	3.78	very valid

The research results relate to the level of practicality of the Curriculum Review SLP as shown in Table 4 below.

Table 4: Practicality of SLP Curriculum Review

No.	Assessed Components	Score	Criteria
1.	SLP format	3.90	Very practical
2.	Depth of material	3.84	Very practical
3.	Implementation of SLP	3.76	Very practical
4.	Media use	3.68	Very practical
5.	Use cases	3.75	Very practical
6.	Settlement of cases	3.60	Very practical
7.	All aspects	3.76	Very practical

Discussion

The research results show that the components contained in the SLP for Curriculum Review have met the standard requirements and criteria in preparing the SLP. SLP Review The developed curriculum has complete component standards and this is in accordance with the opinion of Syafarina and Setiawan[11] who state that complete SLP components can increase learning achievement for lecturers when conducting learning. This is also the opinion of Rikayani et al[12] who state that the SLP format really needs to be adapted to the ongoing curriculum to meet administrative requirements for lecturers.

The learning outcomes of graduates and the final abilities that students are expected to achieve in the designed Curriculum Study course are included in the good category. Although this category still needs to be improved. However, obtaining a good rating is sufficient in a learning plan. In the findings of this research, four domains are written that will be achieved in graduate learning outcomes, namely regarding attitudes, general knowledge, special knowledge and skills. This is in line with the research results of Wijaya et al[13] which stated that graduate learning outcomes need to have the domains of attitudes, general knowledge, special knowledge and skills.

Reconstructing graduate learning outcomes and final abilities in line with the study material of the Curriculum Review course as an important part of implementing the process of adapting to developments in information and communication technology. This section contains material on technological developments as a direction for changes to the biology curriculum. The study material in this research is in line with the learning outcomes of graduates. According to Rofi'ah and Kusna[14], the determination of study material in lecture material is explained by the learning achievements of graduates. This is also in accordance with the preparation of the SLP which is guided by Permendikbud number 3 of 2020 article 12 paragraph 3.

The findings of this research are that the learning method used in planning learning is to study the curriculum that will be taught to students, namely using the case method. This case method is seen as being able to improve students' problem-solving abilities. The results of Putri's research[15] show that the use of the case method is very effective in changing intellectual and

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critical abilities in problem solving. Likewise, the results of research presented by Asep[16] show that the application of the case method can enable students to learn actively to improve their thinking abilities and competence.

The learning planning for this Curriculum Review course contains active student learning experiences. This is because students use learning methods in the form of case studies. The cases discussed can make students further hone their thinking skills. Also, student motivation and learning outcomes in studying are increasing. This is in line with the research findings of Nurkhin et al[17] that the application of the case method in learning can increase student learning activities and produce more optimal learning outcomes.

The writing of the Curriculum Review SLP as a result of development is included in the very good category, both in writing format and grammar. Judging from its validity and practicality, it is stated to be very good. This is in line with the research results of Muhsinin and Fatmawati[18] which stated that the format and grammar in preparing SLP need to have very good criteria. Likewise, the opinion of Yulinda, et al[19] stated that the validity and practicality of the SLP is very important and the results of their research findings were stated to be very good.

The findings of this research are that the validity and practicality of the Curriculum Review SLP are stated to be very good, and this can be followed up in the form of implementation. Proper planning in lectures needs to continue to be followed by the implementation of lectures that are very good and consistent with the results of the planning. In this way, excellent student learning achievements will be produced. Curriculum Review lectures produce the ability to analyze problems in the biology curriculum in Indonesia and the ability to solve problems.

Conclusion

Based on the results and discussion, it can be concluded that the Semester Learning Plan for the Curriculum Review course is very valid and practical for use in accordance with the applicable curriculum in the FMIPA Biology Education Study Program, Medan State University. The developed SLP Curriculum Review component is complete and in accordance with the applicable SLP standards. The depth of the material is in accordance with the use of cases regarding the curriculum that will be discussed by students at each meeting. The cases discussed by biology education students at each meeting can improve problem-solving abilities and build student character.

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Analysis of basic teaching skills of biology education study program students through microteaching lectures

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Abstract. *This study aims to see the basic skills possessed by students of the biology education study program through microteaching lectures. The design of this study uses quantitative descriptive research, with a total of 30 correspondents in semester 5. The instrument used in the study was the basic teaching skills observation sheet. The aspects of skills observed and the results obtained include: 1) opening and closing lessons are in the 'Good' category; 2) giving reinforcement is in the 'Enough' category; 3) asking questions is in the 'Enough' category; 4) explaining is in the 'Good' category; 5) holding variations in the 'Enough' category and 6) guiding discussions in the 'Enough' category. Overall, it can be concluded that the basic teaching skills sufficiently obtained by biology education students are in the category.*

Keywords: Basic Teaching Skills, Microteaching, Biology learning. Undergraduate

Introduction

Teachers are a profession that has at least four competencies, such as social, personality, professional and pedagogical. These four competencies can be seen both in front of the class and

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outside the class. These competencies in the classroom or teaching and learning process can be seen from the way the teacher teaches. Such as the ability of students to manage the class, provide explanations and provide motivation to their students. Universities, especially those under the teacher training college (LPTK), should facilitate prospective teacher students with these competencies. One example is through microteaching lectures. Microteaching is a training model that allows prospective teachers to learn certain basic teaching skills through a simple teaching process carried out in a special room, where the intern acts as a teacher and his friends as students [1], also Microteaching is a course designed to provide real teaching experience to students before they enter the field or school [2]. Microlearning prepares students as prospective teachers to teach fully in front of the class by providing knowledge, skills, abilities, and attitudes as professional teachers. The field introduction process is needed to train students to become professional teacher candidates, but microlearning begins with training basic teaching skills [3]. Microteaching lectures are courses that aim to train student teachers on how to teach material according to their fields. Starting from planning, implementing in class, evaluating, to reflecting. In this lecture, students usually practice teaching in a peer teaching manner, where fellow students also act as their students. Furthermore, students get feedback from lecturers and their friends. Student teachers also gain basic teaching skills through this microteaching lecture.

Basic teaching skills are a series of abilities needed in carrying out learning by a teacher or educator so that the teaching and learning process can take place effectively and efficiently. (add definitions from several sources). This Another definition of basic teaching skills is teaching competence in elaborating concepts, related to learning materials with a number of fundamental skills [4].

The components of this skill consist of: the ability to open a lesson, explain, guide a discussion, provide reinforcement, hold variations, ask questions, manage the class until closing the lesson. The strategy of opening a lesson (set induction) is an effort or activity to condition students so that they are motivated and pay attention to what they are learning. This aims to provide a positive effect on the teaching and learning process. The activity of closing a lesson is an activity carried out by ending the learning process by summarizing the material taught. Based on the results of research conducted by educators, the greatest learning progress occurs at the end of teaching and learning activities by providing a summary of the main lesson. Providing reinforcement is a special skill possessed by teachers, instructors, and lecturers. Reinforcement is a response given to a behavior that can increase the likelihood of repeating that behavior. The purpose of providing reinforcement is to motivate students to be more active in the learning process in the classroom. Explanation skills are the skills of teachers, instructors, and lecturers in providing information orally that is managed systematically to show the correlation between subject matter. The main characteristic of explanation skills is a systematic and well-organized explanation. Explanation skills are about the teacher's ability to make students understand what they are learning through explanations by providing examples from the theory. Teachers must also know and understand the use of variations in teaching and learning activities. Skills in using variations in teaching are related to mastery of teaching methods and questioning skills. Skills in using variations are planned and created in the teaching implementation plan. Stimulus variations are activities carried out by teachers aimed at overcoming students' boredom and increasing their attention [5].

Furthermore, basic questioning skills for teachers in the classroom are the ability to ask questions that facilitate students' understanding and involvement in the learning process. These skills include various forms of questions, from open-ended questions that encourage critical

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thinking to closed-ended questions that help students clarify basic concepts [6]. Basic skills in guiding classroom discussions are the teacher's ability to direct student conversations so that learning takes place actively, focused, and involves the participation of all students. These skills enable teachers to create a collaborative learning environment where students can express their opinions, listen to other views, and develop their understanding of the material in depth [7].

Microteaching activities can be a great way for students to learn before they become field practitioners or become teachers in the future. Research conducted by [8] showed that the implementation of microteaching activities for the opening and closing aspects was included in the good category with an assessment percentage of 84.41%. Explanation skills were also included in the good category with a percentage of 82.40%, while class management skills were in the good category with a percentage of 81.90%. The percentage of assessment components in microteaching performance from other studies showed the following results: lesson opening skills got 73.2% with a good category, learning media usage skills 78.5% with a good category, method selection skills 65% with a fairly good category, explanation skills 75% with a good category, class management skills 60.2% with a fairly good category, and lesson closing skills 74% with a good category [9]. The results of the study related to the analysis of microteaching activities showed variations with a minimum category of fairly good.

Although basic skills teaching have been taught through microteaching lectures such as in the Biology Education Study Program in State University of Medan, there is still a tendency for students to have difficulty in applying these skills effectively. These difficulties include a lack of self-confidence, the use of inappropriate learning methods, and managing students' learning focus. There are many factors that cause these problems, such as a lack of understanding of the basic concepts of teaching, lack of practice and practical experience in real situations.

Therefore, it is important to conduct an analysis of students' basic teaching skills in microteaching lectures to assess their skills in various aspects of opening and closing lessons, explaining, asking questions, making variations, providing reinforcement and guiding discussions. The results of this study are expected to provide a clear picture of areas that need to be improved in the microteaching learning process, as well as provide recommendations to improve the quality of teaching and students'readiness to face the challenges of the wider world of education.

By conducting this analysis, it is expected to determine the effectiveness of microteaching lectures as a means to train students' teaching skills. This aims to prepare prospective educators who not only have mastery of the material, but also qualified teaching skills, in accordance with the demands of the increasingly complex world of education.

Research Methodology

This study uses a quantitative approach to measure students' basic teaching skills in a more structured and objective manner. The research design used is a survey with a structured observation sheet by students and lecturers about the basic teaching skills possessed by students during microteaching sessions. The sample of this study was 30 students in semester V in the biology education study program, biology department, FMIPA Unimed. Sampling was carried out by random sampling. The research instrument used an observation sheet with predetermined criteria to objectively assess students' basic teaching skills. The grid of the observation sheet can be seen in Table 1.

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Table 1. Observation Sheet Grid Basic Teaching Skills Student

No	Aspect	Description	Number of items
1	Skills open close lesson	● Motivating student like interesting attention ● Arousing a sense of desire know student ● Convey teaching materials ● Convey objective learning ● Choose activity learning in accordance Topic using media/ tools help with appropriate ● Do various interactions ● Do apperception (making) link) ● Reviewing return teaching materials (conclusion) ● Do evaluation learning ● Give bait come back Give act carry on like giving homework, assignments , plans to be made come	10
2	Skills give strengthening	● Giving strengthening in the form of mimic face ● Give strengthening exercise ● Give strengthening with method approach ● Give strengthening in the form of object or symbol ● Give reinforcement in a group student ● Give strengthening to personal certain ● Give strengthening with quick ● Show warmth and enthusiasm ● Give strengthening in a way meaningful ● Avoid negative response	10
3	Skills ask	● Disclose question in a way clear ● Disclose question in a way short disclose question with another way ● Centralize attention student ● Moving turn ● Spread question to students (individuals) ● Spread question to all over student ● Responding student when ask or ● Give time think ● Practice student For ask ● Submit question in a way tiered ● Push the occurrence interaction between student ● Give strengthening to student after answer / ask	12
4	Skills explain	● Show structure serving ● Use sentence the right effective ● Give relevant examples ● Use tool help ● Use variation intonation ● Submit question For explore understanding student ● Give bait come back	7
5	Skills stage variation	● Using variation voice (intonation) ● Stage change motion body / facial expression advance ● Give time silent For student speak ● Focus view to all over ● Give emphasis voice when explain grain important teaching	7

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			• Use variation tool learning aids and /or media • Stage variation pattern interaction in learning such as , groups , classics , or individuals	
6	Skills guide discussion		• Formulate return the problem that will solved • Explain steps discussion • Marking agreement and disagreement • Close discussion with to summarize / to summarize • Motivating student For do ask answer • Wait response student • Give student For participate • Prevent speak in a way excessive	8

Research data analysis using descriptive statistics like analysis frequency and average for see how far students control skills teach they . Category achievement ability base teach student can seen in Table 2.

Table 2. Guidelines for Student Creativity Level Categories

Value Range	Category
>80	Very Good
71 – 80	Good
60 – 70	Enough
<60	Poor

Results

The results of observations of students' basic teaching skills conducted in biology microteaching lectures showed that overall basic teaching skills scored 70, meaning that these skills were in the "Enough" category. The basic teaching skills observed consisted of six components, namely 1) opening and closing lessons; 2) providing reinforcement; 3) asking questions; 4) explaining; 5) making variations; and 6) guiding discussions. A comparison of the results obtained from each of these components can be seen in Figure 1.

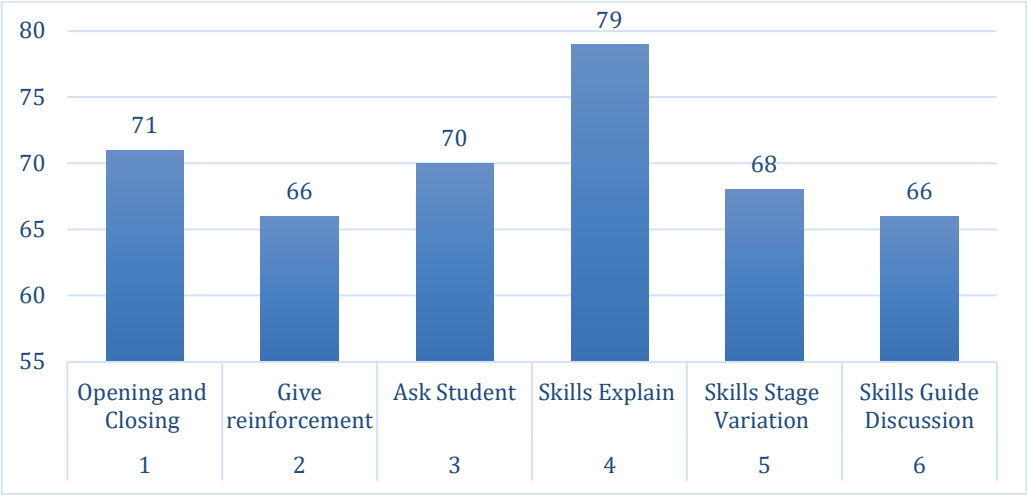

Figure 1. Comparison of Observation Results Component Basic Teaching Skills

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Lesson Opening and Closing Skills: This component observes 10 indicator points of teaching practice activities in microteaching classes. Based on the data obtained on the lesson opening and closing skills, the indicator 'delivering material' obtained the highest score while the lowest score was the indicator 'conducting learning evaluations. However, overall, the lesson opening and closing skills of Biology Education study program students at Medan State University are included in the 'Good' category. The score and value achievements of each indicator can be seen in Table 3.

Table 3. Skills Opening and Closing Student Lessons

No	Indicator	Score	Category
1	Motivating student like interesting attention student .	61	Enough
2	Motivating student For arouse curiosity know student .	76	Good
3	Convey teaching materials	93	Very good
4	Convey objective learning	69	Enough
5	Choose activity learning in accordance Topic using media/ tools help with appropriate	80	Good
6	Do various interactions	64	Enough
7	Do apperception (making) connection with life daily)	76	Good
8	Reviewing return teaching materials (conclusion)	81	Very good
9	Do evaluation learning	42	Not enough
10	Give bait come back Give act carry on like giving homework, assignments, plans to be made come	71	Good

Skills give reinforcement: Components This covers 10 indicators observed activities. Indicator ' Provides Strengthening through Body Movement ' gets score highest compared to indicator others . Meanwhile , the indicator ' Giving Strengthening by Approaching ' getting ' score lowest or category less . In overall skills give strengthening student including category Enough. Achievements results observation skills give reinforcement can seen in Table 4.

Table 4. Skills Give Reinforcement Student

No	Indicator	Score	Category
1	Give strengthening in the form of mimic face	77	Good
2	Give strengthening exercise	78	Good
3	Give strengthening with method approach	60	Not enough
4	Give strengthening in the form of object or symbol	64	Enough
5	Show warmth and enthusiasm	64	Enough
6	Give verbal reinforcement in a group student	64	Enough
7	Give verbal reinforcement to personal certain	67	Enough
8	Give verbal reinforcement with quick	69	Enough
9	Give strengthening in a way meaningful	49	Not enough
10	Avoid negative response	69	Enough

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Skills Ask : Components This consists of of the 12 indicators observed through practice teach Dad microteaching lectures . Details scores and values from skills This can seen in Table 5. The data shows that ability student study program education biology For spread question to all over students and respond student when ask including very good category. However, for ability disclose question with another way still low or less . In overall skills ask student is in the category Enough

Table 5. Skills Ask Student

No	Indicator	Score	Category
1	Disclose question in a way clear	80	Good
2	Disclose question with short	76	Good
3	disclose question with another way	46	Not enough
4	Centralize attention student	72	Good
5	Moving turn ask	64	Enough
6	Submit question in a way tiered	66	Enough
7	Spread question to students (individuals)	62	Enough
8	Spread question to all over student	81	Very good
9	Responding student when ask	81	Very good
10	Give time For think	77	Good
11	Practice student For ask	62	Enough
12	Push the occurrence interaction between student	73	Good

Skills Explain : indicators observed in skills This There are 7. Scores and values from every indicator can seen in Table 6. Indicator highest from skills explain is use tool help , while the lowest is in giving bait back . In overall skills This is in the category Good .

Table 6. Skills Explain Student

No	Indicator	Score	Category
1	Show structure serving	79	Good
2	Use sentence the right effective	82	Very good
3	Give relevant examples	82	Very good
4	Use tool help	87	Very good
5	Use variation intonation	81	Very good
6	Submit question For explore understanding student	74	Good
7	Give bait come back	70	Enough

Skills Stage Variation : Indicators observed in skills This as many as 7 points , with score the highest, namely ability use variation voice (intonation). While For score lowest is ability use tool help or learning media. Indicators and scores skills stage variation in a way Details can seen in Table 7.

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Table 7. Skills Stage Variation Student

No	Indicator	Score	Category
1	Using variation voice (intonation)	76	Good
2	Give emphasis voice when explain grain important teaching	66	Enough
3	Stage change motion body / facial expression advance	67	Enough
4	Give time silent For student speak	73	Good
5	Focus view to all over	68	Enough
6	Use variation tool help or learning media	59	Not enough
7	Stage variation pattern interaction in learning such as , group , classical , or individual	64	Enough

Skills Guide Discussion : Indicators observed in skills This consists of of the 8 points that can be seen in Table 8. Highest score found on the indicator close discussion with summarize while score lowest that is ability to mark approval and disapproval.

Table 8. Skills Guide Discussion

No	Indicator	Score	Category
1	Formulate return issues / points to be addressed discussed	68	Enough
2	Explain steps discussion	69	Enough
3	Marking agreement and disagreement	58	Not enough
4	Close discussion with to summarize / to summarize	71	Good
5	Motivating student For do ask answer	64	Enough
6	Wait response student	67	Enough
7	Give chance student For participate in discussion	67	Enough
8	Prevent speak in a way excessive (giving) chance to more students active speak)	62	Enough

Discussion

Based on the results obtained above, to answer the objectives of this study is the basic teaching skills of students of the biology education study program in semester V of the 2024/2025 academic year are in the fairly good category. For the components of explaining and opening/closing lesson skills, they obtained a better category than other skills. This shows that students are still focused on explaining activities when opening, core activities to closing lessons. Other skills, such as providing reinforcement, asking questions, doing variations and guiding discussions need further practice through microteaching lecture activities.

Through microteaching, basic teaching skills can be trained. Microteaching is one of the lecture programs that students rely on to explore their teaching abilities. Because with this lecture, students can provide input to their peers. Similar research also revealed the importance of assessments from other students towards student practitioners in microteaching courses [10]. Microteaching is also a very efficient learning tool because the basic teaching skills of prospective teacher students can be improved [11]. Microteaching lectures in the biology education study program at Medan State University usually facilitate one student for 2-3 practice cycles. This also aims to accustom students to dare to appear to teach in front of their friends and lecturers. From the 2-3 cycles, students get 20-25 minutes to appear, and this is considered a challenge for students to be able to prepare their teaching process quickly. This is also what makes other skills such as creating variations and guiding groups less able to be implemented well by students. Time constraints are also a weakness in the microteaching program which is a research finding from

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[12]. Therefore, from this finding, there needs to be an improvement for the efficiency of time use so that all basic skills can be further improved by each prospective teacher student.

In addition to time issues, students' discussion guidance skills are constrained because there are very few students in one class. Microteaching classes in biology education study programs are usually divided into 6-8 students. If there are students who are unable to attend, this makes the class look empty. So that students who practice being teachers have a little difficulty in dividing discussion groups. Furthermore, in this skill there are also constraints in the part of giving opportunities to students who are more active in speaking, in reality in the field students who act as teachers are still dominant in providing explanations while the discussion is taking place.

Another problem found in the ability of students to provide reinforcement, especially in the indicator of providing reinforcement by approaching students. Student practitioners are less active in moving. Practitioners prefer to stand in front of the class near the teacher's desk. Practitioners do not take advantage of less time to walk around their students' study desks.

The problems found in this study require program improvements so that student teachers can be more skilled at teaching. One solution to overcome the problems that often arise in microteaching lectures is the need to record all practicum activities via video, then provide special time to review things that need to be improved by student practitioners [11].

Conclusion

The conclusion of this research is that the level of Basic teaching skills students in the biology education study program through microteaching lectures is in the 'Enough' category. There needs to be an improvement in the microteaching program to train students so that each of their basic teaching skills becomes even better.

Acknowledgments

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Histopathological characteristics of the kidneys and creatinine levels of female wistar rat exposed chronically to bisphenol a

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Abstract. *Bisphenol A (BPA) is a compound similar to the hormone 17β-estradiol (E2). This study was conducted to investigate the effects of BPA exposure on rat kidney histology after chronic oral administration. The parameters observed were body weight, kidney weight, creatinine levels, glomerular diameter and the number of necrotizing cells in the renal tubules. Rats were divided into 6 groups (1 group consisted of 6 rats). Group I, rats were only given feed. Group II, given corn oil as much as 0.5 ml. Group III, given BPA at a dose of 0.5 mg/kg/day. Group IV, given BPA at a dose of 5 mg/kg/day. Group V, given BPA at a dose of 50 mg/kg/day. Group VI, given BPA at a dose of 500 mg/kg/day. BPA was given orally for 72 days. Measurement of creatinine levels was carried out 5 times. The results of analysis by ANOVA test showed that there was no significant effect ($p>0.05$) of bisphenol a administration on body weight, kidney weight, glomerular diameter, proximal and distal cortical tubule diameter. However, chronic administration of bisphenol a had a significant effect ($p<0.05$) on creatinine levels and mean renal tubular necrosis cells.*

Keywords: Bisphenol A. creatinine. proximal tubule. distal tubule. necrosis cells

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Introduction

Bisphenol A (BPA) or 4.4'-dihydroxy-2.2-diphenylpropane] or 4.4' isopropylidenediphenol is a synthetic compound made through the condensation of acetone molecules and phenol groups. The activity of BPA is similar to 17β-estradiol (E2)[1] and is often referred to as endocrine disrupting compounds (EDCs), as BPA can bind to estrogen receptors α and β (ERα and ERβ)[2].

BPA is used in the manufacture of polycarbonate and epoxy resins, which can be found in drinking bottles, food packaging, medical devices, food coatings and others[3], as a result about 90% of humans are susceptible to BPA exposure and most of the exposure occurs through ingestion, skin and breathing[4]. BPA is produced in large quantities so that by the end of 2023 BPA production has exceeded 7,348,000 tons per year[5]. BPA can leach out of polymers and into the food and beverage supply, putting humans at higher risk of exposure[6].

A lot of evidence explains that BPA causes interference with the endocrine system, by disrupting the hypothalamus-pituitary-gonadal (HPG) axis, causing disruption of reproductive function [7,8,9]. Not only on reproductive function, BPA also has a negative impact on other vital organs such as the kidneys [10]. Moreno-Gomez-Toledano et al[11] reported that BPA administration caused apoptosis in rat podocytes, a significant increase in urea nitrogen, serum creatinine, 24-hour proteinuria and protein-creatine ratio, and a significant decrease in creatinine clearance in kidney functional elements.

Mahmoudi et al[12] reported that the administration of 250 mg/kg BPA for 21 days caused a significant decrease in body and kidney weight, caused an increase in creatinine and urea levels, and caused glomerular and tubular necrosis in the kidneys. Another study also showed that the amount of BPA in urine correlated significantly with creatinine levels in children's urine[13]. Ahmed et al[14] reported that rats treated with BPA showed degenerative changes in the kidneys including narrowing of the glomerular bundle and dilatation of bowman's space. Renal tubule damage showed loss of apical border to pyknosis of nuclei in the epithelium. These histopathologic changes supported elevated ureum and creatinine levels.

Although it is known that short-term exposure to BPA can induce renal histopathological damage and increased blood creatinine levels, it is not yet known how the effects of chronic presence of BPA on both histological and metabolic parameters. This study aims to observe renal histopathology, such as damage to glomeruli, tubules and tubule epithelial cells, and measure blood creatinine levels after chronic administration of BPA to experimental rats.

Materials and Methods

Chemicals and animals

Bisphenol A (BPA) with 98% purity was obtained from Loba Chemie (Mumbai) and corn oil from Nutrifood (Jakarta). Rats (*Rattus norvegicus*) of the Wistar strain (4 weeks old) were obtained from the Faculty of Pharmacy, Universitas Sumatera Utara, Medan and maintained in the animal house of the Faculty of Mathematics and Natural Sciences of Universitas Negeri Medan until 8 weeks of age (body weight 175-200 g). Rats were supplied with pelleted feed type A 202 C (PT. Gold, Bekasi) and water *ad libittum*. During maintenance, the body weight of the rats was weighed daily. Cages, drinking bottles and feeders were made of BPA-free materials. The temperature, humidity and daily dark-light cycle of the experimental room (3 x 4 m) were left natural.

This study has received recommendations and ethical approval on the use of animals in health research from the Animal Research Ethics Committees of the Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Indonesia (approval number 0194/KEPH-FMIPA/2023 dated 25 February 2023).

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Experimental design and treatment

Rats were randomly distributed into 6 different groups, 6 animals each, and placed into individual plastic cage (30 x 20 x 15 cm) covered with wire and layered with rice husk. Rats in group P1 were given distilled water only, P2 with corn oil only, while rats in groups P3, P4, P5, and P6 were given BPA at doses of 0.5, 5, 50 and 500 mg/kg BW respectively. BPA was dissolved in corn oil. Administration was carried out by direct delivery to the stomach by gavage, daily in the morning (09.00-11.00 a.m.) for 72 consecutive days. The final volume of material administered was 0.5 ml. During the treatment period the body weight of the animals was recorded daily.

Blood and tissue collections

Blood, to determine creatinine level, was collected 5 times on days 1, 18, 36, 54 and 72. On days 1, 18, 36, and 54, blood (0.5 ml) was taken from the tail vein while blood samples on day 72 were taken directly from the heart (1 ml) after cervical dislocation along with kidney collection for histopathology. Blood was put into a test tube, allowed to clot, centrifuged (3000 rpm, 10 minutes), then the serum was taken and put into an eppendorf tube and stored in a refrigerator (-20^{o}C) until used for the determination of creatinine levels. After removing the fatty tissue, both kidneys were weighed with an analytical balance, then excised and fixed in 10% NBF solution for histopathological analysis.

Tissue processing

Kidney sections were fixed in 10% NBF solution, dehydrated in alcohol, cleared in xylol, embedded in paraffin, transversely sectioned to 5-8 µm, and stained with haematoxylin and eosin.

Observation

Creatinine levels. Serum creatinine levels were determined using the Jaffe's colorimetric method where creatinine produces quantitatively an orange color with picric acid in alkaline medium[15]. A blank tube, standard tube and sample tube were provided. To the blank tube, distilled water (50 µl) and working reagent (1000 µl) were added; to the standard tube, 50 µl creatinine standard and working reagent (1000 µl) were added, while in the sample tube, serum (50 µl) and working reagent (1000 µl) were added. Then the three tubes were incubated (room temperature, 20 minutes), after which the absorbance intensity was read using a spectrophotometer at λ 500 nm.

Histopathology analysis. Assessment of renal histopathological features was performed using a microscope at 400x magnification. Six slides per group (1 slide per animal), nine fields of view (FOV) per slide for measurement of renal glomerular diameter or 5 FOV per slide (for necrotic cells) were assessed. The diameters of 3 glomeruli or tubules were randomly measured for each FOV. For each glomerulus or renal tubule, the longest and shortest diameters were measured. The measurement results were expressed as the average number of the shortest and longest diameters respectively [16]. The proximal cortical tubule is lined by simple cuboidal epithelial cells with an apical brush border, while the distal cortical tubule is lined by simple cuboidal epithelial cells [14]. The necrotic tubular epithelium was counted in 5 fields for each slide. At least 100 epithelial cells were observed in each FOV.

Statistical analysis

All data were presented as mean ± SEM. Statistical mean differences between experimental

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groups were analysed using one-way analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) post hoc tests. Means were considered statistically different at $p < 0.05$. All statistical analyses were performed using the IBM SPSS Statistics v. 25.0 package.

Results

Although the body weight of the experimental rats tended to increase during the 72 days of experimentation, no significant differences were found between groups (Figure 1). Each group of rats showed approximately the same increase in body weight during the experiment.

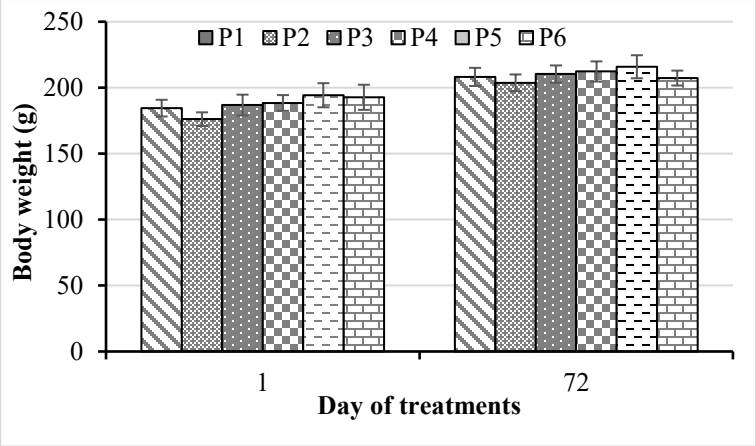

Figure 1. Body weight (mean ± SEM, g) of treated rats on day 1 and day 72 of treatment. Although all rats showed an increasing trend in body weight during treatment, no significant differences were found between groups. Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

Kidney weight and kidney-body weight ratio also showed no significant difference between groups (Table 1). This data also confirmed the body weight data presented in Figure 1.

Table 1. Kidney weight (mean ± SEM, g) and kidney to body weight ratio. There were no significant differences between groups in either kidney weight or the kidney to body weight of rats after 72 days of treatment. Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

Groups	Kidney weight (g)	Kidney to body weight ratio
P1	0.921 ± 0.022	0.064 ± 0.002
P2	0.876 ± 0.022	0.062 ± 0.002
P3	0.877 ± 0.312	0.060 ± 0.002
P4	0.893 ± 0.002	0.060 ± 0.002
P5	0.881 ± 0.023	0.061 ± 0.001
P6	0.899 ± 0.028	0.060 ± 0.001

The changes in blood serum creatinine levels in all animal groups during the experiment are shown in Table 2. The data show that BPA administration resulted in a significant increase in serum creatinine levels compared to the two control groups, P1 and P2 (DMRT test, $p < 0.05$). This significant increase started to be detected on day 18 and continued until day 72 of BPA administration. Table 2 also shows that the increase in serum creatinine level is related to the increase in the dose of BPA administered, the higher the dose of BPA, the higher the serum

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creatinine level that can be detected.

Table 2. Changes in creatinine level (mean ± SEM) of rats during 72 days of treatment. Different superscripts in the same rows indicate significant differences between groups ($p \leq 0.05$, one-way ANOVA and DMRT tests). Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

Day of treatment	Groups					
	P1	P2	P3	P4	P5	P6
1	0.265 ± 0.071^{a}	0.276 ± 0.035^{a}	0.297 ± 0.084^{a}	0.353 ± 0.077^{a}	0.380 ± 0.096^{a}	0.369 ± 0.088^{a}
18	0.310 ± 0.068^{a}	0.316 ± 0.041^{a}	0.380 ± 0.093^{ab}	0.469 ± 0.068^{bc}	0.494 ± 0.086^{c}	0.533 ± 0.089^{c}
36	0.365 ± 0.067^{a}	0.364 ± 0.036^{a}	0.430 ± 0.099^{b}	0.531 ± 0.073^{c}	0.643 ± 0.042^{d}	0.754 ± 0.059^{e}
54	0.460 ± 0.056^{a}	0.431 ± 0.047^{a}	0.515 ± 0.064^{a}	0.709 ± 0.089^{b}	0.731 ± 0.029^{b}	0.884 ± 0.068^{c}
72	0.582 ± 0.050^{a}	0.519 ± 0.076^{a}	0.722 ± 0.056^{b}	0.824 ± 0.077^{bc}	0.896 ± 0.084^{cd}	0.983 ± 0.091^{d}

Figure 2 shows the glomerular diameter of rats after BPA administration for 72 days. No significant change in the glomerular diameter of rats was observed during BPA administration. The smallest glomerular diameter (i.e. 61.2 ± 0.82 µm) was observed in group P6 (given BPA at a dose of 500 mg/kg BW) while the largest diameter (65.15 ± 1.55 µm) was recorded in group P5 (given BPA at a dose of 50 mg/kg BW), these two diameters were not significantly different.

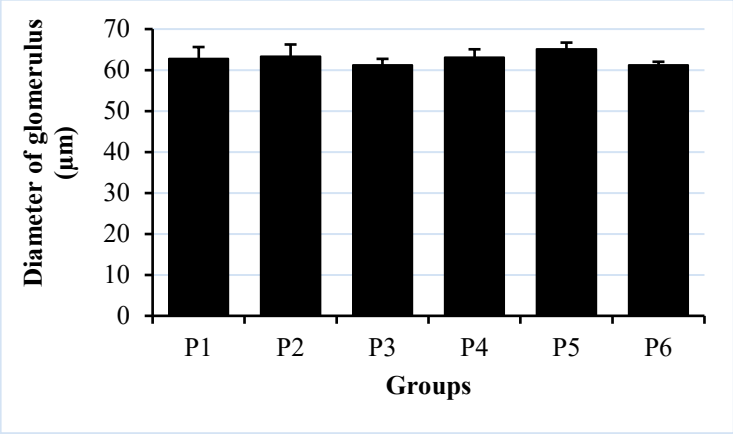

Figure 2. Diameter of glomerulus (mean ± SEM, µm) of rats after 72 of treatment. No significant differences were found between groups in diameter of glomerulus of rats exposed to BPA for 72 days. Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

Similar to the glomerulus, renal tubules also showed no significant changes in diameter, either in proximal or distal convoluted tubules, after administration of BPA for 72 consecutive days (Figure 3). The diameter of proximal convoluted tubules ranged from 36.05 ± 1.33 µm (P6) to 40.55 ± 1.53 µm (P2) while distal sections ranged from 31.33 ± 1.56 µm (P5) and 33.60 ± 1.58 µm (P6).

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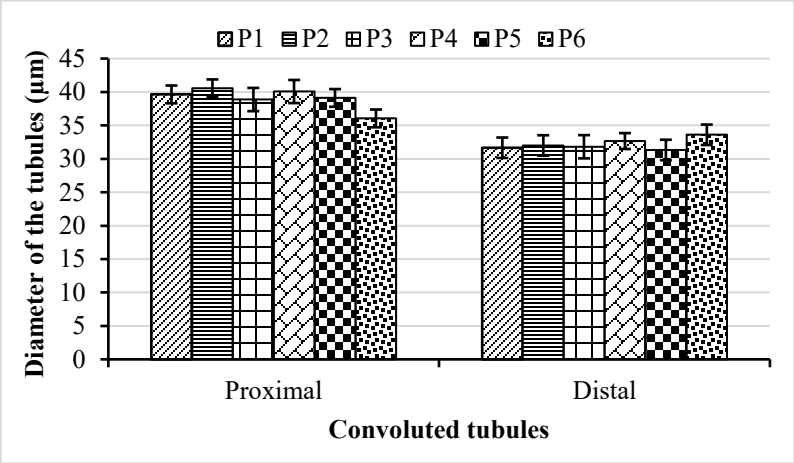

Figure 3. Diameter of renal tubules (mean ± SEM, µm) of rats after 72 of treatment. No significant differences were found between groups in diameter of proximal and distal tubules of rats exposed to BPA for 72 days. Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

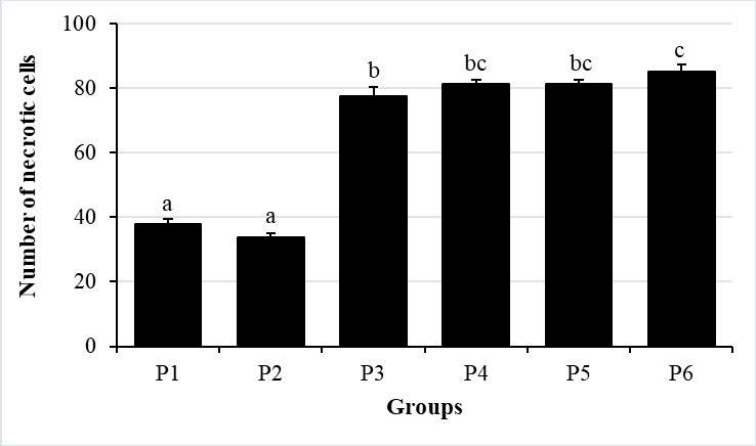

Figure 4. Number of necrotic renal tubule epithelial cells (mean ± SEM) of rats exposed to BPA for 72 days. Different superscripts indicate significant differences between groups ($p \leq 0.05$, one-way ANOVA and DMRT tests). Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days.

The number of necrotic renal tubular epithelial cells after BPA administration for 72 consecutive days is shown in Figure 4. It is observed that BPA administration resulted in a significant increase in the number of necrotic cells ($p \leq 0.05$, ANOVA and DMRT tests). BPA administration may result in a twofold increase in the number of necrotic cells compared to the two control groups (P1 and P2). Fig 5 also shows that the greater the dose of BPA administered, the greater the number of cells that develop necrosis.

Renal histopathological features for each group can be seen in Figure 5. Renal tubular epithelial cells that underwent necrosis were clearly visible in groups P3, P4 and P6. In addition to necrotic cells, the histopathology of rat kidney after BPA treatment also involved the dilatation of Bowman's capsule space, dilatation of blood vessels, infiltration of leucocytes, glomerular atrophy, and extravasated blood (Figure 5).

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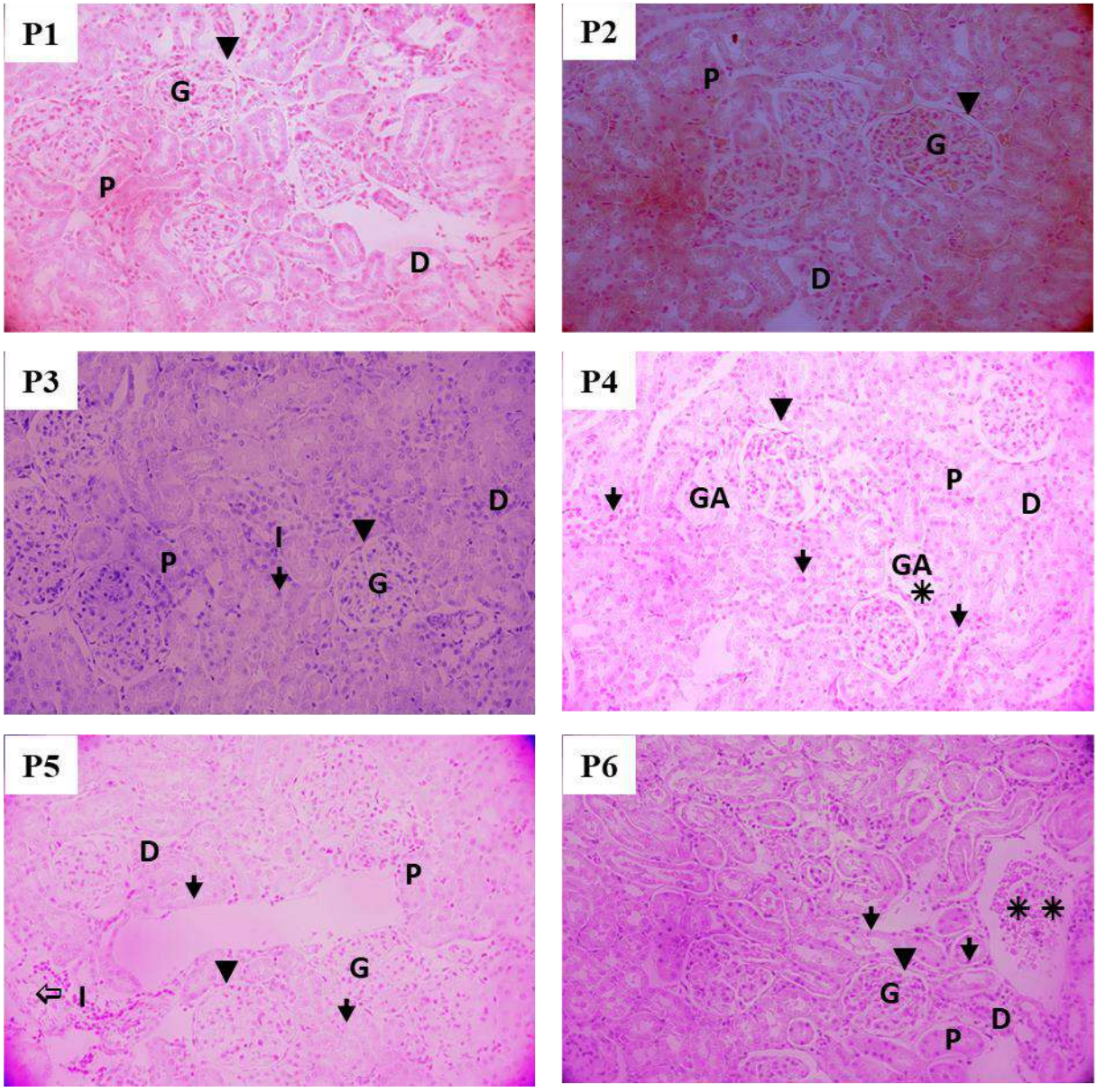

Figure 5. Photomicrograph of rat kidney cortex after 72 days of BPA administration (H&E, 400x). Rats were only given either distilled water (P1), corn oil (P2) or BPA in dose of 0.5 (P3), 5 (P4), 50 (P5) or 500 mg/kg BW (P6) during 72 consecutive days. P = proximal tubules, D = distal tubules, G = glomerulus, GA = glomerular atrophy, I = leucocytes infiltration, ✱ = dilated Bowman's space, ▼ = Bowman's capsule, ⬇ = necrotic renal tubule epithelial, and ✱✱ = extravasated blood.

Discussion

The most obvious and obvious sign of the harmful effects of the test material is the change in body weight [17]. The ANOVA test showed that the results obtained were $p < 0.05$. So it is known that the dose given to the treatment has no significant effect when compared to the control group. Studies regarding the developmental impact of BPA exposure on body weight provide mixed

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results, some reporting weight loss[18,19], while other studies found no significant effect on body weight[20,21].

Organ weight is a reflection of pathological conditions, knowing organ weight can help distinguish between healthy and diseased organs[22]. In Table 1, it can be seen that there is no significant difference between groups regarding kidney weight and kidney relative weight. This is in accordance with the research conducted by[16], but it is different from the research conducted by[23] who reported that BPA administration showed a significant increase in the relative weight of rat kidneys.

Serum creatinine is a commonly used indicator to assess kidney function[24]. Serum creatinine is released into the blood when the kidneys are injured, and an increase in creatinine concentration indicates damage to kidney cells. The study conducted[25] showed that elevated creatinine levels in the blood increase the likelihood of kidney tissue damage due to BPA poisoning.

Table 2 shows that the increase in serum creatinine level is related to the increase in the dose of BPA administered, the higher the dose of BPA, the higher the serum creatinine level that can be detected. This is in accordance with the research conducted by[26,27], which reported a significant increase in creatinine levels and the effect was dose-dependent. While the study conducted by[28] reported that the average creatinine levels reached significant levels only at the highest BPA dose. Serum creatinine is released into the blood when the kidneys are injured, and increased concentrations in creatinine indicate damage to kidney cells. In the study conducted[25] showed that the increase in creatinine levels in the blood. possibly damage to kidney tissue due to BPA poisoning. Previous research linked BPA administration in rats to increased creatinine levels, where BPA caused damage and injury to the podocyte foot process resulting in decreased creatinine contact with the glomerular basement membrane[29]. These results indicate that BPA is harmful to the kidneys and decreases kidney function. Loss of glomerular filtration and/or kidney function can result in a reduced ability to excrete waste products[28].

Since the body regularly produces it, the serum creatinine level may indicate a problem with the kidneys, which is the most common cause of kidney problems. The ability of the glomerulus to filter a substance will decrease as the serum creatinine level increases[30].

Glomerular diameter was measured to determine changes in glomerular diameter in response to BPA administration for 72 days. In microscopic images of the kidney, glomerular diameter indicates the presence of detectable disease. Measurement of this parameter in animal models helps in the prediction of changes in kidney function as well as early detection of such disorders[31]. Microscopically, the BPA-exposed rats had kidneys that had based on glomerular diameter size (Figure 2). Statistically, there was no significant difference in the glomerular diameter of rats treated with BPA with control rats. This result is consistent with the studies conducted by[16,26].

Several studies have reported morphological changes in kidney tissue due to BPA administration. The results of research by[27,32] showed that there was hypercellularity of the glomerulus and bowman space due to BPA administration. Then, the results of[33] revealed that the average glomerular diameter was significantly lower in the BPA-treated group than in the corn oil and distilled water control groups.

In Figure 3, it can be seen that after BPA treatment for 72 days, the average diameter of proximal and distal tubules did not show significant differences after BPA treatment for 72 days, this is in accordance with the research of[26]. Whereas in research conducted by [34,35] reported that the average diameter of proximal tubules in rats given BPA was significantly different compared to control rats.

Damage to the kidney from chronic exposure to BPA can be seen histologically (Figure 5), but

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is not always accompanied by significant changes in glomerular diameter or tubule diameter. This is because the kidney has the ability to adapt to stress, so cellular damage may occur without visible changes in glomerular size or tubule size. This can result in functional damage without obvious morphological changes in glomerular and tubular diameter[36].

Based on Figure 4, it can be seen that the highest number of necrosis cells is in the group of rats given BPA 500 mg/kg BW. This is in accordance with research conducted by[37] said that oral administration of BPA for 30 days caused degeneration and necrosis of proximal and distal contortus tubules in rats (Figure 5). Ahmed et al[14] reported that the epithelium of rat renal tubules experienced cytoplasmic vacuolation, pycnosis of the nucleus and exfoliation of degenerated cells due to the administration of BPA at a dose of 150 mg/kg bw for 70 days.

The increase in the number of necrosis cells in the renal tubules is due to BPA being able to act on cells through transduction pathway activity, where BPA can regulate enzyme activity. In addition, BPA can affect the antioxidant system, causing a buildup of ROS (*Reactive Oxygen Species*) and disrupt cell mitochondrial function[39]. However, researchers reported that ATP deficiency can cause necrosis, resulting in cell death. This was confirmed through a study that explained that BPA-treated rats had decreased ATP production in liver cells[37]. It has also been previously reported that BPA can accelerate the onset of puberty in the offspring of rats exposed to two consecutive generations[38].

In this study, BPA changed the histology of renal tubules by inducing damage to epithelial cells in the tubules, but could not change the size of tubules in the kidney. This is because BPA works at the cellular level[39], therefore BPA can cause cuboidal epithelial cells in proximal and distal tubules to necrose [12,14].

Conclusion

Based on the results of this study, it is concluded that chronic exposure to BPA has no significant effect on glomerular diameter, proximal and distal tubule diameter of white rats (*Rattus norvegicus*), but has a significant effect on creatinine levels and renal tubular epithelial necrotic cells of rat (*Rattus norvegicus*).

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Analysis of the encyclopedia as learning resource to enhance students' science literacy: a literature review

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Abstract. *The low level of science literacy among students is a crucial problem in education today, as shown by the PISA 2022 results where the average science literacy score is still below international standards. Encyclopedia as a comprehensive learning resource has the potential to be a solution to enhance students' science literacy skills. This study aims to analyze the use of encyclopedia as learning resource in enhancing students' science literacy. The research method used a systematic literature review by analyzing research articles published in reputable journals between 2019-2024. The analysis shows that encyclopedias has a positive impact on increasing scientific literacy through providing more interactive and interesting information. The encyclopedia can be used as an alternative learning resource that is used to provide accurate and up-to-date information and can broaden the horizons of its readers. The encyclopedia is also able to improve student learning outcomes and is suitable for implementation as an additional learning resource. The encyclopedia is an effective learning resource to improve students' science literacy skills, especially in the aspects of concept understanding, phenomenon analysis, and application of science methods. The results of this study provide an empirical basis for the development and implementation of encyclopedias as a strategy for improving science literacy in the context of education.*

Keywords: Encyclopedia, Literacy, Science Literacy, Learning Resource, Learning media

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Introduction

In today's globalized era, the education system is faced with the challenge of preparing students to have the skills needed in the 21st century. Competencies such as critical thinking, creativity, collaboration, and communication are becoming increasingly important, yet many students still lack adequate mastery of these skill[1]. Scientific literacy, a crucial component of 21st century skills, involves more than just scientific knowledge; it also encompasses the ability to apply scientific concepts to real-world situations[2].

Science literacy is a person's ability to use scientific understanding, develop critical questions, and draw conclusions based on data and facts in order to understand natural phenomena and the impact of human activities on them, which then become the basis for decision making[3]. Science literacy plays a vital role in modern life as it enables individuals to understand and make evidence-based decisions in the face of everyday challenges. Imagine shopping in a supermarket and reading the label "contains natural ingredients". Without a good understanding of science, we might immediately believe that the product must be safe and healthy. But with science literacy, we can make wiser choices - we understand that "natural" doesn't always mean "safe", and are able to find out more about the ingredients in the product. Science literacy is not just about understanding complicated formulas or theories, but rather our ability to make decisions in our daily lives and contribute positively to the environment around us.

The Program for International Student Assessment (PISA) organized by the Organization for Economic Co-operation and Development (OECD) is an international comparative study that comprehensively measures the science literacy skills of 15-year-old students. In its assessment framework, PISA not only measures the extent to which students can recall science concepts, but further evaluates their abilities in four main dimensions of science literacy. The four dimensions (aspects) are interconnected: competence (science process), science knowledge or content, science context, and attitude[4]. PISA assessment aims to assess education systems by measuring students' performance in mathematics, science, and literacy. Data from PISA measurements of scientific literacy from 2000–2022 indicate that students in Indonesia still have relatively low scientific literacy levels. The scientific literacy achievements of Indonesian students over the past twenty-two years can be seen in the following table.

Table 1. Indonesian students' scientific literacy achievements in PISA (2000-2022)

PISA Study Year	Average Grade/ PISA Standard (500)
2000	360
2003	370
2009	383
2012	382
2015	403
2018	396
2022	383

The low PISA scores indicate that something needs to be improved in the learning process holistically, one of which is the use of learning resources that can improve students' science literacy. Encyclopedia can be used as one of the learning resources to help students in learning including in understanding the material taught. This is because encyclopedias contain a variety of information in a broad, complete, and easy to understand manner. Encyclopedia has its own specialty that contains information accompanied by interesting pictures or illustrations according

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to the topic discussed. The encyclopedia presents accurate and reliable scientific information, so it can be a good reference source for students in improving their science literacy. This is supported by research from Azizah, Y.N. which states that E-encyclopedia teaching materials have the effectiveness to improve the literacy of grade X students as evidenced by the results of the posttest in the form of a questionnaire given by students with a percentage of 81.05% with a very high category[5]. Based on teacher and student questionnaires, 92.30% and get an assessment of the results of student questionnaires of 89.63%. In addition, the science literacy-based digital encyclopedia is suitable for use as a support for learning science literacy in ecosystem material for grade V elementary school[6]. By using encyclopedias, students can improve their ability to read and understand information, and use it as a reference source to solve various problems, both when learning at school and in daily activities.

Most of the teaching resources circulated and used by students do not contain balanced science literacy components[8], so supporting learning resources such as encyclopedias are needed to complement these deficiencies. This imbalance can be seen from the dominance of science content that focuses more on conceptual knowledge, while aspects of the science process, the context of application in daily life, and the development of scientific attitudes do not receive an adequate portion. Encyclopedia, with its characteristics rich in factual information, visual illustrations, and contextual explanations, can be a solution to enrich students' understanding of science phenomena more comprehensively. Encyclopedia can be used as an alternative learning resource that is used to provide accurate and up-to-date information and can broaden the readers' horizons[7]. Through the use of encyclopedias, students not only understand science concepts theoretically, but can also explore how science principles are applied in various fields of life, develop critical thinking skills, and build awareness of the importance of science in the development of technology and society.

Method

The methodology used in this research is Systematic Literature Review with the PICOS framework. The Systematic Literature Review (SLR) method used in this research is applied by collecting articles related or relevant to the topic to be discussed. This research aims to determine the effectiveness of using encyclopedia learning resources in improving scientific literacy in students at various levels of education.The data collection process was carried out on the Google Scholar & Crossref database using the Publish or Perish application using the keywords “Encyclopedia” & “Science Literacy”. The journal criteria used to discuss the article review analysis are discussing “encyclopedia”, “science literacy”. The year of publication of the article is from 2019 to 2024. All articles were analyzed using a qualitative approach that refers to aspects of research objectives, encyclopedias used in improving science literacy in the article.

Table 2. PICOS framework-based literature search criteria

Criteria	Inclusion
Population/Problem	Students (from various education levels)
Intervention	Use of encyclopedia learning resources
Comparators	Learning methods without encyclopedia or with other learning resources
Outcomes	Improved student science literacy (e.g., understanding of science concepts, critical thinking skills in science)
Study design	Quantitative, qualitative, R&D or mixed-method research in education

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Based on the articles used, a total of 10 articles will be analyzed and summarized, the results of which will be used as the subject matter in this study. The article selection stage can be seen in Figure 1.

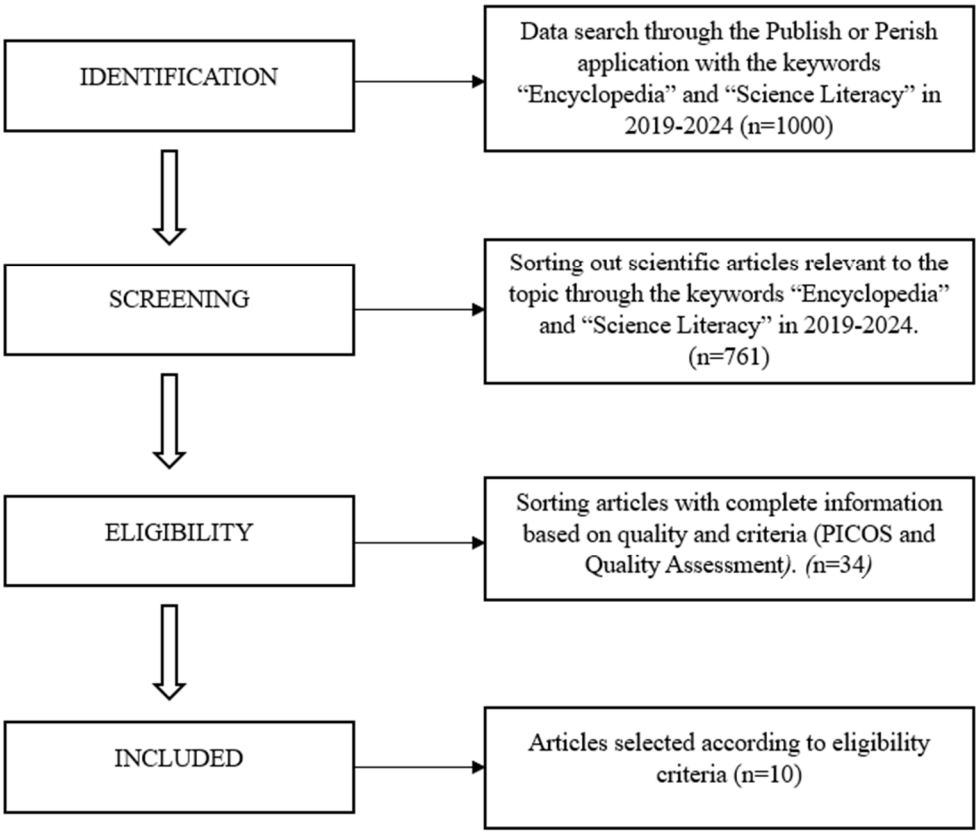

Figure 1. Flowchart of Article Selection

Results & Discussions

This literature analysis studies previous articles published in a reputable publication. This literature shows the results of previous research to obtain information about the issues raised. From the literature exploration using the Publish or Perish application, it was found that there were 1000 articles that were aligned with the keywords "Encyclopedia" and "Science Literacy". The exploration results that have been obtained then go through a screening stage for articles that can be accessed on the basis of the time range starting in 2019-2024 until 761 articles are obtained. In the literature mapping of the analysis of the use of encyclopedias on science literacy, 10 relevant articles were obtained to be used as literature review. The research methods used in the mapped scientific articles are qualitative research and Research and Development (R&D). The results are then classified based on the research findings. The research variables used are encyclopedia and science literacy. The following comparative analysis is focused on describing the search results of scientific articles related to the use of encyclopedias to improve science literacy which are presented in tabular form sorted by year of publication.

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Table 3. Literature Review Results

Author (Year)	Research Title	Relevance	Result
Azizah et al. (2021)	Development of ESD-based E-Encyclopedia of Taro Diversity in Bogor Regency to Improve Students' Digital Literacy	Encyclopedia, Literacy	E-encyclopedia teaching materials have the effectiveness to improve the digital literacy of students in class X MIPA 3. This is evidenced by the results of the posttest in the form of a questionnaire given by students with a percentage of 81.05% with a very high category. Based on teacher and student questionnaires, 92.30% and get an assessment of the results of student questionnaires of 89.63%.
Putri et al. (2023)	The Influence Of Science And Technology Encyclopedia Book Media To Improve Student Reading Literacy Assisted By The Scouting Actualization Model At Cikoneng Elementary School	Encyclopedia, Science Literacy	The results showed that in the application of Science and Technology Encyclopedia Book Media to improve Student Reading Literacy assisted by the Scouting Actualization Model at Cikoneng State Elementary School, students were able to read science and technology encyclopedia books. This is evidenced by the Mann Whitney U test score of 0.195. Through the Science and Technology Encyclopedia Book, students can apply and deepen their understanding of the material studied and is an effective approach to improving student reading literacy at Cikoneng State Elementary School.
Istiani, H. (2023)	Development of an Encyclopedia Based on Local Wisdom to Improve Science Literacy of Third Grade Students of MI NWDI 1 Kelayu	Encyclopedia, Science Literacy	The encyclopedia book based on local wisdom is effectively used to improve students' science literacy. This is evidenced by the results of the analysis for student learning tests in the field trial, 16 students out of 19 students scored above the KKM 65 with an average score of 79.6, so that the percentage of student learning completeness reached 84.2%, with the highest score of 100 and the lowest score of 46.

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Ramadhani, et.al. (2023)	Development of Digital Encyclopedia Based on Science Literacy in Science Learning Ecosystem Material for Grade V Elementary School	Encyclopedia, Science Literacy	The results of this research and development obtained validation from media experts of 88.3% with a very good category, material expert validation of 96.1% with a very good category, and linguist validation of 97.5% with a very good category. The results of one-to-one, small group, and field tests obtained an average percentage value of feasibility of 91.6% with a very good category. Science literacy-based digital encyclopedia products are suitable for use as support in learning science ecosystem material grade V elementary school.
Marinda et al. (2023)	Development Of Encyclopedia Learning Media In Science Subjects Grade 5 Elementary School 58 Lubuklinggau City	Encyclopedia, Science Literacy	The results showed the feasibility of learning media with an average score of 0.87 in the high category. The results of the field trial on teacher responses were 94% and students obtained 100%, both in the positive response category which was declared very practical. The results of the potential effect trial with a score of 0.70 are in the high category. This e-encyclopedia learning media is declared valid, practical and has a high potential effect.
Ningsih, M.P (2023)	Development Of Web-Based Science Encyclopedia Learning Media To Improve Elementary School Students' Science Process Skills	Encyclopedia, Literacy	Web-based science encyclopedia of animal and plant materials has been valid and feasible to use to improve the science process skills of fifth grade elementary school students, support understanding and visualization of a knowledge concept.
Ratminingsih & Subiantoro (2023)	Development of mangrove ecosystem e-encyclopedia as learning sources to improve information literacy skills and environmental care attitudes of students	Encyclopedia, Science Literacy	The results show that the developed mangrove ecosystem e-encyclopedia is very suitable for use in science learning. E-encyclopedia of mangrove ecosystem is effective in improving students' information literacy skills and environmental awareness. Product eligibility is based on the assessment of experts and practitioners in the school.
Agustiani et al. (2024)	Development Of A Biotechnology Encyclopedia Based On Scientific Literacy To Improve Students' Scientific Literacy Abilities Unimed Biology Education Program	Encyclopedia, Science Literacy	T-test results showed a significant difference in scientific literacy abilities between the experimental and control classes (9.344 > 2.002), indicating the effective impact of the Biotechnology Encyclopedia based on scientific literacy.

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Badaruddin et al. (2024)	The effectiveness of science encyclopedia-assisted project-based learning integrated with the STEM approach in enhancing pre-service elementary teachers' scientific literacy	Encyclopedia, Science Literacy	Results revealed that science encyclopedia-assisted STEM-PjBL had a positive modest effect on the achievement of scientific literacy. The scientific literacy of college students in elementary education who received science encyclopedia-assisted STEM-PjBL had moderate enhancement. Additionally, a science encyclopedia assisted STEM-PjBL significantly enhanced scientific literacy. Educational practitioners can implement a science encyclopedia-assisted PjBL integrated STEM approach to enhance scientific literacy resulting in high achievement in science education.
Ayuningtyas & Kuswandi (2024)	Pteridophyta E-Encyclopedia of Kelud Mountain to Study of the Diversity of Fern Species in the Environment on the RICOSRE Model to Improve Student's Information Literacy	Encyclopedia, Science Literacy	The research results show that the pteridophyta e-encyclopedia are feasible by lecturer and stated to be practical by teachers and students. The conclusion is the information literacy of students who use e-encyclopaedia's in RICOSRE learning is proven to be higher than students who do not use it.

Based on the results of the search for scientific articles relevant to the topic in this study, two types of research or research designs were found, including 2 quantitative studies and 8 Research And Development (RnD) published from 2019-2024. In quantitative research, A test of scientific literacy was adapted and used to measure scientific literacy. Descriptive and inferential statistics were used to describe and analyse the data of scientific literacy. Meanwhile, data collection techniques in Research and Development (R&D) research use observation sheets, questionnaires, interviews, validity tests, feasibility tests, and practicality tests.

Based on quantitative research written by Badaruddin et al. and Putri et al., encyclopedias have a positive influence on students' science literacy[9,10]. The science and technology encyclopedia not only provides extensive information on various fields of science and technology, but also plays an important role in enhancing students' literacy skills. Through reading and searching for information in the encyclopedia, students can develop critical thinking, analysis, and synthesis skills[9,15]. The interactive format of the digital encyclopedia is very suitable for the learning style of elementary school students. Features such as images, videos, and simulations make science learning more fun and effective, making it easier for students to understand complex material. This article emphasizes that the combined use of encyclopedia books and scouting models is effective in improving students' reading literacy. This study also highlights the importance of reading encyclopedia books to expand students' general knowledge, especially in today's digital era, where reading interest in Indonesia is still relatively low. Meanwhile, Badaruddin's article explains that the integration of science encyclopedia in Project Based Learning can improve the scientific literacy of prospective primary education teachers. This approach proved to be more effective than traditional project-based learning in improving students' scientific understanding[10]. This study also highlights the importance of implementing effective educational strategies in science learning to improve scientific literacy.

Based on research and development (RnD) research, it shows that the encyclopedia product is feasible to improve science literacy in elementary schools, high schools, and universities. The

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developed encyclopedia is feasible to use as a supplement to teaching materials and has the effectiveness to improve digital literacy of grade X students[5,11]. Science literacy-based digital encyclopedia is a learning innovation that presents scientific information in an interactive flipbook format. This encyclopedia can be accessed anytime and anywhere through various devices, such as smartphones and computers, making it accessible for students to learn independently[6,12]. In addition, the web-based science encyclopedia is considered valid and feasible to use to improve the science process skills of fifth grade elementary school students, support understanding and visualization of a knowledge concept[13]. There is a significant relationship between science literacy and science process skills[14]. So that with the increase in students' science process skills, it will be positively correlated with students' science literacy abilities. Besides being useful for enhancing the science literacy of elementary school students, encyclopedias can also enhance science literacy in college students. Agustiani showed a significant increase in the scientific literacy skills of students who used the encyclopedia, thus confirming the effectiveness of using the encyclopedia as a learning resource[16]. Ayuningtyas concluded that the effectiveness test showed a significant improvement in students' information literacy, with the experimental group using e-encyclopedia obtaining higher scores than the control group[17]. These findings confirm that encyclopedia integration in learning can improve students' information literacy skills, which are essential for the 21st century.

From the 10 selected literatures, there are 8 articles that are Research & Development studies. This research produces encyclopedia products with various themes, various academic levels, and in various forms both in digital and printed form. The eight articles can be seen in table 4 below.

Table 4. Encyclopedia produced based on literature review articles

Researcher (Year)	Media Types of Encyclopedia	Level	Field of Science / Topic
Azizah et al. (2021)	E-encyclopedia	Senior High School	Biodiversity
Istiani, H. (2023)	Printed	Elementary School	Local Wisdom
Ramadhani, et.al. (2023)	E-encyclopedia	Elementary School	Natural Science / Ecosystem
Marinda et al. (2023)	Printed	Elementary School	Natural Science
Ningsih, M.P (2023)	Digital / Web-based	Elementary School	Natural Science
Ratminingsih & Subiantoro (2023)	E-encyclopedia	Elementary School	Mangrove Ecosystem
Agustiani et al. (2024)	Printed	University	Biotechnology
Ayuningtyas & Kuswandi (2024)	E-encyclopedia	Senior High School	Botany / Diversity of Fern Species

Based on table 4, there are five encyclopedias created in digital form, and 3 in printed form. Digital encyclopedia or E-encyclopedia has several advantages over the printed version. Digital encyclopedias are practical and tend to be favored by students because they can be accessed easily using a smartphone [5]. This is also supported by Kundariati & Rohman's research which states that E-encyclopedias that can be accessed via smartphones offer high learning flexibility, in line with the trend of mobile-based learning that has been popular over the past two decades[18].

From the 8 encyclopedias produced, 5 encyclopedias are intended for elementary school students, 2 encyclopedias for high school students, and 1 encyclopedia for university students. One of the main advantages of encyclopedias for elementary school students is their clear and age-appropriate presentation of information. Unlike other sources of information, encyclopedias arrange information in a concise and organized way, making it easier for students to understand

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the key points of each topic. This is especially helpful for students who are still developing their reading and information-seeking skills, as they can build their basic knowledge more effectively. However, this does not mean that the use of encyclopedias is limited to elementary school students. Encyclopedia is a universal learning resource that can be applied to all levels of education. Each level of education can use encyclopedias as learning resources by adjusting the content of the encyclopedia.

Conclusion

This research reviews various literatures related to the use of encyclopedias as learning resources in elementary schools, high schools, and universities. Based on the analysis of various studies, it was found that encyclopedias have great potential in enhancing students' science literacy at various levels of education. Encyclopedia also has feasibility and practicality as a learning resource and is flexible which is not owned by conventional teaching materials. With its comprehensive and accessible characteristic, encyclopedias can be an ideal learning resource for students in developing critical thinking, information analysis and problem-solving skills. The findings have broad practical implications for educators, educational policy makers and curriculum developers in designing literacy-oriented learning programs. The results of this study provide an empirical basis for the development and implementation of encyclopedias as a strategy for improving science literacy in educational contexts.

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Exploration of Biopreneurship Learning in Biology Education Students

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Abstract. *Based on the World Economic report through the International Monetary Fund (IMF), the unemployment rate in Indonesia reached 5.2% in April 2024. This figure makes Indonesia the country with the highest unemployment rate in ASEAN. State University of Medan, through its biology education study program, strives to minimize that number by defining graduate profile achievements, one of which is entrepreneurs in the field of biology education, by developing the Bioentrepreneurship course. However, in practice, out of the many biological research results, only a few have been successfully developed in the market. The purpose of this research is to examine the extent to which products produced by students are feasible for development in the global market. The assessment of the instruments conducted includes the evaluation of product processing and biopreneurship product analysis to determine the achievement of biopreneurship indicators. The data obtained in this study were analyzed using qualitative descriptive methods. Based on the results of the data analysis obtained, it can be concluded that the 45 biopreneurship products produced by biology education students can be applied globally with evaluation criteria showing that 65% of the products fall into the very good category and 35% into the good category, as well as the achievement of biopreneurship indicators with a percentage of 92.375% in the very effective category.*

Keywords: Biology Education, Bioentrepreneurship, Products

Introduction

The Central Statistics Agency [1] reported that the number of unemployed people in Indonesia as of February 2024 reached 7.2 million, compared to the previous February 2023, which

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reached 7.99 million people. Last February, the number of jobless people in Indonesia was the lowest since the reform era in 1997, at 4.69 million. Compared to Southeast Asian or ASEAN countries, Indonesia's unemployment rate is in first place, where, based on data from the IMF as of April 2024, the unemployment rate in Indonesia reached 5.2%. Meanwhile, Thailand recorded the lowest unemployment rate in ASEAN, which only reached 1.1% as of last April. Around 12% of the unemployed in Indonesia are currently dominated by diploma and bachelor's graduates.

The above problems are the main priority for the country and each university in producing graduate profiles. The government has made several efforts to reduce unemployment rates by continuing to find and create new jobs for the community through MSMES (Micro, Small, and medium Enterprises) to encourage increased national competitiveness. While in universities themselves, MBKM activities have begun to prepare university graduates with mature soft skills and hard skills relevant to the times' needs. Overcoming the gap in competency between new graduates and the needs of the world of work encourages collaboration between universities and industry in organizing learning to increase the relevance of the skills of Indonesian university graduates with the needs of the world of work and industry. That way, the number of unemployed graduates in Indonesia can be reduced. Medan State University, as a producer of superior human resources, also wants to take part in reducing the unemployment rate in addition to routinely carrying out jobstreet activities, strengthening alum ties, and developing one branch of biology education, namely the biopreneurship course, which can foster interest in entrepreneurship as early as possible. Biopreneurship is an acronym for the words biology education and entrepreneurship. The merger means that students can connect or apply the concepts of biology and biology education, such as biotechnology, microbiology, development of teaching media, and others with entrepreneurial skills and business management, hoping to birth innovations and positively impact life. In other words, biopreneurship is an empowerment approach that combines biological concepts with entrepreneurship [2][6]. This course is expected to spearhead in facing the rapid global challenges ranging from technological developments to competition for jobs. This course can develop students' skills and knowledge so that they have provisions after graduation. In this case, a person's ability is required to determine and evaluate business opportunities in managing existing resources [3]. Able to move knowledge and innovation from the academic world to the industrial platform [4] so that using biological materials or research results that have sales value can become marketable products [5]. That is also in line with the profile of graduates produced by biology education students at Medan State University, one of whom is an entrepreneur in the field of biology education.

Biopreneurship learning for Unimed biology education students is appropriate and supports 21st-century skills, known as 4C (creativity, critical thinking, communication, and collaboration); this competency can improve life skills and careers so that it can direct students to recognize their potential, talents, and interests, especially in developing entrepreneurial activities. Research on biopreneurship includes increasing interest in entrepreneurship in Islamic boarding schools [6], in schools [7], increasing the entrepreneurial spirit, life skills [8], soft skills [9] enthusiastic in developing businesses in the field of biology [10], mindset development [11]. Research on product development includes providing material and product manufacturing practices without market needs analysis [12]; market needs analysis has been carried out further, but product development is limited to conventional biotechnology products, biological products from fermented soybeans [13]. The novelty in this study is that students develop products based on the results of previously conducted research so that they can generate ideas to increase the selling price of a commodity by adding more value to a commodity, such as adding properties,

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changing shape, giving product characteristics, adding flavors with higher nutritional content, and so on, it is necessary to explore bio entrepreneurship learning for biology education students by evaluating the products produced through direct product feasibility surveys or exhibition activities.

Research Methods

The subjects in this study are all biology education students who are taking the biopreneurship course. There are 45 products produced by biology education students. The steps for product refinement begin with the application of concepts in the form of design, product creation, feasibility testing, and marketing of the resulting products, whether they are in the form of food, health, or new energy. The assessment of the instruments conducted includes product evaluation as well as product processing evaluation and biopreneurship product analysis to determine the achievement of biopreneurship indicators [14]. The data obtained in this study were analyzed using qualitative descriptive methods. Each product is considered eligible for the next stage if it achieves a percentage of ≥80%.

Results and Discussion

This research was conducted in the second semester of the 2023/2024 academic year with fifth-semester biology education students. The research activity involved implementing case method-based learning, where students analyzed biopreneurship products that meet market needs. In this case, the sample is given the opportunity to explore ideas as much as possible, starting from discussions and developing their creativity in creating biopreneurship products. In line with the opinion of [15] students build their own knowledge by participating in the implementation of biopreneurship product creation, so that the integration of biological concepts and entrepreneurial concepts can run effectively, especially in terms of enhancing creativity. A meaningful learning atmosphere is formed that provides students with learning and practical experiences, starting from the ability to identify and recognize opportunities, design, create new business ideas, and produce goods and services that are ready for further development.

Samples are given motivation and reinforcement regarding the market potential and opportunities for the product idea to be marketed, starting from the type, specifications, and alignment with societal trends, so that in this case, the resulting biopreneurship product has novelty and adds value compared to similar products already available in the market. In general, students associate biopreneurship only with biotechnology themes such as yogurt production, tempeh production, and tape. It seems that students have not fully explored the various potentials of biological sciences that can be implemented in the biopreneurship course. The potential of products in biopreneurship activities serves as an important foundation to see high value, enabling the next stage, which is business product development. The categories of products produced can be seen in Table 1.

Table 1. Category Products Biopreneurship

Name of Product	Quantity of Product
Culinary	13 Product
Crafts	9 Product
Educational Games	6 Product
Cosmetics	13 Product
Total Products	45 Product

Based on Table 1, out of the 45 products made, the production of cosmetic products occupies the highest position in product development. This is based on market needs analysis and BPS data from 2021 regarding a 9.61% increase in the cosmetics industry, accompanied by BPOM data

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showing a 20.6% increase in the number of industries in 2022. With total revenue increasing by 48% from 2021 to 2024. This is based on the growing consumer knowledge about product ingredients that are safe for health.

Meanwhile, the second highest product is culinary, based on market demand analysis that food is a basic human need. We consume food every day, and this happens repeatedly, thereby increasing demand. Innovation in biopreneurship products produced has high taste and nutritional value and enhances the local potential of an area. The third highest product is handicrafts. Market needs analysis shows that many potential resources in certain areas are underutilized. For example, chicken feather lathes produce chicken feather waste, which can then be creatively assembled into chicken miniatures. This market needs analysis is very important to conduct because it turns out that items which initially had no functional value generate unlimited creativity. Market opportunity analysis according to Fitriady is important to see the needs and desires of consumers in order to assess the effectiveness and efficiency of the product and whether it meets the tastes and needs of the market [16].

After the product is ready to launch in the market, it is necessary to evaluate its sustainability. The importance of instilling consistency in product development direction, what characteristics you want to create. The mechanism of this business operation includes business development and strategies for maintaining business continuity. In this case, it is also important to implement promotional strategies both online and offline; this marketing strategy can also be effective with the creation of attractive product and packaging designs.

After designing all the ideas and strategies to be implemented, the students are then given the opportunity to pour these ideas into biopreneurship products over the course of several weeks. As long as the working mechanism continues, discussions on the progress of product development will be conducted more intensively.

Table 2. Presentase Products Biopreneurship

No	Biopreneurship Indicators	Persentase	Category
1	Reading business opportunities	98	Very effective
2	Creating products	90	Very effective
3	Determining the tools and materials used	100	Very effective
4	Planning the product creation process	90	Very effective
5	Observing the product's level of usedulness	88	effective
6	Processing products on a large scale	85	effective
7	Conducting a biopreneurship product opportunity analysis	100	Very effective
8	Evaluating products	88	effective
Average achievement of biopreneurship indicators		92,375	Very effective

In providing the latest innovations, students developed product designs and gave them unique names that are easy for consumers to remember, such as HyPo TEA (tea made from red dragon fruit peels), TerrMoss (moss terrarium), amuser lotion (mosquito repellent made from lemongrass), Dragonoodle (noodles made from dragon fruit peel waste), etc.

After the biopreneurship products are completed, an exploration or exhibition activity is held in

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the Biology building at Unimed. Students are given the opportunity to present the advantages of the biopreneurship products directly to the participants and create a booklet with a brief description of the products. The results of the achievement of biopreneurship indicators in the booklet can be seen in Table 2.

Based on the data in Table 2, the indicators for the biopreneurship material are considered complete with an average percentage of 92.375%. The highest score was in determining the tools and materials used; in this case, students were able to identify the necessary resources and organize the product creation process to be available within the specified time. The next highest percentage is on the indicator of creating product opportunity analysis, as in each meeting the researcher presents calculations of capital, production costs, and profit calculations, which help students determine the costs needed to implement the biopreneurship product. Meanwhile, the lowest score on the indicator for processing products on a large scale. This is because the product testing phase has not yet been conducted, such as ensuring that the quality meets the established standards. Testing requires a certain period, especially for cosmetic products that have been produced.

In the biopreneurship product exploration activities, each respondent participating in the biopreneurship exploration of biology education provides an assessment of the products that are suitable for further development. Out of 270 respondents who visited during the exploration activity, they provided evaluations through a Google form with assessment criteria including the selection of material types, material quality, aesthetics, benefits, hygiene, price suitability with the product, logo usage accuracy, and originality. The data is presented in the following Graph 1.

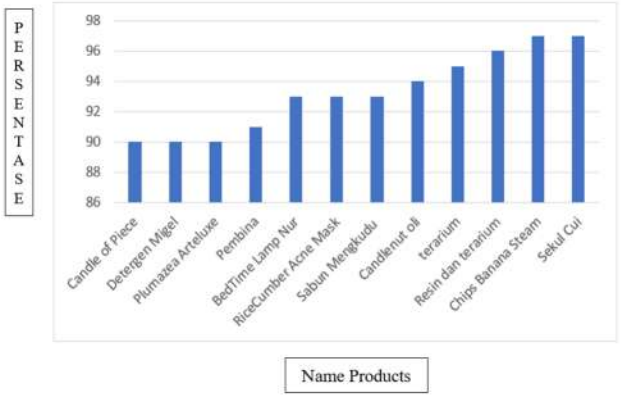

Figure 1. Biopreneurship Product Results

Out of the 45 biopreneurship products developed by students, there are 12 products that received the highest scores and are very worthy of further development, including Candle of Piece, Detergen Migel, Plumazea Arteluxe, Pembina, BedTime Lamp Nur, Rice Cumber Acne Mask, Noni soap, Candlenut oil, Terarium, Resin and terrarium, Chips Banana Steam, Sekul Cui. (Graph 1).

From Graph 1, there are 3 products that received the highest scores, namely (1). SekulCui (banana-based jam) received a high score of 97, not only because of its attractive design but also because it utilizes banana peel waste, and the resulting product has a natural sweetness without using artificial sweeteners. (2). Chips Banana Steam with a score of 97 are also made from banana stems, which are high in fiber and beneficial for health, including detoxification, treating stomach acid, stabilizing blood sugar, and controlling cholesterol. (3). resin and terrarium with the same value of 96. If viewed from the perspective of benefits, in addition to being used as souvenirs, it can also be used as a learning medium in biology. This is because the liquid form of the resin

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makes it easier for us to adjust the resin content to the mold. The advantages gained also vary depending on the level of difficulty and the color patterns produced.

(a) (b) (c)

Figure 2. three products with the highest ratings (a) sekulCui (b). chips banana steam (c) terrarium and resin

Next, the 45 biopreneurship products were revalidated by four lecturers teaching the biopreneurship course at State University of Medan. The validation data by experts is presented in Graph 3 Expert Responses Regarding Biopreneurship Products in Biology Education.

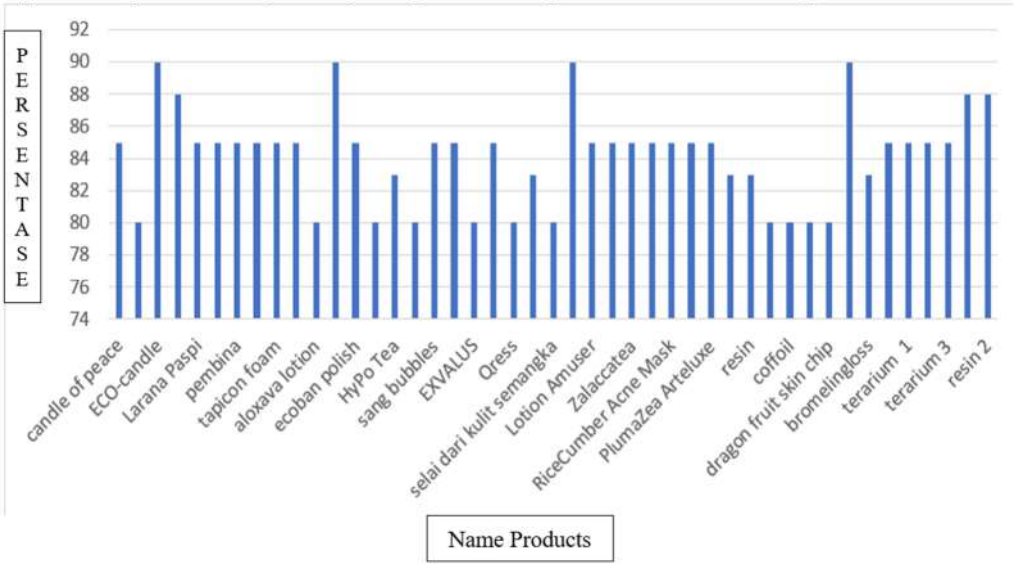

Figure 3. Expert Responses Regarding Biopreneurship Products in Biology Education

Out of 45 products, a suitability test was conducted to analyze the accuracy and consistency of the produced products to achieve the expected skills [17]. A practicality test was conducted to assess the ease of use of the products in daily life or, preferably, their usefulness in learning activities[18]. Next, the effectiveness test aims to analyze the constraints of the produced product in enhancing the expected skills [19]. From the test results, there are 4 products with the highest values, namely Eco-Candle, Carbon Milan, Terrmoss, and Exocarps Dragonis Tint. (Figure 2).

The first product is (1). Eco-Candle is an eco-friendly candle made from used cooking oil waste and natural dyes, also combined with various aromatherapy scents to relax the nervous system. The use of waste materials demonstrates the level of concern among students and enhances creativity. The innovation in this biopreneurship product is creating a relaxed and enjoyable

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atmosphere at home and preventing the spread of dengue-carrying mosquitoes. (2). The second product is carbon milan, which is a floor cleaner made from used cooking oil waste. In addition to using environmentally friendly materials, it is also more economical. The result of this product has already been implemented as a floor cleaner in the biology department building itself. (3). Terrmoss or terrarium is like a transparent glass container that serves as a home for small plants, in this case, innovatively using moss. Moss has biofiltration properties, meaning it absorbs air pollution and converts it into water and carbon dioxide, thereby helping to clean the air inside the house. Moss also absorbs carbon dioxide and releases oxygen. Thus, moss can help improve indoor air quality, making it very effective in stabilizing indoor humidity.Please provide the text you would like me to translate. (4). Exocarps Dragonis Tint is a lipstick made from natural ingredients with the assumption of beautifying while maintaining lip health. In addition to making lips more rosy and looking fresh, the lip tint made from honey can also moisturize and prevent lips from drying and peeling, making it safe to use even for 24 hours in an air-conditioned room.

Figure 4. The best biopreneurship products according to experts

From Graph 2, the product evaluation categories are then determined based on the evaluation sheet, that out of the 45 biopreneurship products produced by students, there are 16 products in the good category, which is 35% of the total, and 29 products in the very good category, which is 65%.

Discussion

The activities conducted in this research are capable of integrating biology and entrepreneurship concepts into learning, enabling students to apply research results and their understanding commercially, thereby enhancing creativity The indicators for assessing creativity include thinking activities, discovery, originality, and utility value [20]. Meaningful learning that is formed enables students to identify and recognize opportunities, design, create new business prospects, and produce products, goods, and services. [21] The product that ranks third highest not only generates new innovations but also provides very high utility value for consumers. So, in market development for industrial scale, it can be seen from the multifunctionality of the produced goods. Consumers tend to buy products provided they receive benefits that are commensurate with the price paid. [22] Generally, consumers will compare product prices with those of competitors. [23] Entrepreneurship is closely related to a person's values, abilities, and behavior in creating and innovating. Therefore, entrepreneurship is a value necessary to start a new venture or a process of doing something new and different from what already exists [24][25][26].

Conclusion

Based on the results of the data analysis obtained, it can be concluded that the 45 biopreneurship products produced by biology education students can be applied globally with

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evaluation criteria showing that 65% of the products fall into the very good category and 35% into the good category, as well as the achievement of biopreneurship indicators with a percentage of 92.375% in the very effective category.

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Effect of ethanol extract of leaf of biden spilosa (l) on the hematological profile of alcohol-greated white rats

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Abstract. *The World Health Organization (WHO) reported that alcohol consumption is a serious problem in adolescents. This study aims to determine the effect of Bidens pilosa ethanol extract on body weight gain and serum malondialdehyde (MDA) in consuming alcohol Wistar rats. Three-months-old animals were divided into four groups (six animals in each): control (K0) and group receiving 20% of alcohol (ethanol) (K1), groups receiving 20% of alcohol (ethanol) and given EEBP 300 and 600 mg/kg body weight respectively for K2 and K3. Both alcohol and EEBP were administered orally every day for 42 days using a gastric tube. EEBP was administered two hour after alcohol administration. Body weight was measured every day before treatment. On the 43rd day, the rats were killed by decapitation, the blood was collected using an Efendorf tube coated with EDTA, then centrifuged to obtain serum. Serum is used to measure MDA levels. The data obtained were analyzed using one-way ANOVA. The results showed that alcohol significantly ($p<0.05$) increased MDA levels in the serum of K1 group rats. Administration of EEBP in treatments K2 and K3 reduced MDA significantly if compared to MDA levels in treatment K1 and even decreased to reach MDA levels in the control group of rats. There was no effect of EEBP on body weight in the second and fourth weeks. However, at week six, the body weight of the rats that only consumed alcohol decreased significantly compared to the control group, while in the K2 and K3 groups the body weight of the rats was significantly higher compared to the K1 group.*

Keywords: alcohol, Bidens pilosa, body weihr, malondialdehyde (MDA)

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Introduction

The problem of alcohol use has become a serious problem throughout the world. The World Health Organization (WHO) has conducted research in 42 countries and reported that alcohol use is a serious problem in adolescents [1]. Every fifth teenager over the age of 14 years reported drinking large amounts of alcohol episodically, while 16% and 4% of boys aged 15 and 11 years, respectively, stated they drank alcohol at least once a week [2]. The consequences of the high frequency of alcohol consumption in adolescents not only include the risk of developing alcohol addiction [3], but also other risks related to health, because WHO indicates more than 200 potential diseases due to alcohol consumption [4]. Especially for teenagers, the consequences of regular alcohol consumption are very dangerous. The most important of these are acute poisoning and chronic effects including liver cirrhosis, which continues to increase in frequency. Several research results explain that chronic alcohol consumption can cause disorders of the kidneys [5], liver function [6].

If excessive amounts of free radicals are caused by consuming alcohol and soft drinks, liver function will be disrupted and the liver's natural antioxidants will no longer be able to fight these oxidants, so the liver needs exogenous anti-oxidants [7]. If liver problems occur caused by free radicals, for example caused by alcohol consumption, the level of oxidative damage to the liver can be determined by measuring MDA (Malondialdehyde) levels, SOD (Superoxide Dismutase) enzymes and ROS (Reactive Oxygen Species) levels. Therefore, it is important to pay attention to this parameter to see its function as an antioxidant in protecting the liver.

Alcohol consumption can reduce weight. Research shows that weight loss can occur if you consume alcohol. Long-term alcohol consumption can cause disturbances in the metabolism of macronutrients and micronutrients, including decreased absorption of digestive products, impaired transportation and utilization of nutrients, due to the effect of alcohol on the stomach. In summary, alcohol is a risk factor for chronic gastritis, gastric or duodenal ulcers, gastric and intestinal cancer [8]. Alcohol consumption can increase the excretion of nutrients which can increase the risk of deficiencies and malnutrition [9,10]. Therefore, prolonged alcohol consumption may result in decreased body mass gains in animal experiments compared to animals that did not receive alcohol [11].

Chronic ethanol consumption results in an increase in lipid peroxidation products such as malondialdehyde (MDA) and a decrease in antioxidant factors, such as glutathione (GSH) and related enzymes [12], which can ultimately induce apoptosis-mediated cell death [13]. Ethanol has toxic effects on the mouse retina related to oxidative stress. Decreased retinal glutathione concentrations and increased malondialdehyde levels in whole eye homogenates correlated significantly with decreased ERG b waves and Bcl-2 overexpression.

Bidens Pilosa

B. pilosa is a perennial plant belonging to the Asteraceae family, globally distributed in tropical regions. Scientific studies, although not exhaustive, have shown that *B. Pilosa* extracts are antitumor, anti-inflammatory, antioxidant, diuretic, antihypertensive, vasorelaxant, and antiulcerative [14–17]. In traditional medicine, the decoction of the whole plant is used against flu and fevers, while the leaves of the plant are used to treat ear infections, psoriasis, hepatitis, and hemorrhoids also considered to be antipoisonous [18]. *B pilosa* L. contains phenolic compounds and antioxidant activity [19]. One of the largest types of phytochemicals found in the B pilosa L. plant is flavonoids [20]. Flavonoids are stated to have anticancer, anti-inflammatory, antioxidant and bioactivity [18]. Plants that contain antioxidant compounds can ward off free radicals and

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prevent oxidative damage to the liver [21] . From the explanation above, it can be explained that the aim of this research is to determine the effect of *B pilosa* ethanol extract (EBP) on serum MDA levels and body weight gain in mice given alcohol.

Materials and Methods

Animals and Housing

The mice used in this research were mice resulting from mating female and male parents obtained from the Faculty of Pharmacy, University of North Sumatra and then mated in the animal cage of the Biology Department, Universitas Negeri Medan. After giving birth, the rat pups are kept until they are 3 months old. Twenty-four outbred male rats with a body weight range of 180 - 250 g were used in this study. The rats were housed 1 per cage in plastic cages (20 x 15 x 10 cm) containing wood chip bedding for enrichment purposes and exposed to a daily 12-hour light/dark cycle. They were maintained at room temperature (25 ± 3°C) with free access to a standard diet and water.

Processing and Extraction of Bidens Pilosa

The preparation of ethanol extract of B pilosa leaves has been described in previous research [22] as follows. Ketul plants (*B pilosa* L) were obtained from Jonggol Jae village, Arse Tapanuli Selatan District, North Sumatra. 30 kg of fresh leaves are washed clean, then placed on parchment paper and dried in a closed room. Drying is done until the texture is crispy like crackers (± 10 days) then ground little by little using a blender until it forms a powder (simplisia). One kg of simplicia is put into a stainless steel pan, then 96% ethanol is added in a ratio of 1:10 (1 kg of simplicia: 10 L of ethanol) and covered with aluminum foil. This soaking is done for five days and stirred every two days. After the maceration process, it is filtered using a coconut filter, then filtered again several times using Wattman filter paper until the ethanol juice of B pilosa leaves is obtained. The ethanol extract is concentrated using a rotary evaporator to remove or evaporate the ethanol, so that a concentrated pure extract is obtained.

Alcohol administration

The alcohol used in this research was alcohol (C2H5OH) with a concentration of 30%. The administration of alcohol has been previously described in research [22]. Administering alcohol at a dose of 7.9 ml/kg body weight for 35 days resulted in liver tissue damage in experimental animals such as steatosis, degeneration, steatonecrosis and cirrhosis [23]. The alcohol dose in this study was 7.9 ml/kgBB. Alcohol was given every day for 42 days orally using a gastric tube

Administration of Etanolic Ektract *Bidens pilosa* Leave (EEBP)

EEBP was given 1 x 1 day for 42 days orally using a gastric probe. EEBP dosage refers to research [23]. EEBP was given orally to mice in the form of a solution with a concentration of 30%. The extract solution provided was dissolved with 0.5% CMC [24]. EEBP is made by mixing 30 gr of EEBP into 0.5% CMC solvent (0.5 gr of CMC in 100 ml of distilled water). So the EEBP stock solution that has been mixed with 0.5% CMC is 30,000 mg/100 ml CMC or the same as 300 g/ml. EEBP was given at 300 and 600 mg/kg body weight

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Parameter Investigation

On the 43rd day, all mice were weighed and then anesthetized one by one in a chloroform tube, then killed by neck dislocation, to obtain blood. Blood was collected in an ependorf tube that had been coated with EDTA anticoagulant and analyzed for MDA in the blood as follows.

Malondialdehyde (MDA)

Malondialdehyde (MDA) measurements were carried out following the method of [25] described as follows. Serum sample was collected from dislocation on day 43. The malondialdehyde level was analyzed using MDA analyser kit. MDA level analyzed using MDA analyzer kit and performed in the integrated laboratory of the Faculty of Medicine, University of North Sumatra. The level of MDA was measured spectrophotometrically on UV-VIS spectrophotometer (Hitachi, Japan) at 535 nm or by reverse phase HPLC-MS method with single ion monitoring technique. MDA levels are expressed as mmol/L concentrations using calibrating curves and expressed as percentage of decrease in MDA level compared to negative control.

Rat Body Weight Gain

Every day the rat's body weight was weighed. Weight gain is the weight at the end of each week minus the weight on the first day of observation each week. Body weight measurements were carried out for six weeks. Body weight of rats was recorded during the first and the sixth weeks of the experiments (approximately fourty (42) day, and expressed as a the difference of body weight between the first and the sixth week.

Statistical Analysis

Data analysis with the one-way analysis of variance (ANOVA) was conducted with the Duncan's post hoc test. The results were presented as mean ± standard deviation (SD)

Result and Discussion

Malondialdehid (MDA)

Oxidative stress is a term denoting an imbalance between the production of oxidants and respective defense systems of an organism. High alcohol and salt consumption is associated with oxidative stress and increased free radicals, which play an important role in oxidative alterations of proteins and the pathogenesis of hypertension [26]. Oxidative stress in the present study is characterised by an increase in the MDA level.

The concentration of the lipid peroxidation product malondialdehyde (MDA) showed a significant ($p<0,05$) increase (Fig. 1). Alcohol can increase MDA levels in the blood, as was the case in this study. MDA levels in rats given alcohol were significantly higher compared to MDA in control rats and rats given EEBP. MDA levels in the K0, K1, K2 and K3 groups of rat were 2.188 ± 0.413 respectively; 3.105 ± 0.289; 2.096 ± 0.263; and 2.098 ± 0.409

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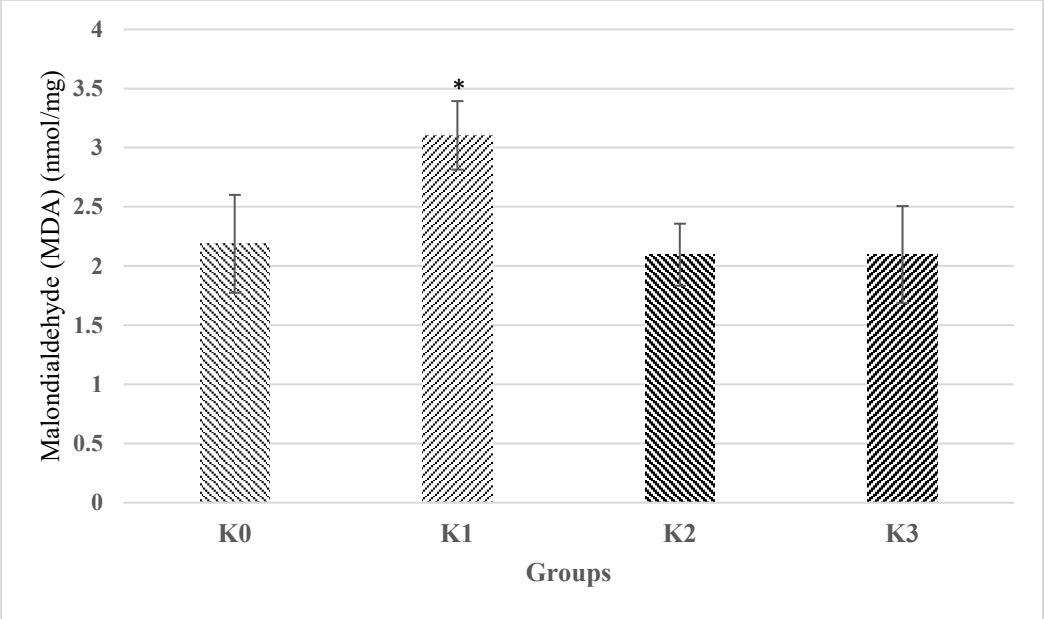

K0: Control group without alcohol or EEBP
K1: Group given Alcohol
K2: Group given alcohol and EEBP 300mg/Kg Body weight
K3: Group given alcohol and EEBP 600mg/Kg Body weight

Figure 1. Rat serum Malondialdehyde (MDA) concentration in all treatments. ∗p < 0.05 vs. all groups.

Figure 1 shows the effects of the etanol extract of *B. pilosa* on MDA levels. It can be seen that the concentration of MDA was significantly increased ($p<0.05$) in rats receiving alcohol (K1). In rats receiving alcohol and also etanol aqueous extract of *B. pilosa* 300 and 600 mg/kg of body weight, significantly prevented the increase ($p < 0.001$) in MDA levels.

The flavonoid hispidulin (6-methoxy-5,7,4′-trihydroxyflavone) has also been observed to prevent bromobenzene-induced liver injury in mice [27]. Total flavonoid *B pilosa* (TFB) has significant hepatoprotective activity and its mechanism is related, at least in part, to its antioxidant properties. Further research is required to investigate the detailed mechanism of the protective effect of TFB on acute liver injury [28].

Body Weight Gain

Weekly weight gain can be seen in Figure 2. In the picture it can be seen that in general the weight gain of the rat decreases day by day. In the first week, the weight gain of K2 and K3 rat was significantly higher than the weight gain of rat in the K0 and K1 groups. Meanwhile, in the second week, the weight of the group of rat that were only given alcohol (K1) increased significantly compared to K0, K2 and K3. In the third week, the weight gain of the control group rat was significantly higher than the weight gain of the K1, K2 and K3 group mice. However, the weight gain of rat in the K3 group was significantly higher than that of rats in the K1 and K2 groups. In the third week, the body weight of K1 mice that were only given alcohol began to decrease. In the fourth week, the weight gain in the control group of mice was significantly higher than the weight gain in the other three groups. However, mice that were given alcohol and given

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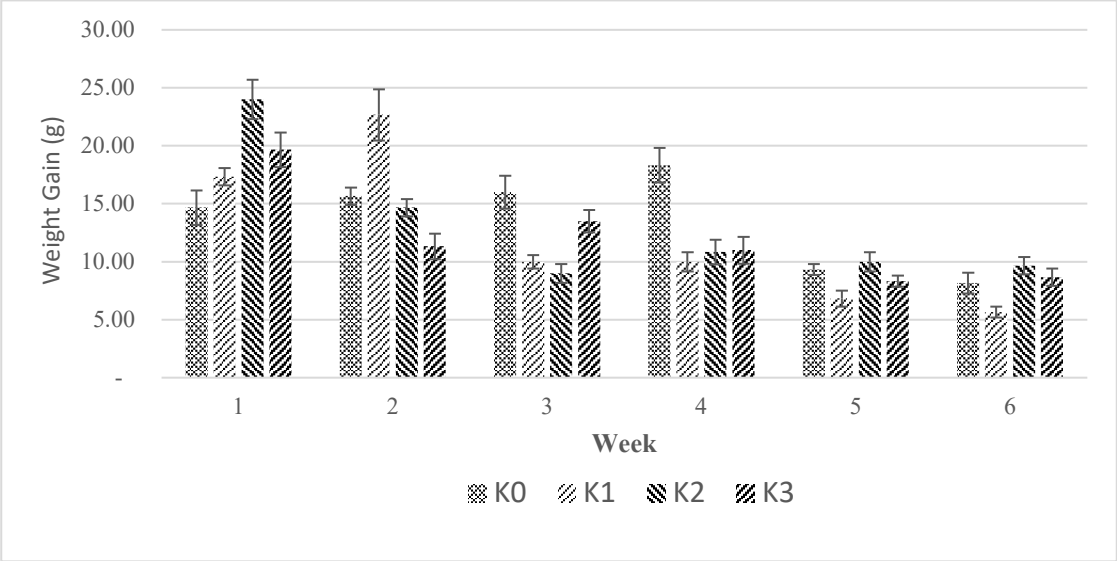
EBP both 300 and 600 mg/kg gained significantly more body weight compared to the group of rat that were only given alcohol (K1).



K0: Control group without alcohol or EEBP
K1: Group given Alcohol
K2: Group given alcohol and EEBP 300mg/Kg Body weight
K3: Group given alcohol and EEBP 600mg/Kg Body weight

Figure 2. The effect of *Bidens pilosa* on body weight of rats induce alcohol.

In the fifth and sixth weeks, the weight gain of rats that were only given alcohol (K1) significantly decreased compared to the controls, K2 and also K3. At the sixth week, the weight gain of rat in the K3 and K4 groups was significantly higher than the weight gain of control rats and rats given alcohol.

Alcohol can cause weight gain in a couple of ways. First, alcohol is high in calories. Some mixed drinks can contain as many calories as a meal, but without the nutrients. Second, you also may make poor food choices when you drink. In this study, alcohol increased body weight, this is in accordance with the research results that explain that consumption of ethanol calories will favor weight gain and metabolic changes and may engrave the risk of cardiovascular diseases, altering the lipid profile and promoting hypertension [29]. Heavy alcohol intake (≥ 30 g/d) contributes directly to weight gain and obesity, irrespective of the type of alcohol consumed [30]. However, the increase in body weight in K1 was only in the second week.

The weight gain of rats in the K2 and K3 groups at weeks three to six was higher than that in the K0 and K1 groups. This shows that EBP can reduce overweight as a result of alcohol consumption. Alcohol can cause lipogenesis which can lead to weight gain. The increase in body weight in the K2 and K3 mouse groups was due to the ability of *B pilosa* to prevent lipogenesis. As explained by previous researchers [31] *B pilosa* significantly decreased the adipogenesis and lipid accumulation, B. pilosa and GHT suppressed adipogenesis and lipid content in adipocytes and/or animals via the down-regulation of the Egr2, C/EBPs and PPARγ pathways, suggesting a novel application of B. pilosa and GHT against obesity.

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Conclusion

The ethanol extract of B pilosa leaves (EBP) is hepatoprotective with its ability to reduce MDA levels in the serum of mice given alcohol. EBP also has an effect on reducing weight gain due to alcohol consumption.

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Body composisition and physical performace of north sumatera wushu athletes

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Abstract. *Physiologically, male athletes have less body fat and higher muscle mass than women. So that male athletes find it easier to regulate oxygen consumption to the muscles, so that maximum performance can be achieved when exercising, especially in improving performance to achieve the best achievements in competitions. This study aims to see the effectiveness of body composition on the physical condition of Wushu athletes in North Sumatra. The subjects in this study were North Sumatra athletes who participated in a training camp consisting of 14 people consisting of 9 men and 5 women. To obtain data, athletes took body composition tests and physical condition tests according to which consisted of flexibility tests, abdominal muscle endurance, arm muscle endurance, balance, right sealing muscle endurance, left sealing muscle endurance, agility, right fitness muscle explosive power, left ringing muscle explosive power, arm muscle explosive power, power endurance, speed, core stabilization, aerobic endurance, anaerobic capacity*

Keywords: body composition, wushu, physical performance

Introduction

Wushu, also known as kung-fu, is a millennial martial art originating from China. Wushu competitions include Taolu and fighting competitions. Taolu competitions are characterized by standardized empty-handed, long-arm, and short-arm martial arts. Performance assessment is based on application, agility, speed, and strength. The fighting category has different weight categories for male and female athletes. In the fighting category, wushu consists of 3 rounds of 2 minutes each with a 1-minute break and is characterized by punching, kicking, and throwing techniques (1). Wushu is characterized by many styles, complex action structures, asymmetry, and many movements. Wushu training specifically emphasizes the realization of “essence, Qi, and spirit”, which requires accuracy and coordination of the motor center related to the cerebral cortex

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(2).

The lower the percentage of body fat and the higher the percentage of body muscle, the more it will increase physical fitness (3). Good body composition will certainly produce good body condition for athletes, so that it can improve physical fitness, especially for the training period. If an athlete has the right body composition, it can allow the athlete to also have good physical condition.

Each sport has unique characteristics and specific physical conditions. To achieve higher performance, athletes must have a specific increase in body composition according to their sport discipline, and this provides additional support to achieve higher performance and certain sports. For Sanda competitions, weight classification is used to classify athletes and against 8 weight categories for men. Because the competition is based on weight categories, the body composition needed in each category is certainly different. Identification of the athlete's body shape is also useful so that we can recognize changes in performance. This also facilitates the achievement of top-level performance and the screening of different practice performance (4).

The results of the study showed that human body composition analysis plays an important role in the performance and training patterns of athletes. The results of the analysis will show the composition of body tissue from a significant performance perspective. Body composition refers to the total mass of a person's body, such as the components of water, protein, fat and minerals in the body that vary according to body density and obesity levels. The results of the study also showed that body composition and sports performance have a close relationship and change according to energy needs in sports activities. To achieve their best performance, athletes must have good body composition and body mass ratio. This will certainly be an important element in determining strategies to improve performance and get maximum results in the match.

The Puslatda Program is a Gradual and Continuous Sports Achievement Development Program as an ideal development vision at the provincial level towards the National level in preparation for the 2024 PON. The mission of sports achievement development is an effort to achieve maximum results in achieving achievements both in single events and in multi-events. The expected achievement target is an increase in the quality of Human Resources, both Athletes and Coaches as well as their control and supervision systems. To get optimal results, it takes harder work and is expected to be more accurate, especially in conducting the selection and recruitment (selection) as well as evaluation of potential athletes and ongoing coaching periodically. This gives us an idea that the efforts made must be based on accurate and precise data. We realize that finding potential achievements is not easy, so it requires precision and accuracy in testing and measuring them.

The most basic understanding is that skill ability is something that is not too difficult to train/build on the condition that you have a trainer who is able to provide good and correct skill training (skill competence). Because the results of skill ability training will be recorded and stored in memory well if accompanied by good physical ability training. While the results of physical ability are never stored in memory (must be trained continuously). Therefore, we must measure physical ability well and on target.

The results of research on obese and overweight individuals, it is known that respondents with a high body mass index due to high body adiposity, make the resulting VO2max value low. Low VO2max makes athletes tired during training or competing. Male athletes have higher VO2max values than female athletes. This is because men have less body fat than women. This condition makes it easier to regulate oxygen consumption to working muscles to be more efficient

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(5).

Methods

This study is a cross-sectional study to analyze the effectiveness of body composition on the main physical conditions of Wushu athletes. Body composition measurements carried out consisted of measurements of weight and height, water composition, protein, minerals, and body fat. Measurements of physical conditions carried out consisted of measurements of flexibility, abdominal muscle endurance, arm muscle endurance, balance, right leg muscle endurance, left leg muscle endurance, agility, right leg muscle explosive power, left leg muscle explosive power, arm muscle explosive power, power endurance, speed, aerobic endurance, aerobic capacity. A total of 14 Wushu athletes from North Sumatra were the subjects in this study. Male athletes consisted of 9 people and female athletes consisted of 5 people. All athletes are professional athletes who are currently participating in training camps. A total of 7 athletes participated in Taolu training and 7 athletes participated in Sanda training consisting of match classes according to body weight.

Results

The data from the body composition measurement results can be seen in table 1 below.

Table 1. Body Composition

Name	Height	Total Body Water	Protein	Minerals	Body Fat Mass	Weight
X1	174	39,7	10,6	3,55	8,8	62,7
X2	165	38,9	10,7	3,44	14,7	67,7
X3	165	38,9	10,8	3,44	7,8	60,9
X4	175	42,3	11,5	3,89	13,4	71,1
X5	172	36,9	10	3,61	13,3	63,8
X6	170	34,9	9,4	3,27	9	56,6
X7	171	43	11,7	3,9	9,3	67,9
X8	175	45,3	12,3	4,24	12	73,8
X9	165	34	9,2	3,06	6,3	52,6
X10	165	31,1	8,4	3,01	15,3	57,8
X11	152	27,2	7,3	2,65	11,8	48,9
X12	155	28,8	7,7	2,77	14	53,3
X13	158	29,1	7,8	2,88	11,2	51
X14	159	32,3	8,8	3,23	13,7	58

Physical condition measurement data can be seen in table 2 below.

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Tabel 2. Physical Performance Test Result

	Flexibility	Abdominal Muscle Endurance	Arm Muscle Endurance	Balance	Right Limb Muscle Endurance	Left Limb Muscle Endurance	Agility	Right Limb Muscle Power	Left Limb Muscle Power	Arms Muscle Power	Power Endurance	Speed	Core Stabilisasi	Aerobic Endurance	Anaerobic Capacity
X1	34	89	62	58,37	197	253	9,52	7,89	7,93	3,95	60	2,73	12	51,1	39,53
X2	24	87	62	50,05	140	139	9,62	8,06	7,56	3,8	57	2,67	12	53,7	40,41
X3	29	90	71	43,71	93	137	9,48	7,50	7,45	4	65	2,77	12	53,7	40,85
X4	34	84	51	44,9	191	271	10,69	7,65	7,36	3,85	51	2,84	12	52,6	42,26
X5	29	98	52	43	92	120	9,64	6,89	7,22	5,5	118	2,86	12	58,7	56
X6	18	95	58	45	136	120	9,92	7,20	7,25	4,3	115	2,85	12	56	57
X7	16	97	57	45	188	120	9,84	7,07	7,12	6,3	114	2,82	12	59	53
X8	18	62	58	32,36	136	120	9,92	6,20	6	4	116	2,98	9	56	60
X9	18	62	58	32,36	136	120	9,92	7,20	7,25	3,5	116	2,85	5	59,3	57
X10	41	86	31	51,69	198	168	12,2	5,91	5,21	4,05	64	3,1	12	45	50,49
X11	35	81	39	51,6	115	119	11,2	6,3	6,2	3,4	54	3,15	12	51,1	50,02
X12	31	77	44	51,69	111	114	10,63	6,51	6,5	4	54	3,15	12	45,9	51,44
X13	26	72	30	53	110	113	11	4,6	4,7	4,9	77	3,17	12	54	67
X14	26	88	29	28	124	123	11	5,7	5,68	4,5	117	3,12	8	52	65

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Discussion

The current study shows that Olympic Wushu athletes have low body fat, high flexibility, high leg strength, and moderate anaerobic arm strength. Olympic Wushu, which can be characterized by a mixture of grappling, throwing, and striking techniques, appears to require similar capacities as other martial arts. Compared with athletes in wrestling- and striking-based martial arts, Wushu fighters have similar, but less, body fat levels than noncompetitive martial artists. The body fat levels observed in our athletes are similar to those seen in judokas. Taylor and Brassard observed 12.3% body fat in the Canadian men's judo team. These values are somewhat higher than those found in this study and by Callister et al.. Compared with a nonathlete population, these scores roughly represent the 20th and 24th percentiles. Additionally, these body fat values are lower than those reported by Douris et al. in a novice martial arts population. Significant correlations were observed between body fat and several performance scores. These results suggest that low body fat may be an important factor associated with competitive success in Wushu. In addition, there was a highly significant correlation between body fat and skinfold thickness. Therefore, skinfold thickness can be considered a good predictor of body fat in this athletic population.

The average anaerobic power in Wushu athletes was lower than in other combat athletes. Zabukovec and Tiidus, who evaluated four elite kickboxing athletes, and Horswill et al., who evaluated elite wrestlers, have shown similar values for average arm power in men, but higher peak arm power. The vertical jump, whose movements are closer to Wushu movements than bicycle ergometry, is more specific for evaluating leg power in these athletes. The vertical jump values obtained by the female athletes in this study are in accordance with reports in elite taekwon-do athletes. On the other hand, our male athletes did not achieve the same scores reported in the literature for elite male taekwon-do athletes.

As expected, Wushu athletes have high trunk flexibility. The values achieved by our athletes are somewhat higher than those found in non-competitive martial artists, elite taekwon-do athletes, and elite judo athletes.

Unfortunately, although we required Wushu athletes to perform isometric lumbar strength, we did not find data in the literature comparable to the values obtained in this study.

Blood lactate concentrations after Wingate in male and female athletes reached values comparable to those in other anaerobic combat sports, such as judo and wrestling. By analyzing blood lactate during training conditions, Wushu appears to be a more anaerobic sport compared to other striking combat sports. This is especially true for athletes involved in Wushu rather than Taolu.

It is well known that performance in combat sports depends on several aspects, such as physiological characteristics, anthropometric profile, technical capacity, psychological and emotional status, and nutritional needs. Unfortunately, the importance of these is often underestimated by coaches and athletes. To our knowledge, this is the first study to assess the nutritional profile of highly trained elite Olympic Wushu athletes.

The athletes' protein intake was considered adequate, according to classical recommendations. However, only women met the carbohydrate intake requirements, which were at the lower end of the recommended range. These data are somewhat surprising, as previous studies have shown that male athletes appear to be more likely to fall within the recommended carbohydrate intake range than females. There are two main factors that could explain the suboptimal carbohydrate intake in our study: 1) some athletes, who are trying to lose weight—a common practice in combat sports—may not be able to meet carbohydrate requirements due to

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limited energy intake; and our findings suggest that male athletes consume more fat than their female counterparts. A high-fat diet may be associated with lower carbohydrate intake. Furthermore, we cannot rule out the possibility that the low carbohydrate intake observed in our study may be related to other factors, such as poor availability of carbohydrate-rich foods in the live-eating environment, inadequate practical nutrition skills or knowledge of food composition, and/or underreporting of energy intake and subsequent carbohydrate intake. Although it is well documented that anaerobic performance can be acutely limited by lower muscle glycogen concentrations, we cannot assume based on our data alone that low carbohydrate intake in Wushu athletes' diets will negatively impact their competitive performance. In fact, a recent review by Westman et al. highlighted the lack of consistent evidence supporting the hypothesis that ''carbohydrate loading'' can enhance performance.

In conclusion, Olympic Wushu appears to be a highly anaerobic combat sport. Elite athletes exhibit low body fat, high flexibility, leg anaerobic power and isometric strength, and relatively high arm anaerobic power. These capacities are therefore important for successful competitive performance. Although these athletes consume adequate protein, carbohydrate intake for men is below recommendations, as is often the case in heavyweight combat sports.

This study aimed to investigate the relationship between anthropometric parameters of national-level male Sanda players and sport performance. Research has identified anthropometric determinants that enhance athletes' performance according to their sport. We should be able to identify these advantages and identify current levels and other athletes' performances that support an increased probability of winning in Wushu. Furthermore, it can be used to identify weak areas of athletes and suggestions to improve their performance to a competitive level (ARAZI et al., 2016). In weight-dominated sports, to gain an advantage over opponents, athletes usually try to increase muscle mass and reduce adiposity fat in each weight category to improve their performance (Brito et al., 2012). Therefore, a study was conducted to identify the relationship between body size and martial arts performance. The study revealed that there was no relationship between body circumference and sports performance. Studies have emphasized that strength is an important factor in Wushu due to the wider use of energy systems and rapid action (Schick et al., 2010) and it was found that martial arts athletes' wrist circumference was positively correlated with arm circumference (Marinho et al., 2016). Furthermore, the study also emphasized that there was no difference in body circumference between medal-winning and non-medal-winning athletes (Yetgin, 2022). However, in the study of Iermakov et al., they have conducted a study with anthropometric and kinematic measurements and found that boxers with large wrist and forearm circumferences have shown great arm strength (Iermakov & Podrigalo, 2016). Studies have shown that having longer limbs helps athletes to succeed in punching sports such as martial arts (Formalioni et al., 2020). Longer limbs can provide a reach advantage to perform techniques from a distance (Casolino et al., 2012). So, athletes with long limbs can handle opponents by creating a safe distance. In this study, it was revealed that there is a positive relationship between arm length and tibial length with performance. A comparative study proved that athletes with taller arms represent martial arts sports (Kin- et al., n.d.). A study by Kumar et al. was conducted with 70 Boxing athletes; the results showed that the arm length of boxers was the most significant predictive factor for improving punching performance (Devender Kumar, 2019). Players with high Illiac have shown a higher probability of winning through the study period competition (Sheppard et al., 2008). Another study on the anthropometry and physiology of 28 martial arts athletes revealed that high levels of strength found in the legs and arms of martial arts athletes correlated with limb length (Slimani et al., 2017). But the study of Arazid did not reveal a correlation between

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tibial length and sports performance (Arazi et al., 2016). In competition, most athletes try to kick the face and get a KO from the opponent. In martial arts, a successful takedown brings the athlete to the main issue of victory (Kirk, 2016). Kicks are scored more than punches, favoring longer levers (Górski & Orysiak, 2019). However, studies by Bidge et al., and Scamardella emphasize that there is considerable doubt about the status of martial arts and successful sports (Bridge et al., 2014; Claessens et al., 1994).

Conclusion

Based on the results of the research that has been done, a conclusion can be drawn:

1. Body composition analysis is effective for the physical condition of wushu athletes.
2. The body composition analysis method is expected to be used as a reference for improving body composition.

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Antibacterial potential of ethanol xtract of *Melastoma malabathricum* leaves in inhibiting the growth of pathogenic bacteria

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Abstract. *Traditional medicinal plants have long been used and trusted by the community to overcome various diseases. This study aims to determine the potential of ethanol extract of Melastoma malabathricum leaves in inhibiting the growth of pathogenic bacteria. The method used in this study is the maceration method to obtain a thick extract of Melastoma malabathricum leaves. The next method is to conduct an antibacterial activity test using the disc diffusion method with extract concentrations of 30%, 40%, 50%, 60% and 70%. The results show that ethanol extract of Melastoma malabathricum leaves has the ability to inhibit the growth of pathogenic bacteria in Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 25924, Pseudomonas aeruginosa and Bacillus cereus. This is possible because of the presence of compounds that are thought to have the ability to inhibit the growth of pathogenic bacteria. The conclusion in this study is that the higher the concentration of the extract used, the better the antibacterial activity*

Keywords: (antibacterial, natural medicine, ethanol, growth, potential)

Introduction

The main problem currently threatening human life is infectious diseases, especially infectious diseases caused by pathogenic bacteria. The World Health Organization (WHO) reports that antibiotic resistance has continued to increase significantly in the last five years, resulting in the decreasing effectiveness of conventional antibiotics in treating bacterial infections【1】. One approach that is starting to receive attention is the exploration of natural materials as a source of new antibacterial agents, especially from plants that have high pharmacological potential.

Melastoma malabathricum, also known as "senduduk" in Indonesian, is a traditional plant that is widely used in herbal medicine in Southeast Asia. The leaves of this plant are believed to have antibacterial, anti-inflammatory and anti-diabetic properties, based on empirical evidence of traditional use【2】. However, the scientific potential of *Melastoma malabatricum* as an

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antibacterial, especially through its ethanol extract, requires further scientific validation to support its clinical use【3】.

Melastoma malabatricum is a promising plant species because of its high content of bioactive compounds that can be utilized. Research shows that *Melastoma malabatricum* leaves contain phenolic compounds, which have the ability to damage bacterial membranes, inhibit protein synthesis, and induce oxidative damage to bacterial cells【11】【12】. However, empirical evidence regarding its effectiveness against common clinical pathogens, such as Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa, is still minimal. Therefore, this study is important to evaluate the antibacterial ability of *Melastoma malabatricum* against this bacterial strain, which is a significant infectious agent in humans.

Studies on *Melastoma malabatricum* have so far mostly focused on evaluating basic phytochemical or general pharmacological properties, such as antioxidant and anti-inflammatory activities【4】【5】. Research testing specific antibacterial activity against specific pathogenic bacteria in clinically relevant concentrations is limited. Furthermore, most studies only identified the presence of bioactive compounds, such as flavonoids, tannins, and saponins, without evaluating their dose-response relationship in inhibiting bacteria【6】. This leaves a gap in scientific knowledge regarding the specific antibacterial mechanisms of *Melastoma malabatricum* extract.

The phenomenon that has been in the spotlight in the last five years is the increasing need for natural antibiotic alternatives amidst the global antibiotic resistance crisis. WHO warns that without the development of new antibacterial agents, simple infections may again become a serious threat to public health【1】. In addition, in Indonesia, the high prevalence of bacterial infectious diseases, such as respiratory tract infections and wound infections, exacerbates the impact of antibiotic resistance【7】. The potential of *Melastoma malabatricum* to overcome this problem has not been utilized optimally, considering that its use is still limited to traditional practices without a strong scientific evidence base【8】.

Plants have long been known as natural sources of active ingredients that have a variety of therapeutic benefits. Research on traditional medicinal plants continues to grow as the need for new effective antibacterial agents increases. Globally, more than 80% of the population in developing countries use plant-based medicines for their primary health needs【9】. The antibacterial properties of plants are generally due to the content of secondary metabolites, such as flavonoids, alkaloids and tannins, which have been shown to have activity against various bacterial strains【10】.

The antibiotic resistance crisis has become a serious concern both locally in Indonesia and globally. Studies show that more than 700 thousand deaths per year are caused by untreatable infections due to antibiotic resistance【1】【13】. Indonesia, as the country with the second largest biodiversity in the world, has great potential in developing medicines based on natural ingredients to overcome this problem. However, exploration of local biological riches such as *Melastoma malabatricum* is still not optimal. Most of the research conducted is limited to descriptive studies without further steps towards clinical trials or pharmaceutical product development【14】.

For example, previous research in Malaysia showed that ethanol extract from *Melastoma malabathricum* leaves had antibacterial activity against Gram-positive and Gram-negative bacterial strains【15】. However, these results have not been extended with in-depth studies of the mechanism of action, stability of the active compound, and its effectiveness at concentrations

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suitable for clinical application. Therefore, it is important to carry out further studies with a more systematic approach to understand the pharmacological potential of this extract.

Apart from scientific gaps, there are also challenges in translating research findings into applicable solutions. Although *Melastoma malabatricum* is known to have therapeutic potential, its use in the formulation of antibacterial pharmaceutical products that meet safety and effectiveness standards is still very rare. This is due to a lack of collaboration between researchers, the pharmaceutical industry, and policy makers【16】. With the increasingly urgent need for new antibiotics, this research is expected to contribute to the development of a solid scientific evidence base to support the practical application of *Melastoma malabatricum*.

This research not only addresses the challenge of antibiotic resistance, but also supports the conservation of local biodiversity through an evidence-based scientific approach. By identifying and validating the antibacterial properties of *Melastoma malabathricum*, it is hoped that these findings can encourage the development of plant-based antibiotics as an environmentally friendly and sustainable alternative. In addition, this research is relevant to national efforts to increase pharmaceutical independence and reduce dependence on imported products.

This study aims to fill the gap in the literature by evaluating the antibacterial potential of ethanol extract of *Melastoma malabatricum* leaves against the growth of certain pathogenic bacteria, thus making a significant contribution to the development of natural ingredient-based antibacterial agents that can be used as alternative or complementary therapy in overcoming antibiotic resistance.

Material and Methods

The research activities carried out in this study were to identify secondary metabolite compounds from the ethanol extract of *Melastoma melabathricum* L. leaves which have antibacterial potential. This research will be carried out at the Microbiology Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan on Jalan Willem Iskandar, Pasar V Medan Estate, Percut Sei Tuan, Deli Serdang. This research is planned to be carried out from April 2024 to October 2024.

Sample Preparation and Making Simplicia

A total of 10 Kg of *Melastoma melabathricum* L, were collected by picking bright green leaves from sequence number 3 from the top of the leaf to sequence number 7. The secondary metabolite content in young plants was higher than in old plants (Hayati et al, 2022) . The *melastoma melabathricum* L. that has been collected is washed with running water until clean and then air-dried in a room that is not exposed to direct sunlight for ± 3 days. Then *Melastoma melabathricum* L. was dried using an oven at 50o C for 1x24 hours. The initial parameter for stopping the drying process is marked by leaves that can be crumpled. The sample was then ground using a blender until it was dry *Melastoma melabathricum* L. leaf powder.

Preparation of Melastoma melabathricum L. Leaf Extract.

200 grams of *Melastoma melabathricum* L. fine powder was soaked in two liters of 96% ethanol solvent with a solvent ratio of 1:10 (w/v). The maceration process was carried out 2 times. In the first maceration, it is soaked for 3 days and stirred every 1x24 hours. After 3 days, the soak was filtered using a Bunchner to obtain filtrate and residue and collected in different containers. After

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that, the filtrate obtained was concentrated using a rotary vacuum evaporator at a temperature of 400 C to obtain a thick extract.

Antibacterial Activity Test

Testing of the antibacterial activity of ethanol extract of *Melastoma melabathricum* L. leaves against pathogenic bacteria was carried out using the disc diffusion method. The NA medium was poured into a petri dish as much as ±15 ml and left until it solidified. The pathogenic bacterial suspension was evenly smeared onto a petri dish containing NA media using a cotton swab. Disc paper with a diameter of 6 mm was soaked in Senggani leaf ethanol extract with various concentrations and in chloramphenicol solvent as a positive control and 96% ethanol solvent as a negative control. The paper disc that has been soaked is placed on the surface of the media using tweezers in the desired position. Then the petri dish was incubated in an incubator for 1x24 hours at 37ºC. After incubation, the inhibition zone was observed by looking at the clear zone that formed around the paper disc and measured using a caliper.

Result and Discussion

The antibacterial activity test of the ethanol extract of Senggani leaves (*Melastoma melabathricum* L.) against the bacteria *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25924, *Pseudomonas aeruginosa* and *Bacillus cereus* was carried out using the disk diffusion method with varying concentrations of 30%, 40%, 50^%, 60 % and 70% with as many repetitions as possible 4 times. The antibiotic chloramphenicol in this study was used as a positive control (+) and the solvent ethanol p.a was used as a negative control (-). Based on research conducted on the ethanol extract of senggani leaves (*Melastoma melabathricum* L.), it is known to have antibacterial activity in inhibiting the growth of Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 25924, Pseudomonas aeruginosa and Bacillus cereus.

Table 1. Antibacterial activity of ethanol extract of Senggani leaves (Melastoma melabathricum L.)

Bacteria	Concentration (%)				
	30	40	50	60	70
Escherichia coli	7,62	8,42	8,97	9,67	11,26
Staphylococcus aureus	7,92	8,15	8,61	9,56	10,87
Pseudomonas aeruginosa	10,1	10,4	10,55	11,95	12,8
Bacillus cereus	8,55	8,65	8,75	8,95	9,3

Based on the table above, data obtained from measuring the inhibition zone of antibacterial activity of senggani leaf extract (*Melastoma melabathricum* L.) concentrations of 30%, 40%, 50% and 60% against the bacteria *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25924, *Pseudomonas aeruginosa* and *Bacillus cereus* included in the medium category. An ethanol extract concentration of 70% is an effective concentration in inhibiting the growth of *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25924, *Pseudomonas aeruginosa* bacteria in the strong category. Results of the antibacterial activity test of senggani leaves against the bacteria *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25924, *Pseudomonas aeruginosa* and *Bacillus cereus*.

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Figure 1. Results of antibacterial activity test of senggani leaves (*Melastoma melabathricum*) against *Escherichia coli* ATCC 25922 bacteria. Treatment a) 30%. B) 40%, c) 50%, d) 60% and e) 70%.

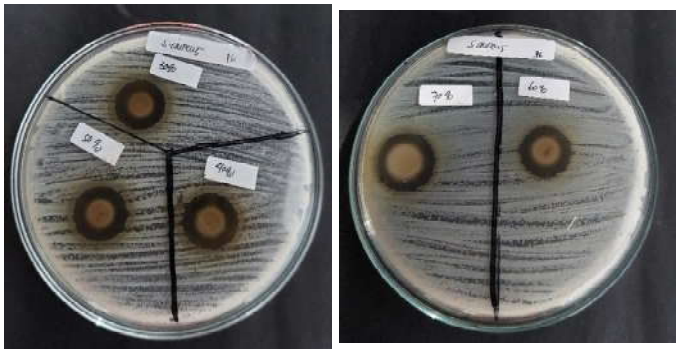

Figure 2. Results of the antibacterial activity test of senggani leaves (*Melastoma melabathricum* L.) against the bacteria *Staphlococcus aureus* ATCC 25924. Treatments a) 30%, b) 40%, c) 50%, d) 60% and e) 70%.

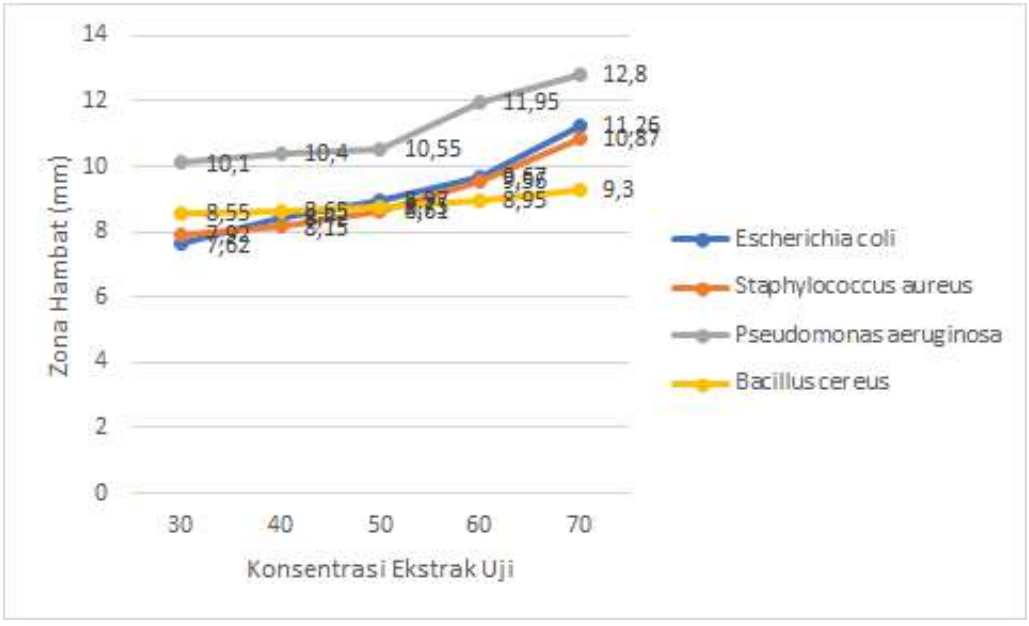

Figure 3. Antimicrobial Activity Graph of senggani leaves

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Testing of the antibacterial activity of the ethanol extract of senggani leaves (*Melastoma melabathricum* L.) was carried out using the Kirby-Baurer disc-diffusion method as evidenced by the formation of a clear zone around the disc paper on the test medium used. The bacteria used in this research were *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 25924 pure culture or ATCC (American Type Culture Collection). The ethanol extract of senggani leaves (*Melastoma melabthricum* L.) has potential as an antibacterial against the bacteria *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25924, *Pseudomonas aeruginosa* and *Bacillus cereus*, this is indicated by the formation of a clear zone around the paper disc as shown in Figure 1 and Figure 2

The criteria for antibacterial strength are an inhibition zone diameter of ≤ 5 mm or less which is categorized as weak, an inhibition zone of 5-10 mm is categorized as moderate, an inhibition zone of 10-20 mm is categorized as strong, an inhibition zone of ≥ 20 mm or more is categorized as very strong [17]. Based on the data contained in Table 4.1, it shows that the largest inhibitory zone diameter in inhibiting *Escherichia coli* bacteria is shown by treatment with a concentration of 70% of 11.26 mm with a strong category, and the smallest inhibitory zone is shown by treatment with a concentration of 30% of 7.62 mm in the medium category. For the *Staphylococcus aureus* bacteria, the largest inhibition zone was shown by the treatment with a concentration of 70% at 10.87 mm in the strong category and the smallest inhibition zone was shown by the treatment with a concentration of 30% at 7.92 mm in the medium category. The results of the Duncan test on *Escherichia coli* bacteria showed that a concentration of 60% had a significant difference with concentrations of 30% and 70%. At concentrations of 40% and 50% the average inhibition zone was different and increased, but it was not significantly different from the concentration of 60%. The results of the Duncan test on *Staphylococcus aureus* bacteria at a concentration of 50% were significantly different from those treated at concentrations of 60% and 70%. At concentrations of 30% and 40% the diameter of the inhibition zone was different and increased, but it was not significantly different from the treatment at concentrations of 30% and 40%. For the Pseudomonas aeruginosa bacteria, data was obtained that the highest activity was at a concentration of 70%, including the strong category. This also applies to the Bacillus cereus bacteria test, where the best concentration for inhibiting the growth of pathogenic bacteria is 70%, which is in the medium category.

The differences in the diameter of the inhibition zone at each concentration on the growth of *Escherihia coli, Staphylococcus aureus, Pseudomonas aeruginosa* and *Bacillus cereus* bacteria indicate the influence of secondary metabolite content. A concentration of 70% is the optimum concentration in inhibiting the growth of Escherihia coli, Staphylococcus aureus, Pseudomonas aeruginosa and Bacillus cereus bacteria because it has the largest inhibition zone. Table 1. shows that the diameter of the inhibition zone for *Escherihia coli, Staphylococcus aureus, Pseudomonas aeruginosa* and *Bacillus cereus* bacteria increases as the concentration of senggani leaf extract increases. This is indicated by the increase in senggani leaf extract given, the more active substances are dissolved in the senggani leaf extract, the greater the ability of secondary metabolites of senggani leaf extract to diffuse to inhibit bacterial growth. The diffusion speed of a substance is influenced by several factors, such as temperature, surface area, and substance concentration. The greater the concentration of the substance, the higher the diffusion speed, so that the diameter of the bacterial inhibition zone formed will also be greater [17].

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Conclusion

The potential of the ethanol extract of senggani leaves in inhibiting the growth of pathogenic bacteria is known to have potential. Data was obtained that the ethanol extract of senggani leaves was able to inhibit the growth of pathogenic bacteria, where the higher the concentration of the extract, the better the activity inhibiting the growth of pathogenic bacteria.

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Antibacterial activity of ethanol extract of biden pilosa l. in inhibiting the growth of pathogenic bacteria

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Abstract. *Utilization of plants, especially leaves, is one of the efforts to reduce antibiotic resistance rates. One of the plants that is thought to have potential as an antibacterial is Biden Pilosa L. leaves. Biden Pilosa L. leaves have been used by the general public as medicinal plants by consuming them directly. This encourages further study of its potential as an antibacterial. This study aims to determine the potential of ethanol extract of Biden Pilosa L. leaves as an antibacterial using the maceration method. Based on the results of the research that has been done, the extract of ketul leaves (Bidens pilosa L.) has antibacterial activity against Escherichia coli, Staphylococcus aureus, Bacillus cereus and Pseudomonas aeruginosa bacteria. The study was conducted using the diffusion method using 5 different concentrations with 4 repetitions for each concentration. Based on the results obtained, it shows that the higher the concentration of the solution, the better the antibacterial activity.*

Keywords: (Inhibitor, Ethanolix exract, Antibacteria, Leaves, Diffusion)

Introduction

Pathogenic bacterial infections are a global health problem that continues to increase, especially with the emergence of antibiotic resistance. Antibiotic resistance has become a serious threat to the treatment of various infectious diseases, causing high morbidity and mortality rates [1]. One solution that is starting to be developed is the use of bioactive compounds from plants as natural antibacterial agents [2].

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Biden pilosa, known as a herbal plant with various benefits, has been used traditionally to treat various diseases such as respiratory tract infections, wounds and inflammation [3]. Biden pilosa leaf extract is reported to contain bioactive compounds such as flavonoids, alkaloids and tannins which have antimicrobial activity [4]. Although the antibacterial potential of this plant has been reported, research on the specific effectiveness of Biden pilosa leaf ethanol extract in inhibiting the growth of major pathogenic bacteria is still very limited.

The selection of Biden pilosa as a research object was based on empirical and scientific evidence regarding the content of its active compounds. The flavonoids and tannins in Biden pilosa have a mechanism of action that inhibits bacterial cell wall synthesis and disrupts membrane permeability [2]. However, most available studies used methanol or water extracts. Little attention has been paid to ethanol extract which has the advantage of extracting bioactive compounds of polar and semi-polar nature [4].

In addition, with increasing bacterial resistance to conventional antibiotics such as amoxicillin and ciprofloxacin, exploration of new antibacterial agents from herbal plants is becoming a priority. Biden pilosa has the advantage of being easy to obtain, can be cultivated cheaply, and has pharmacological value that has been recognized in various cultures [3]. This research also supports policies for the development of nature-based traditional medicines initiated by various developing countries, including Indonesia [1].

Previous studies have examined the antibacterial activity of Biden pilosa, but many of them are general and not specific to a particular extraction method or particular pathogenic bacteria. For example, Oliveira et al. [3] reported general antibacterial activity without testing major pathogenic bacteria such as Staphylococcus aureus or Escherichia coli. In addition, research testing the ethanol extract of Biden pilosa leaves is still very limited, especially regarding the minimum inhibitory concentration (MIC) and its antibacterial mechanism [5].

Research regarding the antibacterial activity of Bidens pilosa has been carried out, but most of it still focuses on extracts using solvents such as water or methanol, while the potential of ethanol extracts has not been widely explored. Ethanol extract is known to have advantages in extracting polar and semi-polar bioactive compounds, such as flavonoids and alkaloids, which are known to have antibacterial potential [4]. In addition, previous studies often only assessed general antimicrobial activity without focusing on specific pathogenic bacterial targets, such as Escherichia coli and Staphylococcus aureus, which are the main causes of clinical infections [5].

Furthermore, the mechanism of bacterial inhibition by Bidens pilosa extract is not fully understood, especially in the context of biofilm disruption or inhibition of enzymes associated with antibiotic resistance such as β-lactamase. Previous studies focused more on the direct effect on bacterial growth without examining the potential of this extract in suppressing these resistance mechanisms [3]. In addition, most studies are in vitro, while validation in in vivo models that are more relevant for clinical applications is still very limited.

This research gap indicates the need for further exploration of the antibacterial activity of Bidens pilosa ethanol extract, including tests against specific pathogenic bacteria, minimum inhibitory concentrations (MIC and MBC), as well as its mechanism of action at the molecular level. This research is expected to make a significant contribution to the development of plant-based antibacterial agents that are more effective and applicable. By addressing this research gap, it is hoped that new insights can be gained to overcome the increasing global challenge of antibiotic resistance.

The limited exploration of the antibacterial activity of natural compounds against resistant bacterial strains is a phenomenon gap in science. In particular, there have been no studies

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comparing the effectiveness of Biden pilosa leaf ethanol extract against Gram-positive and Gram-negative bacteria [4]. Another phenomenon that has not been widely studied is the influence of bioactive compounds in Biden pilosa leaves on bacterial resistance mechanisms, such as biofilm production and resistance gene mutations [2].

The antibacterial activity of herbal plant extracts is usually influenced by the phytochemical content such as flavonoids, alkaloids, tannins and saponins. Flavonoids work by damaging bacterial cell membranes, while tannins can precipitate bacterial cell wall proteins, resulting in cell lysis [3].

Pathogenic bacteria such as Escherichia coli and Staphylococcus aureus are often used in antibacterial tests because they are the main models of Gram-negative and Gram-positive bacteria. Differences in cell wall structure between Gram-positive and Gram-negative contribute to variations in sensitivity to antibacterial compounds [5].

Ethanol extracts are often chosen in phytochemical research because they can dissolve polar compounds such as flavonoids and semi-polar compounds such as alkaloids, thus providing a broader picture of their potential bioactivity [4]. By understanding the mechanism of action of the bioactive compounds in this extract, research is expected to make a significant contribution to the development of herbal-based antibacterial agents.

This study seeks to fill important gaps in previous studies of Bidens pilosa, by placing a particular focus on the potency of the ethanol extract, specific pathogenic bacterial targets, resistance mechanisms, and in vivo validation. Thus, this research not only expands scientific knowledge regarding herbal plants, but also contributes to the development of alternative therapies in dealing with antibiotic resistance. This research is important to explore the potential of local plants as alternatives or supporters of synthetic antibiotics, considering the increasing prevalence of resistant pathogenic bacteria [5]. Therefore, this study aims to evaluate the antibacterial activity of the ethanol extract of Biden pilosa leaves against several major pathogenic bacteria.

Materials and Methods

This research activity was carried out to determine the activity of Biden pilosa ethanol extract in inhibiting the growth of pathogenic bacteria. This research was carried out at the Microbiology Laboratory, Faculty of Mathematics and Natural Sciences, Medan State University on Jalan Willem Iskandar, Pasar V Medan Estate, Percut Sei Tuan, Deli Serdang. This research was carried out from April 2024 to October 2024. The population and sample in this study was Biden pilosa leaf extract obtained from the surrounding South Tapanuli area.

Leaf Collection Biden pilosa L. Leaf Preparation

Bidens pilosa L. leaves were obtained from Sipirok South Tapanuli. Sampling of Bidens pilosa L. ketul leaves by picking leaves that are fresh green and not rotten. Ketul leaves were taken from sequence number 3 from the leaf shoot to sequence number 10, this is because leaf number 3 from the shoot is physiologically mature so it has maximum secondary metabolite content [6]. Leaves of the same size and color indicate leaves that are of maximum age and level of development [7]. Biden pilosa L leaves that have been collected are then washed in running water until clean and then air-dried in a room that is not exposed to direct sunlight for ± 3 days [8]. Biden pilosa L. leaves were then dried in an oven at 50°C for 24 hours until dry. Dry samples are marked with leaves that can be crushed. The sample is then powdered or mashed using a blender.

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Preparation of Biden pilosa L. Leaf Extract.
300 grams of Bidens pilosa leaf powder was macerated with 900 ml of ethanol pa solvent with a solvent ratio of 1: 3 (w/v). The sample was homogenized in a closed container for 3 days with occasional stirring. The liquid extract is then filtered using Whatman No. 1 filter paper, the dregs are macerated again with the same solvent and ratio for 1 day. All maceration filtrates are combined and evaporated using a rotary vacuum evaporator until it becomes a thick extract using a temperature of 40°C. The extract obtained was stored in a refrigerator at 4°C [9].

Antibacterial Activity Test
Mueller Hinton Agar (MHA) media was poured into a sterile petri dish ± 15 ml and allowed to solidify. Testing of the antibacterial activity of ketul leaf extract (Bidens pilosa L.) was carried out using the disc diffusion method or the Kirby-Bauer method. The bacterial inoculum was evenly smeared on a petri dish containing MHA media using a sterile cotton swab. A sterile cotton swab is inserted into a tube containing a suspension of Escherichia coli, Staphylococcus aureus, Bacilluse cereus and Pseudomonas aeruginosa bacteria then smeared evenly on the MHA medium. Paper discs with a diameter of 6 mm were soaked in 0.1 ml of ketul leaf extract solution with varying concentrations of 30%, 40%, 50%, 60%, 70% and the solvent used as a control extract. The negative control in this study was ethanol p.a., which did not have inhibitory power against the test bacteria and as a comparison the solvent did not affect the extract activity test (Utomo et al., 2018). Meanwhile, the positive control used was amoxicillin. After the solution has been completely absorbed, the paper disc is placed on the MHA media using sterile tweezers containing the test bacteria, then incubated at 37°C for 24 hours. The clear zone formed around the disc paper was measured using a caliper to indicate antibacterial activity. To see antibacterial activity, the inhibitory activity category is used.

Result and Discussion

Based on research that has been carried out using the ethanol extract of ketul leaves (Biden Pilosa L) to inhibit the growth of pathogenic microbes, various tests were carried out with different concentration levels, apart from that, the results of the research also looked at the content of compounds that have the potential to act as antibacterials from the ethanol extract of ketul leaves. The complete results can be explained as follows:
Based on the results of research that has been carried out, ketul leaf extract (Bidens pilosa L.) has antibacterial activity against the bacteria Escherichia coli, Staphylococcus aureus, Bacilluse cereus and Pseudomonas aeruginosa. The research was carried out using the diffusion method using 5 different concentrations with 4 repetitions for each concentration. Based on the results obtained, it shows that the higher the concentration of the solution, the better the ability of antibacterial activity. The research results can be seen in the following Figure and Table.

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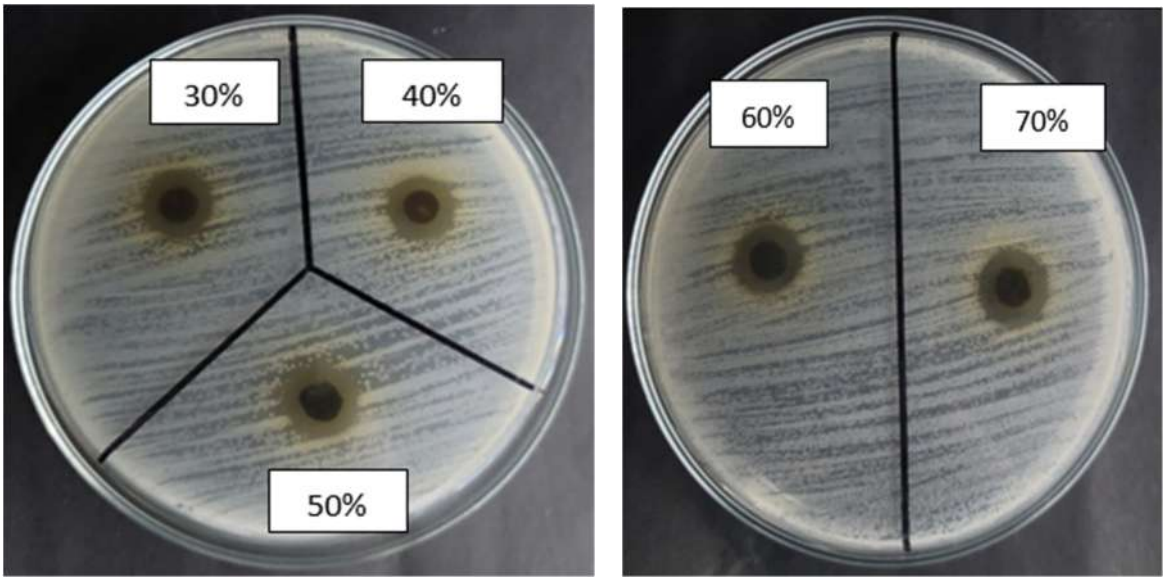

Figure 1. Diameter of the inhibition zone at each concentration of Escherichia coli test bacteria

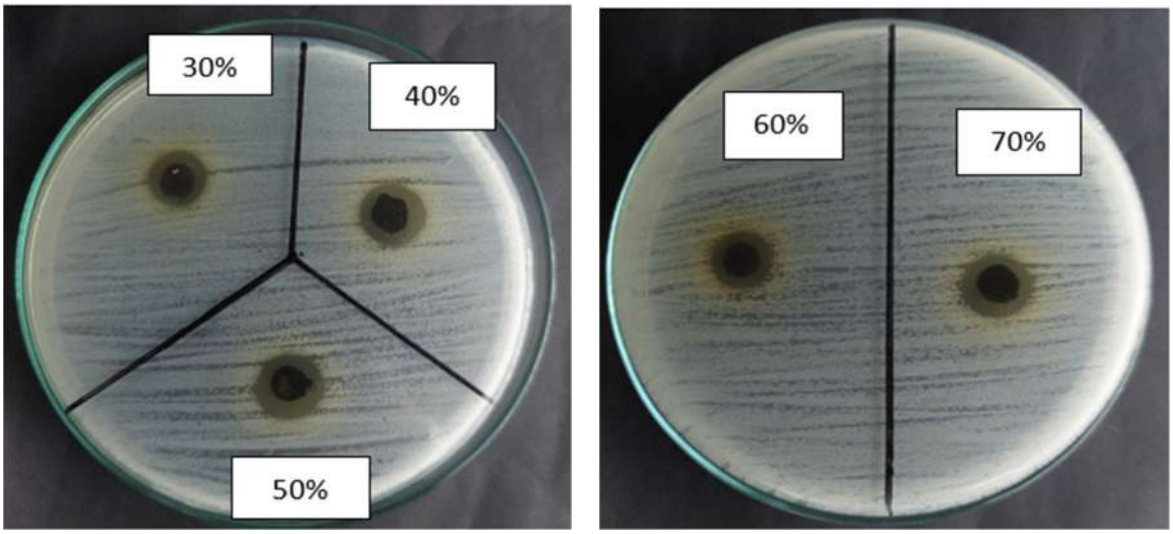

Figure 2. Diameter of the inhibition zone at each concentration of the Staphylococcus aureus test bacteria

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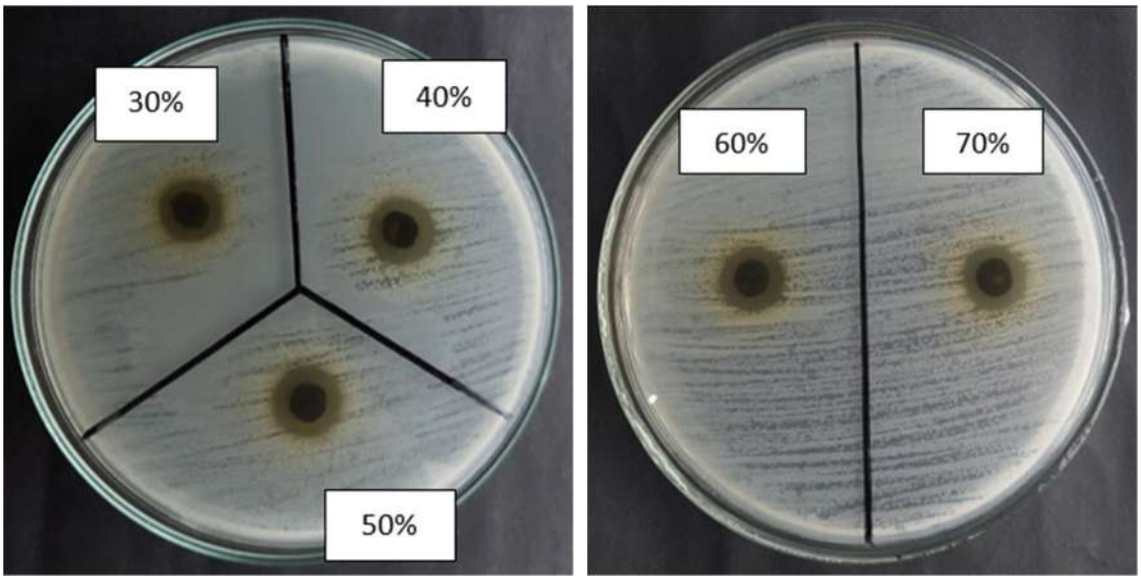

Figure 3. Diameter of the inhibition zone at each concentration of the Bacillus cereus test bacteria

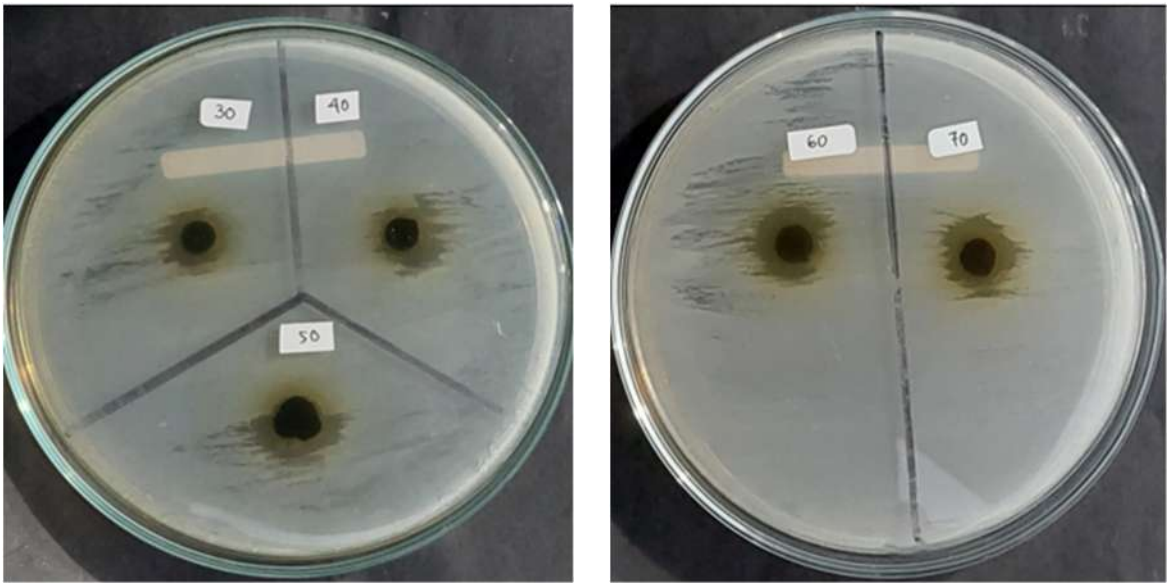

Figure 4. Diameter of the inhibition zone at each concentration of the test bacteria Pseudomonas aeruginosa

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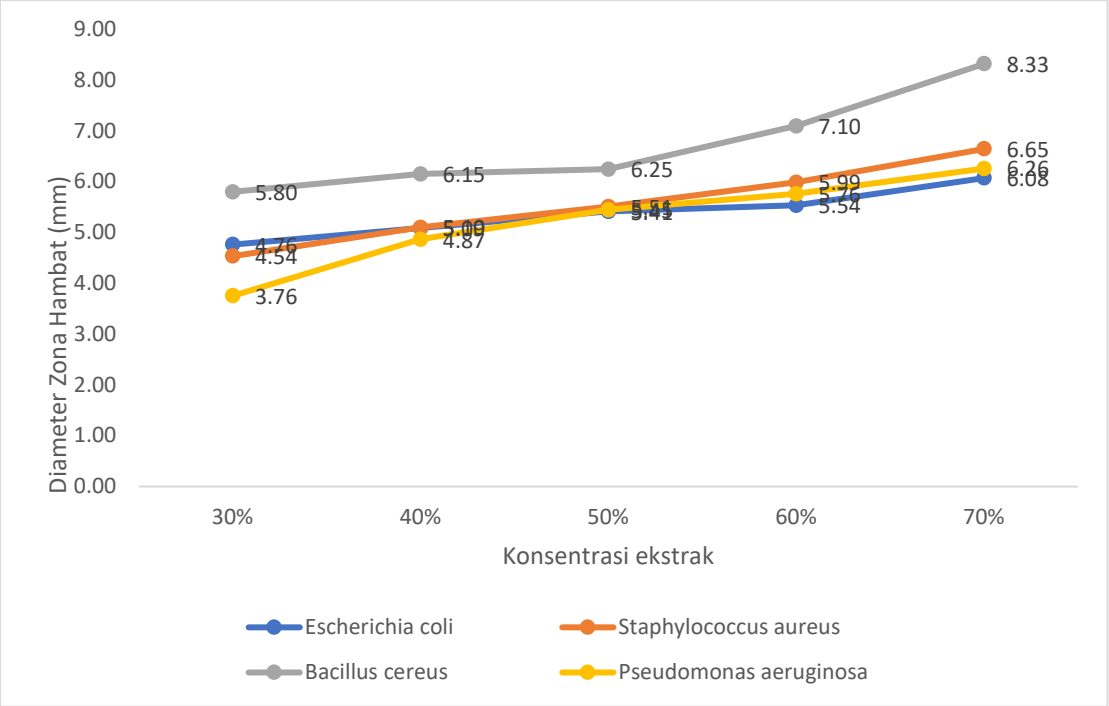

Figure 5. Graph of Antibacterial Activity of Ethanol Extract of Bidens Pilosa L Leaves.

Based on Table 4.1, it shows the antibacterial activity of ketul leaves (Bidens pilosa L.) against Escherichia coli bacteria with a concentration of 30% including in the weak category, concentrations of 40%, 50%, 60% including in the medium category, while for Staphylococcus aureus bacteria the concentration of 30% is included in the weak category, 40%, 50%, 60% fall into the moderate category. For Bacillus cereus bacteria, ranging from weak to moderate, as well as Pseudomonas aeruginosa bacteria, where at a concentration of 30% it is classified as weak, 40% to 70% is classified as moderate. A concentration of 70% is an effective concentration in inhibiting the growth of Escherichia coli, Staphylococcus aureus, Bacillus cereus and Pseudomonas aeruginosa bacteria. The inhibition category that emerged from Bidens Pilosa ethanol extract was from weak to moderate. When compared with the positive control, there is a significant difference. However, the advantage of using plants as natural antibacterials has the advantage of reducing resistance that arises as a result of the use of antibiotics that are not as recommended.

Bidens pilosa leaf extract is known to contain various bioactive compounds which are able to inhibit the growth of pathogenic bacteria through a complex mechanism. The flavonoids in Bidens pilosa play an important role in damaging bacterial cell membranes. This compound can disrupt the lipid structure of cell membranes, increase membrane permeability, so that ions and essential compounds leak out of bacterial cells, which ultimately causes cell lysis [10]. In addition, tannin, which is also contained in this extract, is known to be able to interact with bacterial cell wall proteins, inhibit peptidoglycan synthesis, and weaken the cell wall structure, especially in Gram-positive bacteria such as Staphylococcus aureus [11].

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The alkaloid compounds contained in Bidens pilosa ethanol extract are known to inhibit the activity of important enzymes that play a role in bacterial metabolic processes. One of the main targets is the DNA gyrase enzyme, which is important in the bacterial DNA replication process, thus inhibiting the bacteria's ability to reproduce [12]. In addition, the saponins in Bidens pilosa are reported to have a detergent effect on cell membranes, causing the disintegration of the cell membranes of Gram-negative bacteria such as Escherichia coli [13].

Apart from damaging the structure of membranes and cell walls, flavonoids also have the ability to disrupt the formation of bacterial biofilms. Biofilms, which function as protection for bacteria from antibiotics and the immune system, can be inhibited by flavonoids through the mechanism of preventing initial adhesion of bacteria to surfaces as well as inhibiting bacterial communication pathways or quorum sensing [14]. This makes the bacteria more vulnerable to external attacks. This combination of effects often indicates synergy between the various active compounds in Bidens pilosa, enhancing its antibacterial potential [4].

Furthermore, research shows that several active components in Bidens pilosa leaf extract can inhibit bacterial protein synthesis by disrupting the 30S and 50S ribosomes, thereby disrupting the production of proteins essential for bacterial survival [15]. With these various mechanisms, Bidens pilosa is not only effective against pathogenic bacteria but also shows potential in overcoming bacterial resistance to conventional antibiotics.

Conclusion

The results showed that the ethanol extract of Bidens pilosa leaves had significant antibacterial activity against pathogenic bacteria. An increase in extract concentration directly correlates with an increase in the inhibition zone formed, indicating that this extract is dose-dependent in inhibiting bacterial growth. This indicates that the bioactive compounds in Bidens pilosa leaves, such as flavonoids, tannins, alkaloids, and saponins, have an important role in inhibiting vital bacterial processes, including damage to cell membranes, inhibition of cell wall synthesis, and disruption of biofilm formation.

The larger zone of inhibition at high concentrations shows the potential of this extract as a natural antibacterial agent that can be further developed, both for medical and pharmaceutical applications, especially in treating pathogenic bacteria that are resistant to conventional antibiotics. These findings also emphasize the need for further studies to determine specific molecular mechanisms and validate their effectiveness in in vivo models.

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The influence of practitioner lectures on learning motivation and learning outcomes of school management courses of science education study program, department of biology, state university of medan

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Abstract. *This research aims to examine the influence of practitioner lectures on learning motivation and learning outcomes in School Management courses. The research method used is quantitative with an experimental approach. The research subjects were students. Data was collected through questionnaires of teaching practitioners, learning motivation and learning outcomes questions. Analyzed using linearity and regression tests. The results of the research show that there is a relationship between practitioner lectures and learning motivation of 0.003 with a significant value of <0.05, the coefficient of determination R square is 0.334, so practitioners lectures contribute to student learning motivation by 33.4%. Meanwhile, teaching practitioner lectures is not related to learning outcomes of 0.074, with a significant value of > 0.05. These findings indicate that practitioner involvement in the teaching process can increase student learning motivation, especially in the context of practical application of the material being taught. This research provides important implications for curriculum development and teaching methods in higher education, especially in integrating practical experience into theoretical learning.*

Keywords: Teaching practitioners, Learning motivation, Learning outcomes

Introduction

Along with developments in time and technology, teaching methods continue to develop to meet increasingly complex educational needs and challenges. One approach that is starting to be implemented is involving industry practitioners in the teaching process in higher education [8]. In the context of higher education in Indonesia, innovation is needed so that higher education graduates can adapt more easily to the world of work.

Therefore, input from the business world is very important so that the needs of the world of work can be aligned with learning on campus. In order for this to be achieved, the learning process in higher education needs to involve practitioners who come from the world of work. To accommodate this need, the Ministry of Education and Culture formulated MBKM through Minister of Education and Culture Regulation No. 3 of 2020. This policy aims to provide practical knowledge for students, especially from the practical aspect [9].

In the academic, especially in teaching courses that require practical application such as science learning, the involvement of practitioners is very crucial. They bring real perspectives from the industry that help students better understand and apply the concepts learned. Therefore, the role of practitioners in lectures is not only to improve the quality of learning but also to prepare students for challenges in the world of work. Practitioners support the learning process by providing new ideas, directing discussions, and providing explanations that help students learn and participate actively [2].

The Practitioner Lectures Program is designed to create collaboration between practitioners and higher education in designing and managing courses. Students are expected to gain experience integrating theory with concrete practical aspects, so that they will become more confident and experienced when they enter the world of work. The difference between regular lectures and Teaching Practitioners lies in the existence of a practitioner discussion space with the lecturer during the lecture [5].

Learning motivation is one of the key factors in student academic success. According to Deci [1], high motivation can improve learning outcomes and student involvement in the educational process. However, how teaching methods involving industrial practitioners influence learning motivation still requires further research.

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Practitioner lectures is also expected to be able to improve student learning outcomes of School Management courses. Practitioners are individuals who have experience and expertise in a particular field and are able to integrate practical knowledge into the learning process.

Practitioners have a lot of experience in this field, so their role is very important in the teaching process. Students as students are expected to benefit from the presence of practitioners. This research aims to determine the effect of practitioner lectures on the motivation and learning outcomes of nature science education students.

Method

This research uses a quantitative approach with an experimental design to evaluate the influence of teaching practitioners on student learning motivation in School Management courses. The main instruments used in this research were practitioner lectures, learning motivation questionnaire and learning outcomes questions. A quantitative approach was chosen because it allows researchers to measure variables objectively and carry out statistical analysis to test research hypotheses [3]. The objects of this research are students enrolled of the School Management course of the Nature Science Education Study Program, Department of Biology, State University of Medan.

Result and discussion

Data results

From the research results, data on practitioner lectures was 78.75, learning motivation was 91.00 and learning outcomes were 82.70. Data recapitulation is as in Figure 1 below.

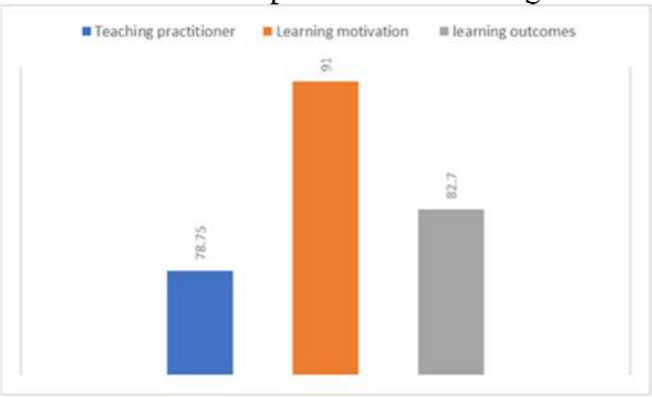

Figure 1. Data recapitulation

Data Linearity Test Results

The results of the ANOVA linearity test are as shown in the following table.

Table 1. Data linearity test results. Practitioner lectures and learning motivation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6048.216	1	6048.216	11.012	.003[b]
	Residual	12083.784	22	549.263		
	Total	18132.000	23			

a. Dependent Variable: MOTIV

b. Predictors: (Constant), PRAK

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Table 2. Results of data linearity test of Practitioner lectures and learning outcomes

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	997.933	1	997.933	3.529	.074[b]
	Residual	6221.042	22	282.775		
	Total	7218.975	23			

a. Dependent Variable: HBLJAR

b. Predictors: (Constant), PRAK

Table 3. Recapitulation of Data Linearity Test Results

No.	Data	Significance	Category
1.	Practitioner lectures and learning motivation	0,003	Linear
2.	Practitioner lectures and learning outcomes	0,074	Not linear

Based on the results of the data linearity test, it can be seen that there is a effect between practitioner lectures and learning motivation with a significant value < 0.05, while practitioners lectures have not effect with learning outcomes, with a significant value > 0.05.

Regression Test

The regression test results obtained from practitioner lectures with learning motivation are as shown in the following table.

Table 4. Regression test results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.578[a]	.334	.303	23.436

a. Predictors: (Constant), PRAK

Table 5. Results of Correlation Coefficients

Data	R^2	Kontribusi (%)
Learning Practitioner and learning outcomes	0,334	33,4

The results that there is a real effect between practitioner lectures on learning motivation in School Management courses. Because the r value is positive, it means that the longer of practitioner lectures duration, the greater the of learning motivation. Where the coefficient of determination R square is 0.334, practitioner lectures contribute to learning motivation by 33.4%.

Discussion

There is a real effect between practitioner lectures on learning motivation in School Management courses in general, amounting to 33.4%. The analysis obtained that the influence of the correlation coefficient is positive means that the influence is positive, that is, the longer the duration of the practitioner's teaching, the greater the student's learning motivation.

In accordance with [7] research results, there was a significant increase in the learning motivation of students taught by practitioners compared to those taught by academic lecturers ($p < 0.05$). These findings indicate that practitioner involvement in the teaching process can increase student learning motivation, especially in the context of practical application of the material taught. This research provides important implications for curriculum development and teaching methods in higher education, especially in integrating practical experience into theoretical learning.

Likewise, Stack & Bound explains that the presence of research practitioners can explore individual characteristics such as motivation, inner thoughts, feelings, intuition, dreams,

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reflections, experiences, values. Also explained that when writing up their findings, each participant spoke about collective abilities which functioned as a source of motivation and support [4]. Overall, these small, broader domain studies demonstrate the potential for educators to develop and foster collective research that enhances their ability to engage students, improve themselves as professionals and to thrive in research.

Meanwhile, testing teaching practitioners with learning outcomes, this research has not shown any influence. This could be due to the fact that the duration of learning involving practitioners from the industrial world has not been maximized so that students have not been able to understand the material in the course as a whole, thus having an impact on the relationship between these two variables.

Conclusion

It can be concluded that there is a real influence between practitioner lectures on learning motivation in School Management courses in general, amounting to 33.4%. The analysis obtained that the effect of the correlation coefficient is positive means that the influence is positive, that is, the longer the duration of the practitioner lectures, the greater the learning motivation. Meanwhile, testing of practitioner lectures with learning outcomes has not shown effect.

The implication of this research is that higher education institutions should consider involving more industrial practitioners in the teaching process, especially in courses that have direct practical application in the world of work. This approach not only increases students' learning motivation, but also helps bridge the gap between academic theory and industrial practice, better prepare students for future professional challenges.

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Rooting orchids using indole butirat acid (iba) plant growth regulating substances through tissue culture

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Abstract. *Orchid that has a lot of interest because it is relatively adaptable in the lowlands, does not require special care, is easy to flower, has many varieties of flowers. Tissue culture is an alternative to*

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get the orchids in large quantities. This research was rooting orchids using indole butirat acid (IBA) plant growth regulator substances. The research design used was completely randomized design, using growth plant hormone IBA with treatment levels (0, 2, 4, 6) ppm. The parameters observed in this study were a). Number of shoots, b). Number of leaves, c). Number of roots, d). Plant height, e). Plant area of leave, f). Root length. The Anava analysis technique was used to analyze the data from the research and further tests with the Duncan Multiple Range Test with an error rate of 5%. The results showed 1). The number of shoots treated with MS + IBA 2 ppm media, namely 2,3 shoots 2). The number of leaves treated with MS + IBA 2 ppm media produced an average number of leaves more, namely 7.1 leaves. 3). The number of roots treated with MS + IBA 2 ppm media resulted in a higher average number of roots, namely 4.5 roots. 4). The plant height in the MS + IBA 2 ppm medium treated with the highest average yield was 1.3 cm. 5). The leaf area of the MS + IBA 2 ppm media treatment obtained the highest average yield, namely 0.7 cm. 6). The root length of the MS + IBA 2 ppm media treatment obtained the highest average result, namely 0.5 cm.

Keywords: Rooting, Orchid; in Vitro; Indole Butirat Acid

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Introduction

Indonesia is a country that holds the largest wealth of orchid germplasm in the world. There is around 26,000 species, Indonesia has around 6,000 species of orchid plants in the world. Indonesia is a tropical country and has environmental conditions that meet the requirements to guarantee this. orchid plant life. It is estimated that there are around 5,000 types of orchid plants in Indonesia [1]. Because orchids have a high selling value, collectors and business people intend to collect orchids as ornamental plants.

The Dendrobium orchid type is a natural orchid that can grow from the lowlands to the highlands with a light intensity of between 50-100% sunlight [2]. This type of orchid is the orchid that is most widely known by ordinary people. Dendrobium is a group of orchids that is no less popular than other types of orchids such as Phalaenopsis. Dendrobium orchids have large pseudobulbs, which means they are organs that function to store water [3]

Dendrobium is also one of the orchids that has a lot of interest because it is relatively adaptable to lowlands, does not really require special care, easy to flower, besides that the dendrobium orchid has the ability to receive direct sunlight without harming itself and during winter. Dendrobium requires very little water. This type of orchid is one of a kind, because the flowers are durable and not easy to fall off, with a very varied flower shape and color, and easy to pack for cut flowers.

Generally, consumers want plants that have or are ready to flower to be purchased so that they can immediately enjoy their beauty without having to bother taking care of them until they flower, therefore most orchid sellers only sell plants that have or are ready to flower to attract consumers [4].

Propagation through tissue culture is also an alternative technique to overcome this [5] and can also help produce more uniform and quality seedlings [6]. The success of in vitro plant propagation is influenced by several factors such as the selection of explants used, explant sterilization, basic media composition, the use of growth regulators (PGR) especially auxins and cytokinins as well as environmental factors where the culture is placed [7], [8]. Growth regulators have a role in the process of growth and development for plant survival [9].

Tissue culture is a technique to obtain new plants in large quantities, a relatively short time, having the exact same physiological and morphological properties as the parent plant. This in vitro technique is expected to obtain new plants that are superior [10]. Tissue culture is one of the alternatives to obtain orchid plants Dendrobium sp. in large quantities. Rooting is a very important stage in the formation of planlets for in vitro micropropagation. MS (Murashige and Skoog) media is a medium that is widely used in in vitro culture and MS media can be combined with PGR for rooting such as IBA (Indole Butirat Acid). IBA is a type of auxin that encourages cell division, so it is needed for root formation [11].

Materials And Methods.

This research was conducted at the Physiology Laboratory, Department of Biology, UNIMED, YAHDI Tissue Culture Laboratory, Jalan Lambung No. 18 Tanah 600 Medan Marelan. In vitro Dendrobium sp. orchid explants were used as material for rooting. Using MS media, sterile distilled water, alcohol (70% and 90%), sucrose, agar, IBA. Standard tissue culture tools were used in this study.

The research design used is Factorial Randomized Complete Design (CRD), using ZPT IBA with treatment levels (0, 2, 4, 6) ppm, The parameters observed in this study were a). Number of buds, b). Number of leaves, c). Number of roots, d). Plant height, e). Leaf area, f). Root length. Factorial ANOVA analysis technique was used to analyze the research data and further test with Duncan Multiple Range Test (DMRT) with 5% error rate.

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Results

Number of Shoots

The number of shoots was observed at 12th weeks after planting, by counting the number of shoots that grew from all explants.

Table 1. Analysis of variance (ANOVA) Effect of IBA Application on the Number of Buds of Orchid *Dendrobium* sp

Effect of Variance	Degree of Freedom	Number of Squares	Mean Square	F Count	F Table 0.05
Treatment	3	5.125	1.708	7,07	0.002
Eror	20	4.833	0.241		
Total	23	9.958			

The result of analysis of variance showed that the addition of IBA significantly influenced the number of buds of Dendrobium sp. orchid with F_{Count} 7,07 > F_{Table} 0,002.

Table 2. Average Number of Shoots of Dendrobium sp. at 12th Weeks After Planting

No	Treatment	Average Number of Buds
1	MS + IBA_2	2.3333 a
2	MS + IBA_0	0.3333 b
3	MS + IBA_4	0.3333 b
4	MS + IBA_6	0.1667 b

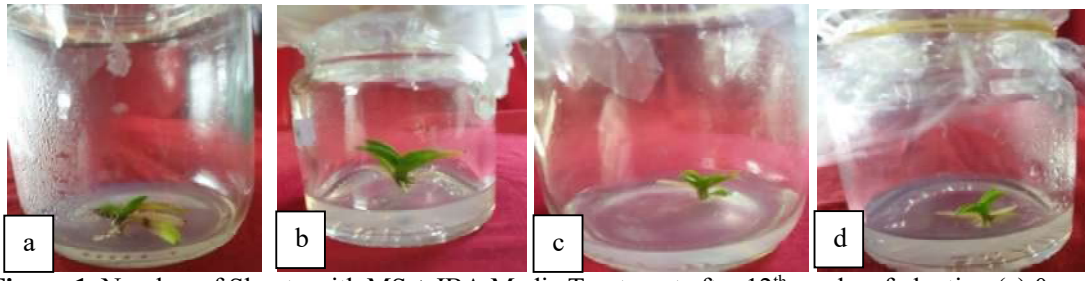

Figure 1. Number of Shoots with MS + IBA Media Treatment after 12th weeks of planting (a) 0 ppm concentration, (b) 2 ppm concentration, (c) 4 ppm concentration, (d) 6 ppm concentration

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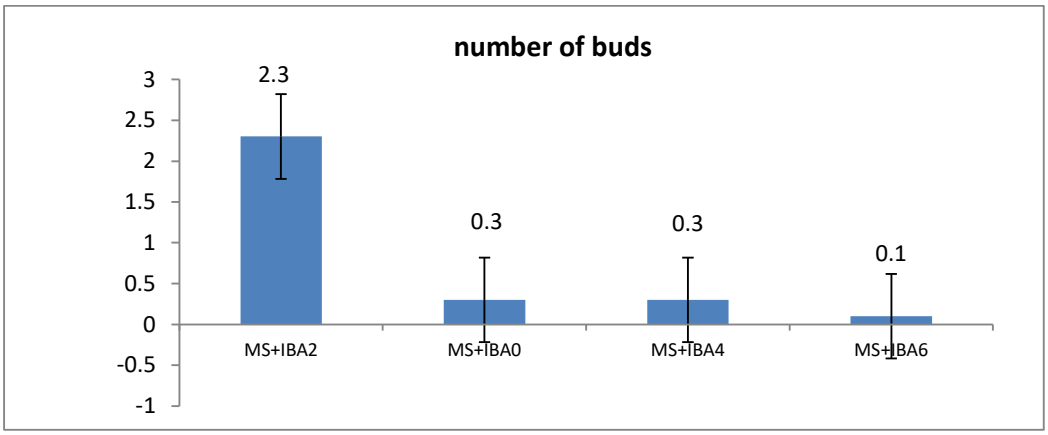

Figure 2. Number of *Dendrobium* sp Orchid Buds after 12th weeks of planting

The number of buds was observed on the 12th week after planting, by counting the number of buds that grew from all explants. The result of analysis of variance showed that the addition of IBA significantly influenced the number of buds of Dendrobium sp. orchid with F_{count} 7.07 > F_{table} 0.002.

MS+IBA2 media treatment produced the highest average number of buds, and MS+ IBA0 and MS+ IBA4 media treatments produced the same average number of buds. This condition is likely due to the absence of growth regulator intake that spurs shoot multiplication in the growth medium. In MS + IBA6 media, the lowest average number of shoots was produced. [12] reported that treatment with high concentrations of auxin can cause plant stress and inhibit growth. This condition illustrates that there is a metabolic disturbance during shoot growth. Research by [13] with Arabidopsis mutants showed that defects in auxin transport or auxin response also produce shoots with altered morphology, and leaves with morphological defects. IBA levels that are given too high can also suppress the number of buds formed, due to the nature of auxins that can inhibit bud formation. In accordance with the opinion of [7] although auxin is clearly necessary for the induction of shoot and root growth, at higher concentrations auxin can actually interfere with and inhibit growth.

Number of Leaves

The number of leaves was observed at 12th week after planting, by counting the number of leaves that grew from all explants.

Table 3. Analysis of Variance (ANOVA) Effect of IBA Application on Number of *Dendrobium* sp Orchid Leaves

Effect of Variance	Degree of Freedom	Number of Squares	center squared	F Count	F Table 0.05
Treatment	3	17.453	5.819	3.58	0.032
Eror	20	32.500	1.625		
Total	23	49.958			

The result of analysis of variance showed that the addition of IBA significantly influenced the number of leaves of Dendrobium sp. orchid. F_{count} 3,58 > F_{Table} 0,032.

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Table 4. Average Number of Leaves at 12th Weeks After Planting

No	Treatment	Average number of leaves
1	MS + IBA_2	7.1667 a
2	MS + IBA_4	5.8333ab
3	MS + IBA_0	5.1667ab
4	MS + IBA_6	5.0000 b

The results of the observation of the number of leaves can be seen in the form of a graph below:

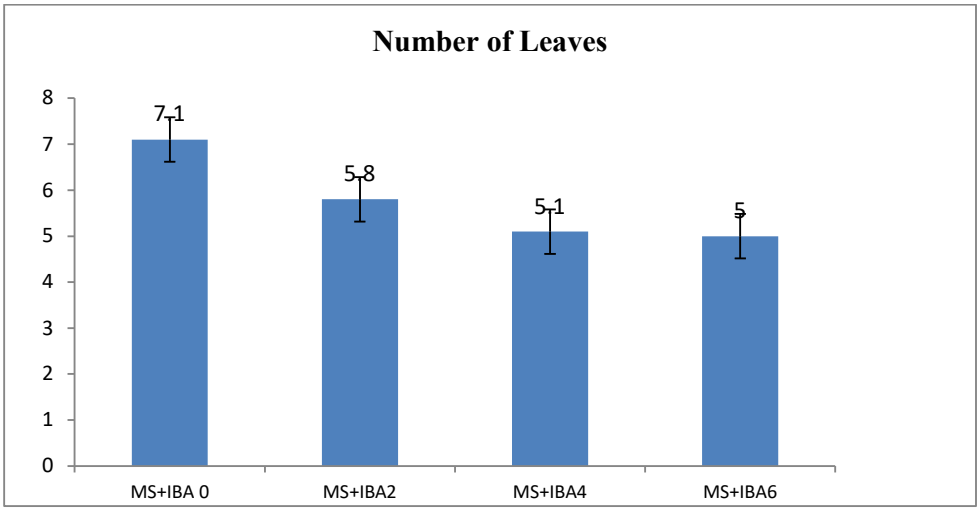

Figure 3. Number of *Dendrobium* sp Orchid Leaves,. after 12th weeks of planting

The number of leaves was observed at 12th week after planting, by counting the number of leaves that grew from all explants. The result of analysis of variance showed that the addition of IBA significantly influenced the number of leaves of Dendrobium sp. orchid with F_{count} 3.58 > F_{Table} 0.032. In MS + IBA2 media treatment resulted in more average number of leaves compared to MS + IBA0, MS + IBA4 and MS + IBA6 media treatment which the average number of leaves was less and not significantly different, from the table above it can be seen that the higher the concentration of IBA, the less the number of leaves. The results of research by [14] on the treatment of IBA 200 µM/l media, plantlets produced more leaves than other treatments, namely 3.33 leaves/plantlet. Plantlets that grew on media supplemented with IBA with concentrations of more than 200 µM/l media had fewer leaves (1.33 leaves/plantlet).

This is in accordance with one of the functions of auxin in leaf formation is to help the development of prospective leaf meristem tissue [15]. Auxin can affect leaf growth. Leaves are one of the plant organs that are very important, especially for photosynthesis so that plants produce food and experience optimum growth. the increasing number of leaves, the size of the length and width of the leaves, the greater the effect on plant growth [16].

Number of Roots

The number of roots was observed at weeks 12th after planting, by counting the number of roots that grew from all explants.

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Table 5. Analysis of variance (ANOVA) Effect of IBA Application on the Number of *Dendrobium sp.* Orchid Roots

Effect of Variance	Degree of Freedom	Number of Squares	center squared	F Count	F Table 0.05
Treatment	3	7.797	2.597	4.65	0.012
Eror	20	11.167	0.558		
Total	23	18.953			

The result of analysis of variance showed that the addition of IBA significantly influenced the number of leaves of Dendrobium sp. orchid. F_{count} 4,65 > F_{Table} 0,012

Table 6. Average number of roots at 12th weeks after planting

No	Treatment	Average number of roots
1	MS + IBA_2	4.5000 a
2	MS + IBA_4	4.0000 a
3	MS + IBA_6	2,6667 ab
4	MS + IBA_0	2.1667 b

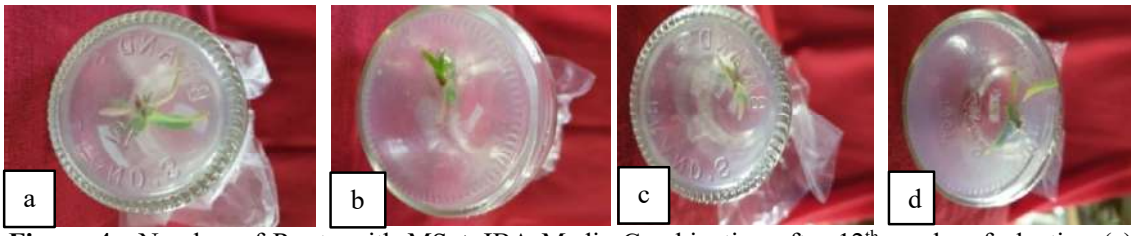

Figure 4. Number of Roots with MS + IBA Media Combination after 12th weeks of planting (a) Concentration 0 ppm, (b) Concentration 2 ppm, (c) Concentration 4 ppm, (d) Concentration 6 ppm

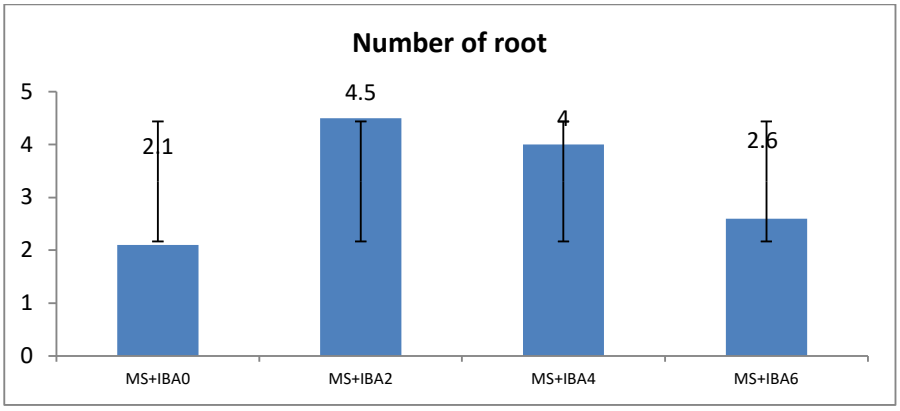

Figure 5. Number of *Dendrobium* sp Orchid Root after 12th weeks of planting

The number of roots was observed on the 12th week after transplanting, by counting the number of roots that grew from all explants. The result of analysis of variance showed that the

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addition of IBA significantly influenced the number of leaves of Dendrobium sp. orchid with Fcount 4.65 > FTable 0.012.

The observation of root color of Dendrobium sp. orchid explants at the time of root initiation can be seen in Figure 4 At 12th week after planting period, the color of the growing roots is dominated by green color. Judging from the MS + IBA2 media treatment, the average number of roots is more than the MS + IBA0, MS + IBA4 and MS + IBA6 media treatments. The treatment without the provision of auxin into the media showed the lowest results on the average number of roots. This condition may be due to the absence of growth regulator intake that spurs root multiplication in the growth media. Figure 4 shows the growth of roots in Dendrobium sp. explants grown in media with the addition of auxin type IBA. The roots that grew in the treatment media were single roots found on Dendrobium sp. shoots, but there were also treatment media with two roots that grew on Dendrobium sp. shoots.

The average number of roots on Dendrobium sp. explants with the addition of auxin type IBA as much as 2 ppm showed that the roots grew best than the IBA concentration of 0 ppm, 4 ppm and 6 ppm. Auxin has an important role in root initiation in in vitro culture, this is explained by [17] that auxin plays a role in triggering the formation of lateral roots from undifferentiated callus, but in the medium given exposure to light the explant response to auxin is reduced. [18] states that the provision of IBA can increase the speed of rooting so that the quality and vigor of plants will increase as well. IBA also plays an important role in the process of cell division and enlargement, especially at the beginning of root formation. In addition, IBA absorbed by plants will depend on the concentration given and will determine cell division. If the IBA to be absorbed is high, the cell division process will take place quickly so that root formation will be faster. This condition results in root growth in treatments with certain concentrations of IBA better than without IBA treatment [19]

It is also explained by [20] that the type of auxin IBA is superior and effective in stimulating root activity because of its stable chemical properties and its ability to work longer. IBA also spurs cell elongation which causes root growth. This is in line with what is expressed by [21] that the provision of solutions or powders containing auxins will increase the number of roots formed. Good root growth is indicated by an increase in the number of roots which will directly increase root weight. This is because IBA given at the right concentration is able to improve the level of root growth which results in better absorption of water and nutrients.

Plant Height

Plant height was observed in the 16th weeks after planting, by measuring the overall height of the plant using millimeter paper.

Table 7. Analysis of Variance (ANOVA) Effect of IBA Administration on the Height of Dendrobium sp. Orchid Plants

Effect of Variance	Degree of Freedom	Number of Squares	Mean Square	F Count	F Table 0.05
Treatment	3	0.351	0.102	6.92	0.002
Eror	20	0.338	0.016		
Total	23	0.689			

The results of the analysis of variance showed that the addition of IBA had a significant effect on the height of Dendrobium sp. orchid plants F_{count} 6,92> F_{Table} 0,002.

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Table 8. Average Plant Height at 16th Weeks After Planting

No	Treatment	Average Plant Height
1	MS + IBA_2	1.31667 a
2	MS + IBA_0	1.21667 a
3	MS + IBA_6	1.16667 a
4	MS + IBA_4	0.98333 b

The results of observations of the combination of MS + IBA media (0, 2, 4, 6 ppm) can be seen in the image below:

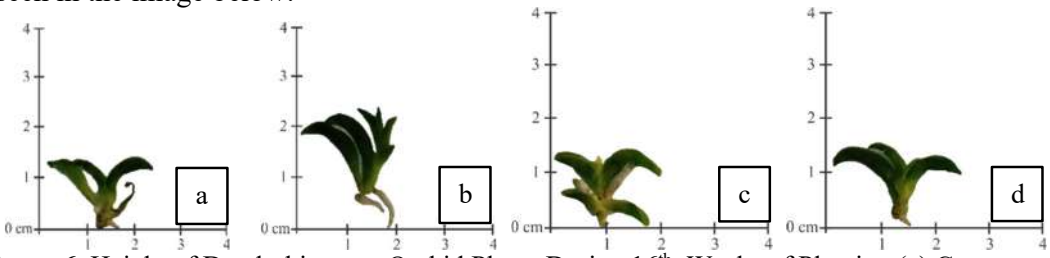

Figure 6. Height of Dendrobium sp. Orchid Plants During 16th Weeks of Planting (a) Concentration 0 ppm, (b) Concentration 2 ppm, (c) Concentration 4 ppm, (d) Concentration 6 ppm

Plant height was observed at 16th week after planting, by measuring the overall height of the plant using millimeter paper. The result of analysis of variance showed that the addition of IBA significantly influenced the plant height of Dendrobium sp. orchid with F_{Count} 6.92> F_{table} 0.002.

In MS+IBA2 media treatment, the highest average result on plant height was 1.31667 but not much different from MS+IBA0 and MS+IBA6 media treatments and in MS+IBA4 media treatment, the lowest average amount of plant height was 0.983. The highest plant height was produced in MS+IBA2 media but not significantly different from MS media without IBA. These results indicate that the concentration of natural auxin in plants (endogenous) is thought to be sufficient to encourage the growth of plant height. The increase in explant height is caused by two processes, namely cell division and elongation, both of these processes occur in the meristem tissue, namely at the stem growth point so that the plant grows bigger and is positively correlated in determining plant yield [22]. She research on black orchids treated with VW base media without the addition of organic matter and auxin gave the best average planlet height. Increasing the concentration of IBA tends to suppress plant height (Table 8). In line with the results of research by [23] where the endogenous auxin content in orchid explants is thought to be high enough, so the addition of exogenous auxin will increase the total balance of auxin and cytokinin.

The increase in plant height is a reflection of plant growth due to the division of primary meristematic cells that cause plants to increase in length or increase in height which is irreversible (cannot return to its original form). Plant growth is a series of physiological processes of plants in forming a complex organ unit with the addition of weight and size of plants [24]. The provision of auxin is able to stimulate protein synthesis in plant tissues that can lead to increased permeability of cell walls, thus stimulating cell division and elongation that will affect the increase in planlet height [25]. Stem elongation occurs due to the process of division, elongation and enlargement of new cells that occur in the apical meristem and stem internodes, which causes the plant to increase in height.

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Leaf Area

Leaf area was observed in the 16th week after planting, done by placing the leaf part on millimeter paper

Table 9. Analysis of variance (ANOVA) Effect of IBA Administration on Leaf Area of Dendrobium sp. Orchids.

Effect of Variance	Degree of Freedom	Number of Squares	Mean Square	F Count	F Table 0.05
Treatment	3	1.086	0.362	35.64	001
Eror	20	0.203	0.010		
Total	23	1.290			

The results of the analysis of variance showed that the addition of IBA had a significant effect on the leaf area of Dendrobium sp. orchids. F_{count} 35,64 > F_{Table} 0,001.

Table 10. Average Leaf Area at 16th Weeks After Planting

No	Treatment	Average area
1	MS + IBA_2	0.78667 a
2	MS + IBA_4	0.30500 b
3	MS + IBA_6	0.29833 b
4	MS + IBA_0	0.28333 b

The results of observations of leaf length and area can be seen in Figure 8 below:

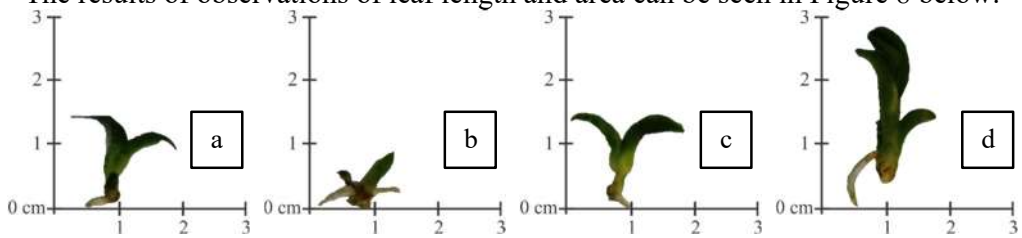

Figure 8. Length and Area of Dendrobium sp. Orchid Leaves During 16 Weeks of Cultivation (a) Concentration 0 ppm, (b) Concentration 2 ppm, (c) Concentration 4 ppm, (d) Concentration 6 ppm

Leaf area was observed on the 16th week after planting, done by placing the leaves on millimeter paper. The result of analysis of variance showed that the addition of IBA significantly influenced the leaf area of Dendrobium sp. orchid with F_{Count} 35.64 > F_{table} 0.001. In MS+IBA2 media treatment, the highest average result was obtained on plant area and MS+IBA0, MS+IBA4 and MS+IBA6 media treatments obtained the average amount of plant height which was not much different. In the table above the leaf area obtained is not much different, this is due to the endogenous ability of each embryo to grow and develop. The increase in leaf area growth is due to the acceleration of cell division and encourages the differentiation process. Cell division requires high energy obtained from auxins and cytokinins and other nutrients. Energy in the form of ATP which is the result of the respiration process is used to synthesize essential compounds, such as proteins, carbohydrates, fats, and other essential compounds. These compounds are needed for the process of dividing new cells that occur in the apical meristem and intercalar meristem.

The process of leaf growth and development requires ZPTs such as auxins and cytokinins as well as other nutrients contained in the growth medium. The provision of auxin

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can affect leaf growth, especially the length of the vascular tissues [4]. This is in accordance with the statement [26] that the length and width of leaves are closely related to the direction of division, enlargement, number, and distribution of cells. The wider the leaf, the more the number of stomata increases. Stomata are very instrumental in the absorption of nutrients and substances needed in the metabolic process of plants to produce assimilates.

Root Length

Root length was observed in the 12th week after planting, done by placing the orchid root section on millimeter paper.

Table 11. Analysis of variance (ANOVA) Effect of IBA Administration on the Root Length of Dendrobium sp. Orchids.

Effect of Variance	Degree of Freedom	Number of Squares	Mean Square	F Count	F Table 0.05
Treatment	3	0.3067	0.1022	19.17	0001
Eror	20	0.1067	0.0053		
Total	23	0.4133			

The results of the analysis of variance showed that the addition of IBA had a significant effect on the area of Dendrobium sp. orchid plants. F_{count} 19,17 > F_{Table} 0,001.

Table 12. Average Plant Height at 12th Weeks After Planting

No	Treatment	Average root length
1	MS + IBA_2	0.55000 a
2	MS + IBA_4	0.41667 b
3	MS + IBA_0	0.31667 b
4	MS + IBA_6	0.25000 c

The results of observations of leaf area, plant height and root length can be seen in the graph below:

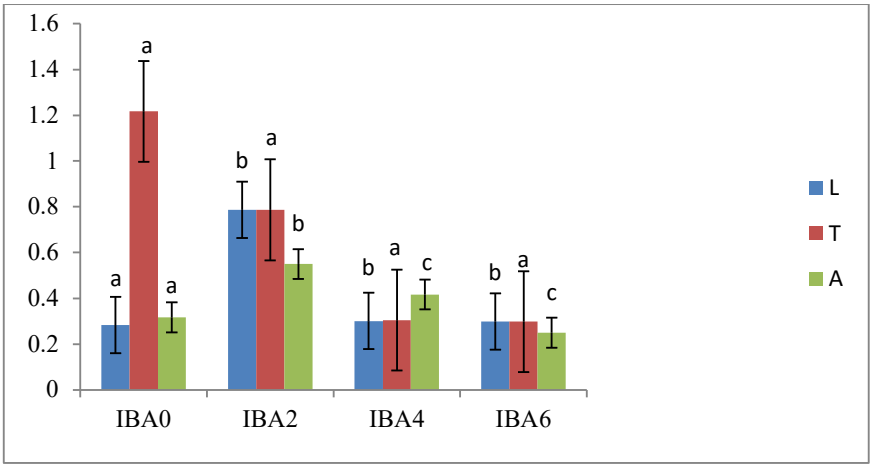

Figure 9. Leaf area, plant height and root length

Root length was observed on the 12th week after transplanting, done by putting the root of orchid on millimeter paper. The result of analysis of variance showed that the addition of

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IBA significantly influenced the root length of Orchid Dendrobium sp. with F_{Count} 19.17 > F_{table} 0.001.

Root length shows the limit of plant's ability to reach certain area in nutrient absorption, so the longer root allows the plant to absorb more nutrients, minerals and water than short root [27]. According to [28], root length has been accepted as a measure of the absorption capacity of the root system. The longer the root length, the more robust the plant will be and the water and mineral salts in the growing medium will be easily absorbed to be channeled to the stem and leaves.

In the MS + IBA2 media treatment, the highest average result was obtained in the length of plant roots and the MS + IBA media treatment obtained the lowest average length of plant roots. Giving IBA (Indole Butyric Acid) at a low concentration of 2 ppm has a real effect on root length. At that concentration (2 ppm), IBA gives an optimal effect on root length. This is because at low concentrations, IBA will encourage root elongation and root formation [29], but the average root length data showed that IBA 2 ppm gave the best results than IBA 0 ppm, 4 ppm and 6 ppm. This is because the optimal IBA concentration of 2 ppm will encourage root growth, while the IBA treatment of 4 ppm and 6 ppm is thought to have exceeded the optimum value so that the activity of cell elongation and division has decreased. This condition is in accordance with the statement of [30], that the effectiveness of exogenous growth substances only occurs at certain concentrations. At too high a concentration it can be damaging, while at too low a concentration it is ineffective. The control treatment produced the average number of root lengths less than the IBA treatment of 2 ppm and 4 ppm. This is because without IBA, endogenous auxin is not enough to accelerate root formation in orchids.

Conclusions

Based on the research that has been done, it can be concluded that the treatment of MS base media and IBA concentrations (0, 2, 4, 6 ppm) affect the growth and development of orchid explants Dendrobium sp. MS + IBA2 ppm media gives the best results on the number of buds, number of leaves, number of roots, plant height, leaf area and root panajang orchid explants Dendobium sp. giving IBA as much as 2 ppm has met the needs of plants so as to produce optimal growth. While the provision of IBA in high concentrations (4 and 6 ppm) can cause plant stress and inhibit the growth of Dendrobium sp. orchid explants.

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The potential of *in vitro* culture of sumatran frankincense (*styrax benzoin* dryander) to produce bioactive compounds as medicinal raw materials

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Abstract. *Exploration of bioactive compounds from tropical woody plants such as Sumatra Frankincense (Styrax benzoin) needs to be encouraged to optimize the economic value of the plant. The problem is that there is the potential for plant extinction due to excessive exploitation to meet the needs of medicinal raw materials. Efforts to overcome these problems have the potential to be carried out through in vitro culture techniques. The objective of this research was to explore the key potential of in vitro culture of Frankincense Sumatera (Styrax benzoin Dryander) plants in producing bioactive compounds of medicinal ingredients. The study was conducted through the stages of culturing Sumatran Frankincense using young leaves from selected parent plants as explants, and then the culture products were used as raw materials to isolate bioactive compounds. In vitro culture has produced large amounts of callus, dried, and isolated using various types of solvents, resulting in isolates containing bioactive compounds. Qualitative analysis and screening stages using gas chromatography-mass spectrometry confirmed the target compounds in the culture including benzoate, cinnamate, benzyl alcohol and vanillin. This study contributes to revealing the use of plant in vitro culture technique to produce chemical compounds of medicinal ingredients.*

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Keywords: *In vitro* Techniques; bioactive compounds; *Styrax benzoin* Dryander; Medicinal compounds; Screening

Introduction

The use of bioactive compounds from medicinal plants has become a current trend and has received a lot of attention, especially bioactive compounds produced by woody plants for the reason that they are relatively safe to use and the environmental pollution effect is relatively lower when compared to synthetic bioactive products. It is inevitable that the need for the types and quantities of bioactive compounds for treatment will increase in line with the increasing types of diseases, and will significantly affect the increase in the need for raw materials for medicines for industry and pharmacy in accordance with the increase in population [1,2]. To meet these needs, sources for producing bioactive compounds need to be explored. The strategy that has been implemented is to explore chemical compounds from plants that have bioactivity and potential to treat diseases, and make them a list of medicinal plants [3]. Indonesia's position in the equatorial region is known as the lungs of the world because it is rich in oxygen-producing woody plants that grow in tropical forests. Sumatran Frankincense (*Styrax benzoin* Dryander) is one of the woody forest plants which is classified as a producer of bioactive medicinal compounds [4]. Frankincense trees grow and develop well in North Sumatra, most of them are still plants that grow naturally, a small number are cultivated plants. This plant is widely known as a producer of sap containing bioactive compounds which are used for various purposes [5]. Frankincense resin has been used as traditional and modern medicine because it has broad spectrum power in curing various types of diseases [6,7]. The chemical compounds above are known to have different activities, namely functioning as antiseptics, used as antioxidants, acting as anti-inflammatories, as antidiabetics, used as anticancer, and for other medicinal purposes [8-11].

The problem is that it takes quite a long time, around 10 years for the *Styrax benzoin* plant from planting to producing frankincense bark sap. As a result, it will be difficult to produce bioactive compounds in a short time to meet drug needs. Producing bioactive compounds from plants often sacrifices plants due to over-exploitation and causes plants to become extinct. Strategies must be implemented so that plants remain sustainable and the production of bioactive compounds can be increased. Plant tissue culture techniques have been used to produce plant seeds in a relatively short period of time, namely plant seeds that have the same genotypic quality as the parent plant [12,13]. The potential of *in vitro* culture techniques carried out on Sumatran Frankincense plants needs to be further explored, namely not only as a means of producing frankincense seeds but also as an alternative for producing chemical compounds as raw materials for medicines from callus. Production of bioactive compounds through tissue culture techniques is a strategy to save medicinal plants from overexploitation so as to avoid extinction and environmental destruction. To overcome the above problems, plant propagation techniques are needed through plant *in vitro* culture which simultaneously produces the bioactive compounds with the same activity with the chemical contained in the original plant, and are then be used as a source of bioactive materials for medicines [14,15]. Producing bioactive compounds using tissue culture techniques will shorten the time required to produce chemical compounds from a long time in the parent plant to a relatively short time at the plant culture level [16]. The purpose of this study is to reveal the use of plant *in vitro* techniques to produce bioactive compounds with medicinal properties from Sumatran Frankincense (*Styrax benzoin* Dryander). The potential of this tissue

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culture technique will be seen from the similarity of the composition of medicinal chemical compounds contained in the *in vitro* culture of the frankincense plant compared to its parent plant.

Methods

Chemicals and Materials

The compounds used in this research include MS media, Baktoagar, the growth stimulator of Indolebutryic acid (IBA) and naphthaleneacetic acid (NAA). Chemicals Ammonium hydroxide (NH_4OH), Chloroform, Diethyl Ether, Ethyl acetate, NaOH, HCl, NaCl, Methanol, n-hexane, $FeCl_3$, $FeCl_3$, Acetic anhydrous, Sodium Sulfate (Na_2SO_4), Dragendorf reagent, silica gel 60 F254 TLC plates, Silica gel 60 F_{254} (0.063-0.200 mm), all obtained from E. Merck. *In vitro* culture raw materials are obtained from the harvest of plant cultures.

Equipment and Instrumentation

The equipment used is chemical glasses as needed, including beakers, volumetric pipettes, Erlenmeyers, separating funnels, measuring flasks, sockets, pestles and mortars. Instruments used as needed include Autoclave, Laminar flow, Analytical Balance, UV VIS Spectrophotometer, Infrared Spectroscopy (ATR Nicolet, Spectrum one), FT-IR (Shimadzu/IR Prestige-21), and Gas Chromatography-Mass Spectrometry (GCMS 7890B).

Research procedures

The research was conducted in two large parts including plant tissue culture to produce callus, and isolation of bioactive compounds contained in the callus culture following previous research procedures [17]. The research stages are conducting *in vitro* culture to prepare raw materials for culture, and isolating and screening of the bioactive compounds contained in the plant culture, as shown in the research stages in Figure 1.

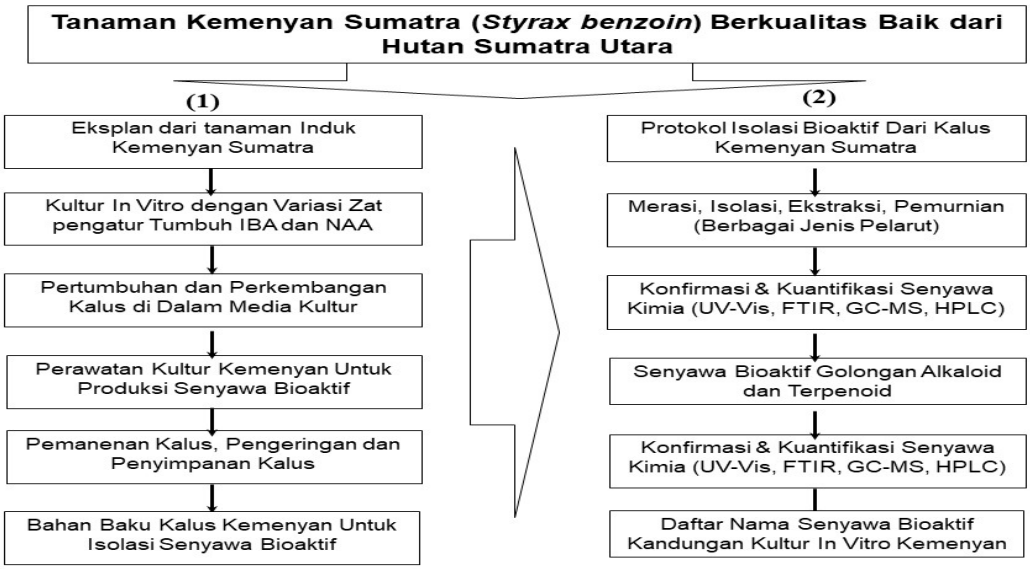

Figure 1. Research stages to reveal the potential of *in vitro* techniques of Sumatran Frankincense to produce bioactive compounds with medicinal properties: (1) *In vitro* culture of frankincense, and (2) Isolation and analysis of bioactive compounds.

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The tissue culture technique of Sumatran Frankincense plants includes preparation of plant materials, provision of culture media, selection of plant explants, *in vitro* treatment to produce frankincense cultures for use in the next stage. *In vitro* culture techniques are carried out under optimum conditions, namely using a combination of the growth regulators Indolebutryic acid (IBA) and naphthaleneacetic acid (NAA) as described in previous experiments [18]. To provide the culture material of frankincense plants, explants harvested from selected Sumatran Frankincense trees have been provided. Explants that have gone through a very strict sterilization stage are then planted in a culture medium that has been enriched with growth regulators under optimum conditions, then incubated under aseptic conditions at 1000 lux irradiation, for 16 hours/day, by controlling the temperature at 25-27 ^{o}C for a month, as an opportunity for the explants to grow and develop into potential plants in the medium. The callus and plant buds formed in the culture are then harvested and dried, stored in a desiccator, crushed, sieved (mesh), and used them for the isolation of bioactive compounds.

Isolation and Screening of Bioactive from Plant Cultures

The bioactive isolation stage is needed to obtain isolates containing bioactive compounds from culture material. The isolate was then analyzed to ensure the content of bioactive compounds, which is targeted as alkaloid and terpenoid groups. Isolation of bioactive compounds was carried out using callus raw materials from plant tissue culture results. Callus samples were dried, ground, weighed, dissolved in various types of solvents, refluxed, evaporated until dry, and then extracted using various types of solvents. The filtrate is acidified or alkalized, extracted using diethyl ether or chloroform, purified, crystallized and qualitatively tested. The extracted compounds were then analyzed using UV-Vis, FTIR, HPLC and GC-MS. Bioactive compound products are identified, confirmed and quantified and grouped into types of medicinal chemical compounds.

Results

Frankincense Mother Plant Source of Explants

Mature Sumatran Frankincense trees are of very good quality, namely plants that produce large quantities of super quality incense resin, used as explant sources for *in vitro* culture. The best frankincense trees and young leaves used as a source of explants to be planted in the medium culture are shown in Figure 2.

In Vitro Culture Techniques for Producing Bioactives

In vitro techniques for propagating frankincense plants have been carried out using young leaf explants from the best parent frankincense plants. After incubation for one month, the explants grew and developed into callus in the culture media. Explant growth in the optimum combination of growth regulators has produced callus and plant buds that are ready to be harvested and is then be used as raw materials for isolating the medicinal compounds. The assumption is that when the process of plant growth and development occurs in culture, bioactive compounds will also be produced to support callus growth. The stages of *in vitro* culture of *Styrax benzoin* to change explants into callus, namely raw materials that will be used in bioactive isolation are summarized in Figure 3. The *in vitro* culture technique implemented in this research showed good growth and development. Supplementation with various combinations of BAP and NAA under optimum conditions, it is a combination of 3 mg/L NAA and 3 mg/L NAA in MS media, provides very good growth and development. As many as 83% of the explants grew into callus, and an increase in the

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quantity of callus weight in the culture was obtained which increased 20 times compared to the weight of the explant planted.

Figure 2. Sumatra Frankincense tree for *in vitro* culture: (a) Very good quality mature tree, (b) Young leaves as a source of explants, (c) Explants ready for planting, (d) Planting explants in culture media.

Figure 3. *In vitro* culture of *Styrax benzoin* to produce callus raw material for isolation of bioactive compounds: (a) Planting the explant in the media, (b) Incubating the *in vitro* culture in the room, (c) Callus and potential plants ready to be harvested, (b) Dry culture of the material standard for bioactive isolation.

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Isolation and Screening of Bioactive Compounds

Isolation of bioactive compounds contained in plant cultures is carried out using various types of solvents. The main target of isolation is to see the potential content of alkaloid and terpenoid compounds in the culture. The results of plant culture isolation using various types of solvents along with qualitative identification are presented in Table 1.

Table 1. The content of bioactive compounds in the callus cultures based on qualitative analysis.

No	Alkaloid Group		Terpenoid Group	
	Solvent Type (isolating compound)	Qualitative Test	Solvent Type (isolating compound)	Qualitative Test
1	Ethanol	Mayer's reagent (+++), white lump Wagner's reagent (+++), yellow precipitate Dragendorf reagent (+++), orange-yellow precipitate	Methanol	Lieberman Burchard's reagent (+++), brownish orange.

(-) Not identified; (+) identified as small, (++) identified as medium; (+++) big identification

The identification results showed that the culture fraction isolated using polar solvents such as methanol and ethanol had a large isolate fraction. Qualitative identification using various types of reagents such as Mayer's Reagent, Wagner's Reagent, Dragendorf's Reagent, and Lieberman Burchard's reagent all tested positive for alkaloid and terpenoid compounds. All alcohol fractions have relatively large quantities of alkaloids and terpenoids. The frankincense culture isolate was then analyzed by GC-MS to confirm the presence of the bioactive medicinal compounds, namely through comparative prediction of the chemical yields contained in the database. One example of an isolated bioactive compound has been confirmed as shown in Figure 4. The bioactive compounds contained in the culture are almost the same as those contained in frankincense resin. Several bioactive compounds contained in the frankincense culture has been identified including benzoate, cinnamate, and vanillin derivatives as compounds with medicinal properties. There are still several chemical compounds in the culture have not been identified properly as a proof that tissue culture technique is a good strategy in producing bioactive compounds.

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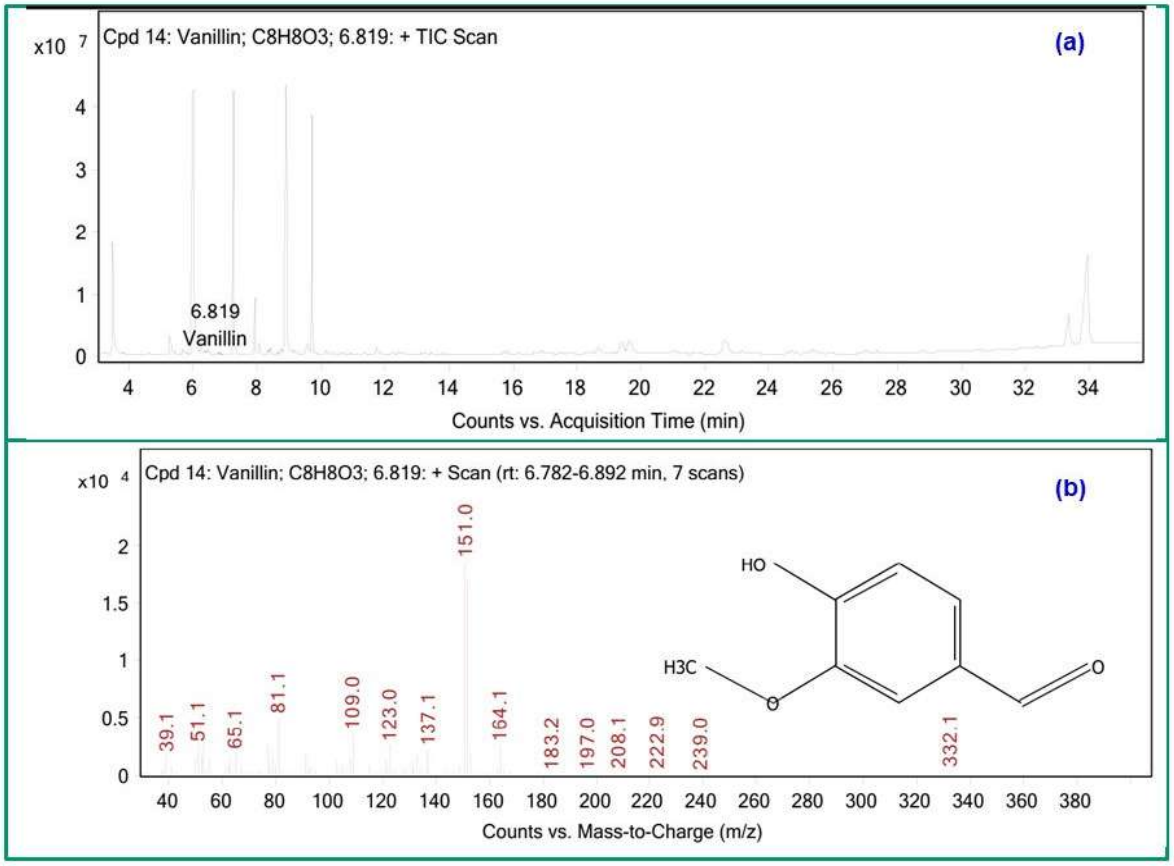

Figure 4. Identification of bioactive compounds in Sumatran Frankincense culture: (a) results of analysis using GC, (b) results of analysis using MS.

Discussion

Finding bioactive compounds in *in vitro* plant cultures is a new breakthrough in efforts to produce bioactive compounds because the success of this technique will provide opportunities to produce bioactive compounds quickly. In this research, plant tissue culture in the propagation of *Styrax benzoin* has been carried out in the media at optimum propagation condition [19-22]. The growth of explants into callus which simultaneously produces bioactives in the process of forming new plantlets provides great hope for the technique of producing bioactive compounds from Sumatran Frankincense culture. Callus culture grows and develops well to have sufficient callus raw materials for the next research stage, isolation of the bioactive [23]. Growth regulators of BAP and NAA have key role to provide a high percentage of explant growth into callus, and the quantity of callus produced within a 30 days incubation period doubles when compared to the quantity of explants [24,25]. Plant weight gain will significantly increase with increasing incubation time, which is in line with development into plants. In this condition, it is known that basal media containing BAP and NAA initiates frankincense plantlets with high intensity and the quality of the callus produced is very good, and the callus mortality rate is also low [26,27].

The research results has confirmed the presence of the bioactive compounds of medicinal ingredients in the callus cultures. Qualitative testing of the compound isolates produced using

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several types of solvents has confirmed positive results for the presence of alkaloid compounds [28,29]. Several terpenoids class compounds were also identified in isolates in small quantities, especially using alcohol solvents. The success obtained from this initial study provides promising future findings that the growth and development of plants in culture will simultaneously produce bioactive compounds. This study indicated that the quantity of bioactive compounds found in the plant culture is still relatively small when compared to the quantity of bioactive compounds contained in frankincense resin. Further studies are needed to be carried out to increase the quantity of the bioactive in callus culture. The success of this preliminary study can become a model to motivate further research in the production of bioactive compounds through tissue cultures technique.

Conclusion

Tissue culture of Sumatran Frankincense plant has great potential to be used as a model for producing bioactive compounds of medicinal properties because it has been proven that the plant culture contained the same chemical compounds as those found in the parent plant. The research stage on the propagation of Sumatran Frankincense has been carried out under optimum conditions (3 mg/L IBA and 3 mg/L NAA in basal media) producing callus raw materials. The plant callus culture is obtained in very good quantity and quality, and the percentage of explant growth into callus is relatively high (83%). The resulting callus culture is sufficient to be used as raw material in the stage of isolating bioactive compounds. Isolation of bioactive compounds from frankincense culture was successfully carried out using various types of solvents resulting in isolates containing bioactive compounds. Qualitative analysis confirmed the presence of alkaloid and terpenoid bioactive compounds in the frankincense culture isolate. The GC-MS analysis confirmed the presence of bioactive compounds in the plant culture, including benzoic acid, cinnamic acid and vanillin. Several other chemical compounds in very low concentrations were also found. The findings of this research are a new model for shortening the time to produce natural bioactive compounds, which has been successful in *in vitro* culture of Sumatran Frankincense, and is expected to be successful when applied to produce bioactive compounds in other medicinal plants.

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Hepatoprotective effect of mobe fruit extract (*Artocarpus lakoocha* Buch. Ham) in rats induced with carbon tetrachloride (CCl4) and histopathological features of the liver

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Abstract. *Hepatitis sufferers need truly effective treatment, which can minimize the risk of side effects and toxicity considering the long-term treatment. The liver is an important organ for the survival of human life because of its function as a center of metabolism and is able to detoxify various harmful substances in the body. To extract the secondary metabolites of the mobe, researchers used the maceration extraction method using ethanol solvents, which would later be able to separate polar compounds such as flavonoids, saponins, and terpenoids. Soaking the extract was carried out to ensure that the desired compounds had dissolved in ethanol. The extract was tested on test animals, namely white rats of the Wistar strain (Rattus norvegicus) which were divided into 5 groups, each of which received different treatments. Each treatment is KN, namely the group that is not given carbon tetrachloride (CCl3) or fruit extract, KP, namely the group that is given carbon tetrachloride (CCl3), KT + PEM, namely the group that is given carbon tetrachloride (CCl3) and Mobe fruit extract. SGOT was examined and the target organ in the form of the liver was slowly removed and weighed then frozen in liquid nitrogen for liver histopathology analysis. The results obtained showed a clear effect of giving mobe fruit extract on the histology of the rat liver, where each dose showed its own differences, and the most influential was the KT + PEM 300 dose, this shows that the accuracy of the dose affects changes in the cytopathological structure of the liver*

Keyword: *Hepatoprotector, Mobe Fruit, Carbon Tetrachloride (CCl4)*

Introduction

The globalization wave across various sectors has significantly influenced people's behavior and lifestyle, including their family eating habits [1]. Liver diseases such as cirrhosis, fatty liver, and hepatitis pose serious health challenges, and their treatments often come with complications [2]. Commonly used medications like interferon, ribavirin, penicillamine, and corticosteroids tend to produce more adverse effects than benefits. However, this combination therapy can lead to severe side effects, including hemolytic anemia and teratogenic risks. Given these concerns, hepatitis patients require a truly effective treatment that minimizes side effects and toxicity, especially considering the necessity of long-term therapy [3].

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The liver plays a crucial role in sustaining human life due to its function as the body's metabolic center and its ability to detoxify various harmful substances [4]. In Indonesia, liver disease ranks among the most prevalent health issues, often resulting from the use of hepatotoxic drugs. Drug-Induced Hepatitis (DIH) is a liver disorder caused by medication consumption. According to the Indonesian Liver Research Association (PPHI) in 2013, approximately 20-40% of fulminant liver disease cases are drug-induced, with around 50% occurring in hepatitis patients [5]. As part of its mission to become a leading institution in education and research, the State University of Medan (UNIMED) aims to address public health concerns and contribute to the development of the herbal industry. The UNIMED Institute for Research and Community Service (LPPM) has formulated a strategic plan focused on fundamental and applied research, including botanical and biological processing for pharmaceutical raw materials, herbal medicine development based on vegetation, and the utilization of metabolites for drug and vaccine production. To mitigate the impact of liver disease, exploring alternative treatments beyond conventional medicine is essential. Various plants have been studied for their hepatoprotective properties, one of which is the fruit of the Mobe plant (*Artocarpus lakoocha* Buch. Ham). This plant has long been used as a cooking spice, particularly by the Batak tribe, and holds potential for further development in liver disease treatment [6].

Artocarpus lacucha Buch. Ham, commonly known as mobe or mobe fruit, is a tropical evergreen species belonging to the Moraceae family [7]. This plant is considered an edible wild species with potential as a small fruit crop and a valuable agent for forest diversification, contributing to sustainable community livelihoods. It plays a role in improving the nutritional intake of indigenous communities and serves as an additional source of income through its various plant-based products [8]. Additionally, mobe provides multiple benefits, including its use as a source of fruit, timber, fodder, firewood, dye, and shade, making it highly valuable both as a food and medicinal plant. Mobe fruit is known for its liver-protective properties. In Thailand, a chocolate-like product called *Puag-Haad* is traditionally used as a remedy for worm infections, particularly tapeworms. Its seeds and bark have been used to treat stomach and liver diseases. While the ripe fruit is sweet and recognized as a liver tonic, the unripe fruit is sour and is associated with appetite loss and blood-related disorders. The roots of *A. lacucha* have demonstrated antibacterial and cytotoxic properties, while its heartwood has shown moderate activity against herpes simplex virus and HIV [9]. The pericarp of the mobe fruit also possesses antibacterial, antioxidant, and insecticidal properties. This fruit contains bioactive compounds such as β-amyrin acetate and lupeol acetate, which have been identified for their anti-hyperglycemic and hypolipidemic effects, making them potential treatments for diabetes and atherosclerosis [9]. Flavonoids, natural organic compounds widely found in plants, play a crucial role in preventing diabetes and its complications. Several studies have shown that flavonoids exhibit hepatoprotective effects in different experimental models, helping combat liver diseases by reducing glucose absorption and improving glucose tolerance. Despite its significant potential as a hepatoprotective agent, research on the mobe plant in Indonesia remains extremely limited, with no existing published studies. Therefore, further investigation is necessary to explore the Hepatoprotective Effects of Mobe Fruit Extract (*Artocarpus lacucha* Buch. Ham) in Rats Induced with Carbon Tetrachloride and Its Impact on Liver Histopathology.

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Method

The experimental animals before being used for research were acclimatized in the animal house of the Chemistry Department, State University of Medan, and fasted for 12 hours without being fed, but given water. The study used a sample of 50 male rats, then the rats were divided into 5 groups, so that the number of samples in each group was 10 rats.

1. Treatment of the KN group

The rats were given 10g of feed every day and their weight was measured every day at 10:00 WIB.

2. Treatment of the KP group

The rats were given 10g of feed every day and were induced with 0.2 ml of Carbon tetrachloride. Their weight was measured every day at 10:00 WIB.

3. Treatment of the KT + PEM 75 mg/Kg group

The rats were induced with 0.2 ml of Carbon tetrachloride and given 75 mg/Kg of Mobe fruit extract every day. Body weight was measured every day at 10:00 WIB.

4. Treatment of KT + PEM 150 mg/Kg group

Rats After fasting, the rats were induced with 0.2 ml of Carbon tetrachloride and given 150 mg/Kg of Mobe fruit extract every day. Body weight was measured every day at 10:00 WIB.

5. Treatment of KT + PEM 300 mg/Kg group

Rats were induced with 0.2 ml of Carbon tetrachloride and given 300 mg/Kg of Mobe fruit extract every day. Body weight was measured every day at 10:00 WIB.

SGOT-SGPT Measurement

Measurement was carried out using the photometric method by mixing serum samples with reagents. Blood serum and SGOT/SGPT reagents were mixed at room temperature (15-30°C). Blood serum was taken as much as 100 µl, then added SGOT/SGPT reagent as much as 1000 µl and incubated at 37°C for 5 minutes. After 5 minutes, the absorbance of the mixture was measured for 3 with a time interval of 1 minute for each measurement with a spectrophotometer at a wavelength of 340 nm [10]

Results And Discussion

Histopathological examination was carried out by sacrificing the test animals at the end of the observation, then the liver organ was taken to be observed microscopically. Making histological preparations using the paraffin block method and staining using Haematoxilin Eosin (HE). Then continued with microscopic examination using a light microscope with a magnification of 400 times in the entire field of view on each preparation.

Table 4.1 Average results of rat liver histopathology scores

Treatment Group	Histopathology Score
Kontrol positif	$111,5 \pm 4,110^{ab}$
Group I	$123,5 \pm 2,112^{abc}$
Group II	$125,6 \pm 2,221^{abc}$
Group III	$126,1 \pm 3,562^{abc}$

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Based on the results of table 4.1 above, it is known that there is a significant difference p <0.05 in each treatment given. Based on the table above, there is a significant difference There is a significant difference in the level of damage to the histopathological structure of the liver between the negative control group and the other groups. This shows that the administration of toxic doses of Carbon Tetrachloride (Ccl4) is enough to cause damage to the liver. Comparison between the normal control group and the treatment group, both treatment I, treatment II, and treatment III, shows a significant difference. This shows that the administration of ethanol extract of mobe fruit for 6 days has not restored liver cells to normal morphology. However, there is a significant difference between all treatment groups and the negative control. This shows that the ethanol extract of mobe fruit is able to provide a hepatoprotective effect. The table above shows the results that there is a significant difference in all treatment groups with normal controls, this shows that the administration of ethanol extract of mobe fruit can provide a hepatoprotective effect but has not been able to repair cells to normal cells. There is a significant difference between the treatment group and the positive control group. This shows that the treatment group showed an improvement effect on hepatocyte cells due to Carbon Tetrachloride (Ccl4) but was not equivalent to the positive control.

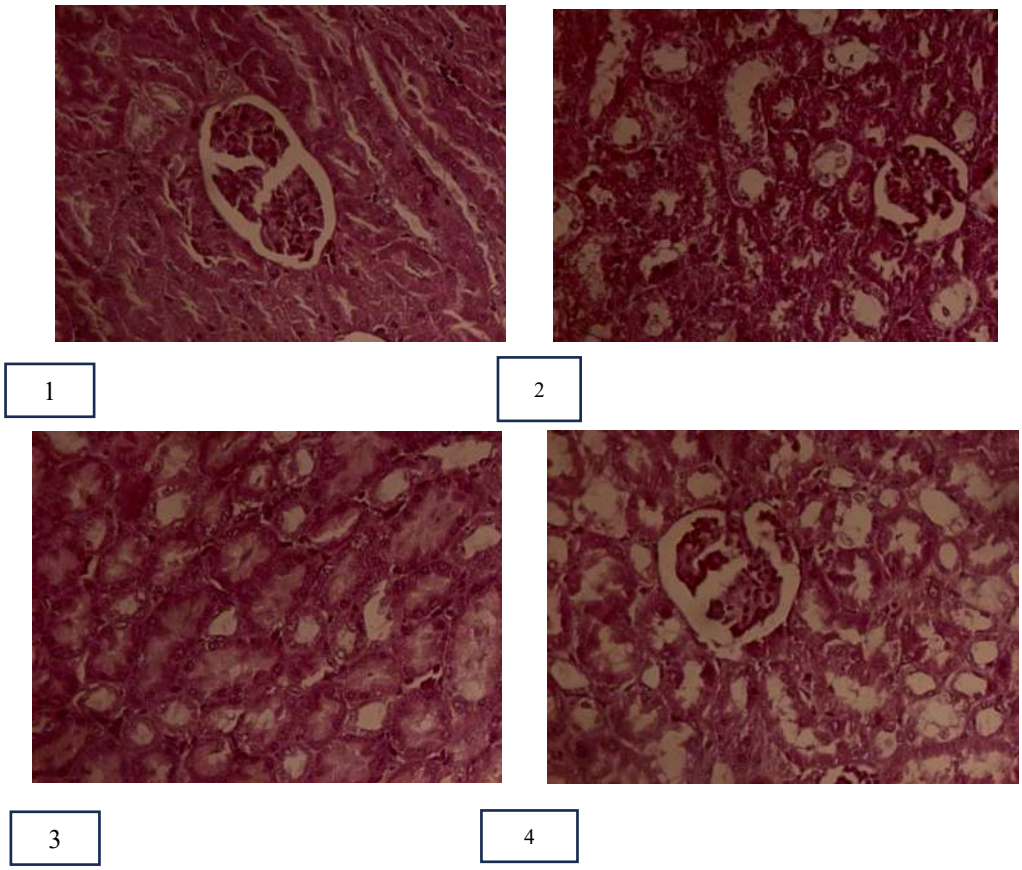

Figure 1 Positive Control, 2. KT + PEM 75 Group 3. KT + PEM 150 Group, 4. KT + PEM 300 Group

According to [11] if the toxic compound that enters is too large so that it is toxic to the liver, it will cause liver tissue degeneration. Then necrosis occurs which can damage liver tissue. One parameter of liver damage is to see the histopathology of the liver. One of the

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histopathology scoring methods used is Manja Roenigk in this method the damage seen is in the form of parenchymatous degeneration, hydropic degeneration and necrosis [12]. The image of cells under a light microscope includes normal cells, parenchymatous degeneration, hydropic degeneration and necrosis.

Conclusion

Giving treatment with mobe fruit extract can reduce the level of damage to liver cells. The level of liver cell damage is higher in the negative control group, this is due to exposure to the toxic substance Carbon Tetrachloride (Ccl4) which can damage hepatocyte cells. Overall, cell damage in the form of parenchymatous degeneration, hydropic degeneration and necrosis that occurs in the liver in all treatment groups, the lowest level of hepatocyte damage was found in the 360 mg/BW treatment group. At a low dose of 90 mg/BW, mobe fruit extract is able to protect cells from liver damage but cannot be used as an effective dose because there is still a lot of liver cell damage

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In vitro testing of serum antiacne jamblang (*syzygium cumini*) essential oil for gymnastic athletes

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Abstract. *Back acne is a scourge for athletes. Acne is a chronic inflammation of pilosebaceous follicles characterized by excessive oil production caused by Propionibacterium acnes bacteria. The flavonoid content in jamblang flower essential oil (Syzygium cumini) can be utilized as an anti-acne treatment. A pharmaceutical preparation that can be used to treat acne skin problems is serum. The purpose of this study was to determine the anti-acne activity of jamblang flower essential oil in inhibiting acne-causing bacteria and formulate a combination of jamblang flower essential oil into a serum preparation to determine antibacterial activity against Propionibacterium acnes. The research method used was experimental to conduct antibacterial activity tests in vitro. The result of the antibacterial activity test on serum showed negative control which is serum base has no inhibition zone, positive control clindamycin phosphate showed an inhibition zone of 13.20 mm, while the inhibition zone of jamblang flower essential oil serum at 30% concentration was 5.7 mm, 40% concentration was 7.38 mm and 50%*

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concentration was 8.11 mm. Statistical analysis was performed by Shapiro-Wilk method, Levene statistic, and One Way Anova ($p<0.05$).

Keywords: Antiacne; serum; Essential oil; Syzygium cumini; Gymnastic Athletes

Introduction

Acne on the back has become a serious problem for athletes in their activities and it could even reduce their performance [1,2]. In the process of healing acne, drugs are needed that can assist the acne recovery process [3,4]. The drugs used can be drugs obtained chemically synthesized and drugs obtained from natural ingredients [5]. Anti-acne chemical synthetic drugs on the market mostly contain antibiotics such as erythromycin and clindamycin [6]. However, antibiotics for acne can give side effects to the skin in the form of irritation, especially when applied on the back of athletes [7]. In addition, it causes resistance in acne-causing bacteria if the drug is used in the long term. In the addition of synthetic compound drugs, the utilization of natural materials in Indonesia intended as drugs has increased. The utilization of natural materials is because natural materials are considered to have smaller side effects compared to drugs derived from chemicals [8,9].

Natural resources that are efficacious as anti-acne drugs include jamblang flowers (*Syzygium cumini*), this plant is one of the medicinal plants that grow in Indonesia. Jamblang (*Syzygium cumini*) is a plant known to have antimicrobial properties and can function as an anti-inflammatory, antiviral, antibacterial, and antioxidant. The content of jamblang (*Syzygium cumini*) flowers include essential oils, phenolic compounds, tannins, saponins, and flavonoids that act as antimicrobials and antioxidants and these compounds can accelerate the wound closure process [10,11,12].

Innovative development of jamblang (*Syzygium cumini*) flower essential oil is required so that it becomes a cosmetic preparation that facilitates its use. So far, there has been no research on formulating jamblang (*Syzygium cumini*) flower essential oil as an inhibitor of *Propionibacterium acnes*. The essential oil of jamblang (*Syzygium cumini*) flower can be innovated in the form of serum preparation because serum is a trendy cosmetic preparation due to its relatively easy way of use, besides that because the skin more easily absorbs products in the form of serum than semi-solid preparations.

Cosmetic preparations in the form of serums can be chosen because of their relatively easy way of use. Serum also has good effectiveness for high concentrations of active ingredients so that the effect obtained is relatively faster because the skin easily absorbs the preparation. Serum also provides a more comfortable effect to spread on the skin surface. With the In vitro research related to antiacne serum preparation of jamblang (*Syzygium cumini*) flower essential oil and its activity test against *Propionibacterium acnes* bacteria, it is expected that jamblang (*Syzygium cumini*) flower essential oil serum is known for its effectiveness against *Propionibacterium acnes* and can be used as an anti-acne serum.

Methods

The research was conducted with an experimental method in the form of antiacne activity test treatment on jamblang flower essential oil serum preparation to determine whether there was an effect on the research subject [2]. The experiment started with in vitro testing of jamblang flower essential oil with concentrations of 30%, 40%, and 50% to determine the optimal concentration that can inhibit bacteria with the largest diameter of inhibition. Serum preparation formulation was

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carried out with the optimal ratio of extract combinations with concentrations of 30%, 40%, and 50%. The tools used in this study include analytical scales, rotary evaporator (Eyela), Laminar Air Flow (Trimas), incubator (Memert), autoclave (Hirayama Hve-50), petri dish, Ose needle, tweezers, Vortex, test tube (pyrex), Erlenmeyer (Iwaki), micropipette, Falcon tube, beaker glass, spreader, measuring cup, bunsen, and caliper.

The materials used in this study include jamblang (*Syzygium cumini*) flowers, 96% ethanol, sterile distilled water, Nutrient Agar (NA), distilled water, DMSO, sterile NaCl, clindamycin, Mc. Farland standard solution, Propionibacterium acnes ATCC 11827, Wagner, Mayer, Dragendrof, H2SO4, FeCl3, HCl, Magnesium, Anhydrous Acetic Acid, Hydrochloric Acid, Chloroform, Sodium acrylates copolymer, DMDM Hydantoin.

Sample Preparation

The materials used were jamblang (*Syzygium cumini*) flowers taken from jamblang (*Syzygium cumini*) trees around the campus of Universitas Negeri Medan, North Sumatra Indonesia. Examination of jamblang (*Syzygium cumini*) flowers was carried out before the study to ensure the correctness of the samples to be used [2,12].

Distillation of Essential Oil

The material used in this experiment was air-dried jamblang (*Syzygium cumini*) flowers. Steam distillation was carried out with 0.5 kg of dried jamblang (*Syzygium cumini*) flowers. Steam distillation is done by steam-water distillation. For steam-water distillation, the material is placed in a rack as the essential oil of jamblang (*Syzygium cumini*) flower is obtained based on the results of experiments conducted with one rack, then enough water is added so that all materials are submerged. The essential oil separation process is carried out by water-steam distillation at a distillation rate of 2L/hour [2,12].

Serum Formulation

Serum formulations were made with an experimental research design using jamblang (*Syzygium cumini*) flower essential oil [13,14]. The serum formulation is shown in Table 1. Dissolve Sodium acrylates copolymer, DMDM Hydantoin with distilled water. Then add the active substance in the form of jamblang (*Syzygium cumini*) flower essential oil. Then homogenize to form jamblang flower essential oil serum. For a positive control serum base, Clindamycin phosphate is added and then homogenized [14].

Table 1. Serum Formula Jamblang (*Syzigium cumini*) flower essential oil

Material	Concentration % (by weight/volume)					Function
	C (-)	C (+)	T1	T2	T3	
Jamblang Flower Essential Oil	-	-	30	40	50	Active compound
Clindamycin phosphate	-	1	-	-	-	Antibacterial
Sodium acrylates copolymer	4	4	4	4	4	Thickener
DMDM Hydantoin	0.2	0.2	0.2	0.2	0.2	Preservative
Aquadest	100	100	100	100	100	Solvent

*Description: C(+) : Positive control with Clindamycin phosphate, C(-): Negative control with serum base T1,2,3 : treatment 1,2,3

Antibacterial Activity Testing

Testing the antibacterial activity of jamblang (*Syzygium cumini*) flower essential oil and jamblang (*Syzygium cumini*) flower essential oil serum preparations was carried out using the disc

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well method, by measuring the diameter of the growth inhibition of *P. acnes* bacteria. The test begins with the preparation of media that has been inoculated with bacteria as much as 100 µl with 1500×106CFU/mL then dripped with test solution using a micropipette as much as 50 µl and incubated for 24 hours at 37˚C in an incubator, after which the diameter of the clear zone around the well hole is measured using a caliper [2,15,16].

Serum Evaluation Test

Organoleptically serum evaluation test includes color, odor, and taste on the skin by visually observing the appearance, then continued with a pH test using a pH meter and a spreadability test using a glass plate [17,18,19].

Data Analysis

The research results were analyzed using statistical tests like the One-Way ANOVA test. Before the One-Way ANOVA test is conducted, the data must meet the requirements of normal distribution and homogeneous variance [19,20].

Results and Discussions

Sample Preparation

Based on the determination of jamblang (*Syzygium cumini*) plants conducted at Herbarium Bogoriense, Directorate of Scientific Collection Management BRIN - Cibinong, Bogor the plants used in this study are Acehnese jamblang plants with Myrtaceae tribe.

Essential Oil Preparation

The jamblang (*Syzygium cumini*) flowers obtained from the field were sorted to separate the flowers with impurities and dried in the sun until the dried jamblang (*Syzygium cumini*) flowers were 0.5 kg. The distillation process obtained the yield of jamblang (*Syzygium cumini*) flower essential oil and showed results that followed herbal pharmacopeia standards. The yield of jamblang flower essential oil is 9.2% > 5.6%. The yield value is related to the amount of bioactive content contained [15,16]. The higher the yield, the higher the content of substances contained in a raw material [13,14].

Antibacterial Activity Testing of Jamblang (*Syzigium cumini*) Flower Essential Oil

The activity test of jamblang (*Syzygium cumini*) flower essential oil was conducted to determine the ability of essential oil to inhibit *P. acnes* bacteria with a concentration of 30%, 40%, and 50% dissolved with 100% DMSO.

Table 2. Serum formula of jamblang (*Syzygium cumini*) flower essential oil.

Concentration (%)	Replications (mm)			Mean	Standard Deviation
	I	II	III		
30	2.91	2.33	3.04	2.76	0.37
40	5.74	5.34	5.71	5.6	0.22
50	10.25	10.65	10.77	10.56	0.27
Control (+)	9.58	9.32	9.49	9.46	0.13

Statistical analysis was conducted to determine the ability of jamblang (*Syzygium cumini*) flower essential oil to inhibit *P. acnes* bacteria, the inhibition zone formed was tested for normality

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using the Saphiro-Wilk method followed by a homogeneity test using the Levene test and obtained a sig. >0.05 so it can be concluded that the data is normally distributed and homogeneous. ANOVA testing was used for hypothesis testing with results <0.05 so it can be concluded that jamblang flower essential oil can inhibit *P. acnes* bacteria. The test was continued with Duncan's test and the result showed that a 50% concentration of jamblang (*Syzygium cumini*) flower oil had a significantly better inhibition zone compared to 30% and 40% concentrations against *P. acnes* bacteria.

Serum Evaluation Test

The results of the organoleptic examination of the serum preparation showed a greenish-orange color with a distinctive aroma and texture that tends to be slightly thick. The change in color of the preparation to greenish orange is due to the addition of jamblang (*Syzygium cumini*) flower essential oil to the serum base. Then the texture tends to be rather thick due to ingredients acting as thickeners and binders, namely Sodium Acrylates Copolymer with a concentration of 4%. At the same time, the resulting aroma is typical of the extract [4,5].

The results of the pH examination of the jamblang (*Syzygium cumini*) flower essential oil serum preparation showed a dosage pH value of 5.5 where the pH in the serum formulation was 4.5 - 6.5.

Table 3. Serum Spreadability Test Results.

Load spreadability test	Results
Control	7.42 cm
50 grams	7.77 cm
100 grams	7.94 cm
150 grams	8.14 cm
200 grams	8.26 cm

The activity test of jamblang (*Syzygium cumini*) flower essential oil was conducted to determine the ability of jamblang (*Syzygium cumini*) flower essential oil to inhibit *P. acnes* bacteria with concentrations of 30%, 40%, and 50% dissolved in 100% DMSO [18,19]. The positive control tested was Clindamycin phosphate 1% dissolved with DMSO 100%. Based on the results obtained, the optimal concentration of jamblang (*Syzygium cumini*) flower essential oil is 50% concentration with the best inhibition ability to inhibit *P. acnes* bacteria.

Serum activity testing of jamblang (*Syzygium cumini*) flower essential oil serum was conducted to determine the ability of the preparation to inhibit *P. acnes* bacteria with variations of preparation concentrations of 30%, 40%, and 50%, then added to the serum base that had been made before [8,17]. In the test, Clindamycin phosphate 1% was used which was homogenized with the serum base to form a positive control, and the negative base used was a serum base without active substance. The results of the inhibition zone diameter of the jamblang (*Syzygium cumini*) flower essential oil serum preparation can be seen in Table 3, which shows that the 50% concentration is the concentration with the largest inhibition zone result of 8.11 mm and forms the optimal inhibition zone to inhibit *P. acnes* bacteria. In serum preparations, the results were greater than the essential oil test. This can be influenced because extracts and clindamycin phosphate tend to be more stable at acidic pH, namely serum has a pH of 5.5 compared to DMSO solvent which has an alkaline pH [11,12].

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Conclusions

A serum formulation of jamblang (*Syzygium cumini*) flower essential oil has an activity to inhibit acne-causing bacteria *Propionibacterium acnes*. Serum of jamblang (*Syzygium cumini*) flower essential oil has the activity of inhibiting acne-causing bacteria *Propionibacterium acnes* with the best effect at 50% concentration forming an inhibition zone diameter of 8.11 mm in the category of moderate bacterial growth inhibition response.

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Combination of hanjeli (*coix lacryma-jobi*) and coffee (*coffea sp.*) essential oils for relaxation of back muscle fatigue because of osteoporosis

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Abstract. *Low back muscle fatigue is one of the musculoskeletal disorders due to osteoporosis which causes pain often suffered by the elderly and former athletes. One non-pharmacological pain management can be done with a back massage with a combination of hanjeli (Coix lacryma-jobi) and*

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coffee (Coffea sp.) essential oil. Back massage is a technique of massage action on the back with slow strokes. This study aimed to determine the effect of back massage with a combination of hanjeli and coffee essential oils on low back pain in elderly former athletes at the Marelan Medan Elderly Social Center. This type of research is pre-experimental with a one-group pretest-posttest design. The number of samples was 17 people selected based on the purposive sampling technique. Data analysis using univariate and bivariate analysis. Based on paired t-test analysis, it shows that doing back massage can reduce the scale of low back pain in the elderly with a value of ρ = 0.000 (<0.05). It can be concluded that there is an effect of giving back massage with a combination of hanjeli and coffee essential oil on the scale of low back pain in the elderly at the Marelan Elderly Social Center. Based on the results of this study, back massage with a combination of hanjeli and coffee essential oil is an alternative nursing intervention to reduce low back pain.

Keywords: *Coix lacryma-jobi; Coffea sp*; Essential Oil; Osteoporosis

Introduction

Aging and osteoporosis caused by the aging process is a mechanism of anatomical, physiological, and biochemical changes that occur in humans with age [1,2]. In the elderly (elderly), all these processes will result in decreased body functions and abilities, thus affecting a series of individual activities [3,4]. The number of elderly people in Southeast Asia is reported as much as 8% of the total population or around 142 million people. In 2050, it is estimated that the elderly population will increase 3 times [5]. In Indonesia, it is estimated that by 2020 the number of elderly people will reach around 80 million people [5,6].

Some of the health problems experienced by the elderly due to decreased body function can be in problems in the musculoskeletal system. It is estimated that 10-15% of muscle strength can be lost each week if the muscles are fully rested, and about 5.5% of muscle can be lost day-to-day under conditions of complete rest and immobility [7,8]. One of the daily physical problems that are often found in the elderly is low back pain [9].

The prevalence of musculoskeletal pain, including low back pain, has been described as an epidemic [10,11]. About 80 percent of the population suffers from low back pain, at least once in their life [12]. Based on the data obtained in the world, it is found that the severity percentage of low back pain in men and women is in the severe category (48.32% and 53.64%), paralysis category (3.35% and 8.68%), and minimal category. (2.68% and 2.64%) respectively [13]. At the age of 40-45, it showed that women have a higher percentage than men with pain when walking, sitting, sleeping, social life, and activities [13,14].

Thus, the older you are, the greater you are at risk for low back pain. Elderly people experience a decrease in body functions, especially the bones so that they are no longer as elastic as when they were young [15]. Data for the number of low back pain sufferers in Indonesia are not certainly known, but it is estimated that low back pain sufferers in Indonesia vary between 7.6% to 37% of the total population in Indonesia [16]. A preliminary study conducted at the Marelan Elderly Social Center, Medan City in 2018 reported that of 80 elderly people at the Marelan Elderly Social Center, 30 people experienced low back pain.

Pain management can be assisted with non-pharmacological therapy. There are several non-pharmacological techniques such as providing a back massage with essential oil aromatherapy [17]. Rubbing with essential oils provides a warm sensation by enabling local blood vessels to dilate. The elderly who were given back massage therapy experienced a decrease in pain from moderate to mild intensity [18]. Hanjeli (*Coix lacryma-jobi*) and coffee oils are aromatherapy that can help improve body circulation. The substance contained in hanjeli is linalool is useful for

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stabilizing the nervous system so that it can cause a calming effect for anyone who inhales it [19]. Based on the description above, researchers are interested in conducting further research on the effects of back massage combined with the use of hanjeli and coffee oils aromatherapy in the elderly with low back pain problems. This study aims to analyze the effect of back massage with a combination of hanjeli essential oil and coffee on low back pain in the elderly at the Marelan Elderly Social Center.

Methods

This study used a pre-experimental research design with a one-group pretest-posttest approach [19,20]. The population in this study were all the elderly who experienced low back pain at the Marelan Elderly Social Center as many as 30 people. The sample in this study was determined by using a sample using the Frederer formula with a purposive sampling technique. The number of samples is 17 people. The inclusion criteria of research subjects were elderly aged 59-66; female gender; elderly who are willing to do back massage; compliments awareness, good communication, and moderate pain level, and she did not use painkillers during the study. Meanwhile, the inclusion criteria in this study were the elderly who have allergies when given oil rubs and cannot communicate well.

The research was carried out for 4 weeks, at the Marelan Elderly Social Center, Medan City. Data Collection was done using a questionnaire of respondents' characteristics and pain measurement observation sheets. Pain was measured using a visual analog scale. Pain measurements were carried out before and after being given back massage therapy with hanjeli essential oil. Data Analysis used in this study was a paired t-test. The intervention was carried out by giving a back massage with a combination of hanjeli essential oil and coffee which was carried out 2 times a week in the morning for 4 weeks.

Results and Discussions

Characteristics of Respondent

Table 1. Characteristics of Respondent at Marelan Social Center In Medan City (n=17)

Characteristics		**f**	**%**
Age			
	60-74	17	100
	75-90	0	0
Gender			
	Men	0	0
	Women	0	0
Job			
	Housekeeper	6	35.5
	Self-employed	5	29.4
	Not Working	4	23.5
	Farmer	2	11.8
Pain Duration			
	1-2 year	12	70.6
	< 1 year	5	29.4

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The results of the analysis of the frequency distribution of the respondent's characteristic data can be seen that the age of respondents with low back pain is mostly at the age of 60-74 with 17 respondents (100%). The most common type of work is ART with 6 respondents (35.3%). The longest period of suffering from low back pain was 1-2 years, with 12 respondents (70.6%).

Table 2. The Effect of Back Massage with Hanjeli Essential Oil at Marelan Social Center in Medan City Year 2024 (n=17)

Variable	f	%	Mean	SD	p-value
Pre-Test					
No Pain	4	23.5		4	
Mild Pain	13	76.5	4.47	13	
Moderate Pain	0	0		0	
Severe Pain	0	0		0	
Very Severe	0	0		0	
Post-Test					0.000
No Pain	13	23.5			
Mild Pain	4	76.5			
Moderate Pain	0	0	0.47	0.87	
Severe Pain	0	0			
Very Severe	0	0			

Based on table 2 above, the result obtained was that those who were in a moderate pain scale of 13 respondents (76.5%) and a mild pain scale of 4 respondents (23.5%) with an average pain scale before back massage with a combination of hanjeli essential oil, and coffee was 4.47. After doing back massage, 13 respondents (76.5%) had no pain and 4 respondents (23.5%) had a mild pain scale with an average pain scale after back massage with a combination of hanjeli essential oil and coffee. 0.47. The difference in the average pain scale before and after the back massage intervention with a combination of hanjeli essential oil and coffee was 4.47, decreasing to 0.47 with a dif mean of 4, with a statistically significant p value = 0.000 (<0.05). The statistical results indicate that there is an effect of back massage with a combination of hanjeli essential oil and coffee on lower back pain in the elderly.

Respondents based on the age of the elderly at the Marelan Elderly Social Center, it was found that the respondents who were over 50 years old with a maximum age of 60-74 years were 17 in number (100%). Age is a factor that aggravates the occurrence of low back pain, so it is usually suffered by elderly people due to a decrease in body functions, especially the bones so that they are no longer as elastic as when they were young. This is in accordance with the research who said that the risk of low back pain increases in the elderly who are getting older [8]. With increasing age, there will be a process of fibrosis and classification of the spine sequentially and close to each other, thus facilitating the onset of pain in the spinal area.

At the age of >54 years due to the presence of intervertebral discs, damage, scar tissue, reduced body part reduction, body disorders, especially in the back. This happens because of middle age, muscle strength and endurance begin to decline so that the risk of muscle complaints increases [9,10].

The distribution of respondents found that the majority of lower back pain patients in the elderly at the Marelan Elderly Social Center were in one gender – female (100%) [19,20]. In

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accordance with the results stated that women have a greater risk of suffering from lower back pain than men [11]. Thus, it shows that women suffer more pain response because they have menstruation and the menopausal process which causes a decrease in bone density due to a decrease in estrogen hormones.

The research states that women are 2 times larger than men because women are influenced by obesity.The prevalence of lower back pain in women is 60.98% and in men 39.02% [17]. The research stated that low back pain is more common in women compared to men because it is influenced by obesity and osteoporosis [15].

Distribution of respondents based on the length of time suffering from low back pain in the elderly at the Marelan Elderly Social Center, it was found that 12 respondents (70.6) had suffered from low back pain for 1-2 years and 5 respondents (29.4) had suffered from lower back pain for less than 1 year. The found that the sufferers of back pain that continued for 12 weeks were more difficult to recover [15,16,17]. This is because the longer the respondent experiences pain can change the patient's thinking and behavior towards pain. The patient's thoughts about pain can cause the patient to feel more sensitive to pain, feel pain and be afraid to move.

The Effect of Back Massage with Hanjeli Essential Oil on Lower Back Pain in the Elderly

Results showed that the pain scale before doing back massage with a combination of hanjeli essential oil and coffee obtained a moderate pain scale of 13 respondents (76.5%) and a mild pain scale of 4 respondents (23.5%) with an average of 4.47. Meanwhile, the pain scale after back massage with a combination of hanjeli essential oil and coffee was found to be painless by 13 respondents (76.5%) and a mild pain scale of 4 respondents (23.5%) with an average of 0.47. The results of hypothesis testing obtained p value = 0.000 (<0.05).

Based on the results above, there are differences in pain perception even though the stimulus is the same. Pain management can be overcome by non-pharmacological therapy using back massage. The most common causes that can cause lower back pain are back muscle stiffness and spasm due to poor body activity and tense posture [12,13].

The research where the level of pain before being given back massage with moderate pain category consists of 22 people with 5 people suffering mild pain [8,9]. Those with level of lower back pain after being given back messages with the category of mild pain consist of 23 people, with no pain as many as 5 people and moderate pain as many as 2 people. The research above shows that back massage is effective for reducing lower back pain levels. In line with the research found that the average pain before being given therapy was 4.83, and the pain most experienced by respondents was in a scale of 5 [9,10]. Meanwhile, after being given therapy, it was found that the average pain after being treated was giving therapy is 2.67, and the pain that is most experienced by respondents is in scale of 2, indicating that there is a significant difference between pain before and after being given slow stroke back massage therapy with essential oils.

The results of observations conducted, it is known that the decrease in pain scale is caused by back massage with a combination of hanjeli essential oil and coffee, where respondents regularly do back massage with a combination of hanjeli essential oil and coffee. This is done 2 times a week in the morning for 4 weeks with a duration of 10 minutes. Based on the explanation above, it can be concluded that compliance with back massage with a combination of hanjeli essential oil and coffee can reduce the lower back pain scale. They assume that doing back massage routinely can reduce the lower back pain scale because previously the lower back pain scale was still high. Back massage is a skin stimulation performed to relieve pain, and it works by encouraging the release of endorphins, which blocks the transmission of painful stimuli [15].

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Conclusions

Based on the results of research and data collection that has been carried out, this study concludes that there is an effect of back massage with a combination of hanjeli essential oil and coffee on low back pain in the elderly. The results of this study provide opportunities for the development of nursing science to develop nursing interventions according to evidence-based practice. The findings in this study can be used as basic nursing scientific data, specifically about complementary interventions in reducing pain on the elderly with low back pain.

This study only involved female respondents due to the minimal number of male respondents experiencing low back pain at the study site. Further research is needed by involving male respondents in a wider population.

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Hematological profile of white rats (*Rattus norvegicus*) in the toxicity test of andulpak leaf ethanol extract (*Homalanthus populneus*)

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Abstract. *Blood is an important component because blood functions as a distributor of substances in the body. Physiological conditions can be characterized by looking at the good blood profile. Hematological profiles can provide a healthy body. The use of plants as traditional medicine continues to be developed because they contain secondary metabolites, but toxicity testing of a plant is needed. This study aims to determine the activity of ethanol extract of Andulpak leaves (Homalanthus populneus) on the hematological profile of erythrocytes, leukocytes, and platelets of white rats (Rattus norvegicus). Samples were extracted by maceration method using pro analysis ethanol solvent. The test was divided into 5 groups, namely the control group cmc 0.5%, treatment group 100 mg, 200 mg, 400 mg, 800 mg. Data analysis was carried out by normality and homogeneity tests. The results of the toxicity test showed that the extract of andulpak leaves (Homalanthus populneus) did not have a toxic effect on the hematological profile of white rats (Rattus norvegicus) which showed that the number of erythrocytes, leukocytes, and platelets was still normal.*

Keywords: Andulpak , Hematological Profile

Introduction

Blood is an important component in diagnosing the health status of living things, whether injured, infected or physiological conditions, because blood functions as a distributor of substances that enter the body or are produced by the body from the metabolic process [1] Good physiological

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conditions are characterized by a good blood profile within the normal range. Hematological profiles can provide information about the presence of a disease and its severity by showing the physiological conditions of the body related to health [2]

Hematology profile is a picture of blood condition after conducting a blood test. Hematology profile plays an important role in helping diagnose various diseases. Blood is an important component in seeing the health condition of living things. Blood consists of plasma and blood cells [3]. Blood plasma is a liquid part that plays a role in regulating the acid-base balance of the blood to avoid tissue damage. Blood cells include erythrocytes, leukocytes, and platelets. Red blood cells (erythrocytes) contain hemoglobin and play a role in circulating oxygen. Blood platelets (thrombocytes) are responsible for the blood clotting process. White blood cells (leukocytes) play an important role in the immune system and are tasked with destroying dangerous foreign objects that enter the body. Hematology profile examination consists of several parameters, namely erythrocyte profile (hemoglobin level, hematocrit percentage, number of erythrocytes), leukocyte profile, and number of platelets [4].

A plant can be used as a basic ingredient of medicine because each plant has secondary metabolites that can be utilized. But the long-term use of a drug must be known its effects. Subchronic toxicity testing of raw materials for medicine can be done to determine the effects of long-term use, so that it can later be applied to humans [5].

Indonesia is a tropical country that has very large biodiversity. Much of this biodiversity can be used as raw materials for medicines. Indonesia has more than 9,609 plant species that can be used as medicine [6]. The use of medicines with plant-based ingredients is much more in demand by the public because it is more economical, has low side effects, and is environmentally friendly to use compared to the use of synthetic drugs. The use of a plant as a base ingredient for medicine will also increase the utility value of the plants used. Plants can be used as base ingredients for medicine because each plant has secondary metabolites that can be utilized. One of the plants that has the potential to be used is andulpak (*Homalanthus populneus* (Geiseler) Pax) [7].

Plants can be used as basic ingredients for medicine because each plant has secondary metabolites that can be utilized. One of the plants that has the potential to be used is andulpak. Andulpak is widely found in North Sumatra but still has a low utility value for the plant. To find out more about the benefits of andulpak plants, research is needed that leads to this.

Research Methods

Research tools and materials

The tools used are graters, cutting boards, beakers, filter petri dishes, test tubes, test tube racks, stirrers, droppers, drop plates, cuvettes, Precisa analytical scales XB 120A series, measuring flasks, Pyrex reflux, measuring pipettes, pro pipettes, droppers, Thermolyne Maxi Mix II vortex, IKA HB 10 Basic series water bath, refrigerator, Marienfeld hematocrit capillary, ice flask, ice gel, microtube, ONE MED® 1 mL syringe, Sysmex KX-21 Hematology Analyzer, standard cage, cage cover, drinking bottle, shovel, OHAUS® scale, Omron digital thermometer, 26G needle.
The main test material used in this study was andulpak leaves (*Homalanthus populneus* (Geiseler) Pax). The test animals used were white rats (*Rattus norvegicus*) male and female Wistar strain aged 2 months, pellet feed and corn.

Types of research

This type of research is experimental research using the Completely Randomized Design (CRD) method.

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Place and time of research

This research will be conducted at Medan State University. It will be conducted from February to September 2024. The sample of this research is a 2-month-old male Wistar strain white rat (*Rattus norvegicus*).

Extract preparation

Extraction was carried out by maceration method with pro analyst (pa) ethanol solvent. A total of 1000 grams of simplicia powder was soaked with the solvent of 1:3. The container was closed and coated with aluminum foil and left for 5 day with occasional stirring. After 5 days, the soaked sample was filtered using filter paper no. 1 and produced filtrate 1 and residue 1. The residu was then added with pro analyst (pa) ethanol solution and soaked for 3 days with occasional stirring and filtered using filter paper and produced filtrate 2 and residue 2. Filtrate 1 and 2 were mixed together, then evaporated using a rotary evaporator.

Treatment of test animals

White rats (*Rattus norvegicus*) after being acclimatized for 2 weeks were then given treatment by administering 0.5% cmc in the control group as much as 1.5 ml in each test animal. Treatment in the concentration group of 100 mg, 200 mg, 400 mg, 800 mg was given as much as 1.5 ml in each test animal using a sonde. Treatment was given every day for 28 days at 09:00 WIB.

Data analysis

The data obtained from the hematological profile measurements of erythrocytes, leukocytes, and platelets were analyzed by conducting normality and homogeneity test.

Results And Discussion

Phytochemical Screening of Andulpak Leaves

Phytochemical screening was carried out using an indicator solution using appropriate reagents in the identification of secondary metabolite compounds. The results of phytochemical screening of ethanol extract of Andulpak leaves (*Homalanthus populneus* (Geiseler) Pax) can be seen in Table 1.1 below.

Table 1.1.Phytochemical Screening of Ethanol Extract of Andulpak Leaves

Secondary Metabolites	Reagent	Andulpak Old Leaf Extract	Andulpak Young Leaf Extract
Alkaloid	Mayer	+	+
	Dragendorff	-	+
Flavonoid	Mg + HCl	+	+
Saponins	Water + HCl 2N	-	-
Steroid	Lieberman-Bouchard	+	+
Phenol	FeCl3	+	+
Glycosides	Molisch + H2SO4	+	+

Information :

\+ : There are secondary metabolite compounds

\- : There are no secondary metabolite compounds

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Based on Table 1.1, it can be seen that old and young leaves of Andulpak positively contain secondary metabolite compounds of alkaloids, flavonoids, saponins, steroids, tannins and glycosides. Phytochemical screening was carried out qualitatively based on the solubility properties of the compounds so that compounds that have the potential to be antibacterial can be identified. Based on the results of the analysis of phytochemical compounds in old and young leaves of Andulpak, alkaloids, flavonoids, saponins, steroids, tannins and glycosides were obtained.

Extraction of andulpak leaves (Homalanthus populneus)

Andulpak leaves (Homalanthus polpulneus) were extracted with Pro Analisys solvent which produced a thick extract with the characteristics of a black extract that produces a strong odor. The content of secondary metabolites found in andulpak leaves are flavonoids, terpenoids, steroids, saponins, and tannins. The weight of the thick extract obtained and the yield value of andulpak leaves (Homalanthus polpulneus) can be seen in table 1.2 below.

Table 1.2Yield of andulpak leaf extraction (Homalanthus polpulneus)

Andulpak leaves	Powder weight (g)	Filtrate weight (ml)	Weight of thick extract (g)	Yield (%)
Andulpak leaves	1000 gr	3800 ml	60.7 g	6.07%

Based on Table 1.2, it can be seen that old leaves with 1000 g of simple powder can produce a thick extract of andulpak leaves (*Homalanthus populneus*) weighing 60.7 g with a yield value of 6.07%.

The effect of ethanol extract of andulpak leaves (*Homalanthus populneus*) on the hematological profile of erythrocytes, leukocytes, and platelets

Subchronic toxicity test of andulpak leaf extract (*Homalanthus populneus*) conducted on white rats (Rattus norvegicus) with different doses, namely 100 mg, 200 mg, 400 mg, 800 mg for 28 days produced a hematological profile of the number of erythrocytes, leukocytes, and platelets as seen in table 1.3 below.

Table 1.3 The average value of hematological profile measurements after administration of ethanol extract of andulpak leaves (*Homalanthus populneus*) for 28 days

Treatment	Erythrocytes	Leukocytes	Platelets
CMC Control 0.5%	7.83	10.74	986
K1 100 mg	8.21	13.46	999
K2 200 mg	8.22	14.71	1039
K3 400 mg	8.37	14.53	1000
K4 800 mg	8.30	14.15	954

Based on Table 1.3 above, the average value for the number of red blood cells (erythrocytes) in the control treatment group cmc 0.5%, k1 to k4 shows a range of values that are not much different, where the average value of the number of erythrocytes in each group is in the range of 7.83 to 8.37 x 106 / µL, the number of average values is still in the normal category. According to Lateo, et al

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(2022) stated that the number of normal erythrocytes in white mice ranges from 7.30-9.68 x 106 cells/µL. Erythrocytes function as hemoglobin carriers which then carry oxygen from the lungs to the tissues, nutrients prepared by the digestive tract, metabolic waste that is secreted into the kidneys, and smooth blood circulation.

The average level of leukocytes in white mice after administration of ethanol extract of andulpak leaves (*Homalanthus populneus*) produced a normal number of leukocytes between the control treatment group of 0.5% cmc and the k1-k4 treatments, namely in the range of 10.74-14.71 x 103/µL. According to Wolfenshon & Lloyd (2013), the number of leukocytes in normal white mice is at a value of 6-7 x103/µL. Andulpak leaves (*Homalanthus populneus*) do not contain toxins that can change the physiological processes of mice and can be consumed, so they do not encourage the body of white mice to increase leukocyte production as a form of body defense.

Function as hemoglobin carriers which then carry oxygen from the lungs to the tissues, nutrients prepared by the digestive tract, metabolic waste that is secreted into the kidneys, and smooth blood circulation.

The homogeneity of the statistical analysis data of the hematology profile measurements of erythrocytes, leukocytes, and platelets of white rats (*Rattus norvegicus*) showed a sig value (P value) Based on mean> 0.05 which means that the data variance is homogeneous. The results of the statistical analysis of the anova test showed that the number of erythrocytes, leukocytes, and platelets in white rats (*Rattus norvegicus*) that had been given andulpak leaf extract (Homalanthus polpulneus) showed a sig value (P value)> 0.05 which concluded that there was no significant difference.

The hematology value in the 0.5% cmc control group was not significantly different when compared to the treatment group, both in the k1 treatment group (100 mg) and in the k4 treatment group (800 mg). This indicates that andulpak leaves (*Homalanthus populneus*) can be consumed because the hematology value in white rats (*Rattus norvegicus*) in the 0.5% cmc control group and treatment (k1-k4) is within the normal range.

CONCLUSION

Based on the research, the ethanol extract of andulpak leaves (*Homalanthus populneus*) contains secondary metabolites from the Alkaloid, Flavonoid, Terpenoid, Steroid, Saponin, Tannin, and Phenol groups. Phytochemical screening was carried out qualitatively based on the solubility properties of the compounds so that compounds that have the potential to be antibacterial can be identified. Based on the results of the analysis of phytochemical compounds in old and young leaves of Andulpak, alkaloid, flavonoid, saponin, steroid, tannin, and glycoside compounds were obtained. In the toxicity test of the sub chronic hematological profile of andulpak leaves (*Homalanthus populneus*) in white rats (*Rattus norvegicus*) Wistar strain which had been carried out for 28 days, it can be concluded that the administration of andulpak leaf extract (Homalanthus polpulneus) does not contain toxins that can change the physiological processes of rats and can be consumed, so it does not encourage the body of white rats to increase the production of leukocytes as a form of defense (does not have toxic properties) and does not affect the profile of erythrocytes, leukocytes, and platelets.

SUGGESTION

Further research is needed, such as long-term toxicity testing, to determine the long-term effects of using andulpak leaves (*Homalanthus populneus*) so that they can be realized as medicinal products in the health sector.

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In Vitro Propagation of Andaliman (*Zanthoxylum acanthopodium* DC.) Using The Growth Regulators Auxin and Cytokinin

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Abstract. *Zanthoxylum that grows in Indonesia is known as Andaliman (Zantoxylum acanthopodium DC) which has been known for its benefits and uses. Research design is sterilization of seed explants using formulation 1) bayclin 50% for 10 minutes, 70% alcohol for 5 minutes, betadine 50% for 5 minutes; formulation 2) bayclin 50% for 30 minutes, 70% alcohol for 5 minutes, betadine 50% for 5 minutes. Sterilization of shoot, node and leaf explants using formulation 1) bayclin 20% + Tween 80 as much as 2 drops for 20 minutes, bayclin 10% for 10 minutes and bayclin 5% for 5 minutes, formulation 2) bayclin 20% for 20 minutes bayclin 10% for 10 minutes and bayclin 5% for 5 minutes. Finally, each formulation was rinsed 3 times with sterile water. Next, the explants were transferred to MS0 media for 4 weeks, sterile explants were subcultured into the propagation media, namely MS + BAP 2.5 mg + TDZ 0.1 mg + PVP 0.1 g/l and MS media + BAP 2.5 mg + PPM 0.1 g/l. Research result, the best composition of sterilant materials for seed sterilization is: Bayclin 50% for 30 minutes, alcohol 70% for 5 minutes, betadine 50% for 5 minutes. The best composition of sterilant materials for shoot, node and leaf explant sterilization is: bayclin 20%, tween 80 as much as 2 drops for 20 minutes, bayclin 10% for 10 minutes, Bayclin 5% for 5 minutes. The best propagation media is MS + BAP 2.5 mg + TDZ 0,1 mg + PVP 0,1 g/l.*

Keywords: *propagation, andaliman, in vitro, auxin, cytokinin*

Introduction

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Andaliman (*Zanthoxylum acanthopodium* DC) which grows in Indonesia has been known for its benefits and uses. Andaliman is a spice/seasoning plant that is utilized by several communities, especially the Batak community [1]. The Batak community usually uses Andaliman to cook special foods such as saksang, naniura, nanigotaan and naniarsik so that it adds a delicious taste and distinctive aroma to the food, where this spice is only known in Batak cuisine so that many know it as Batak pepper [2].

In addition, Andaliman is also used as a medicinal ingredient because Andaliman fruit contains flavonoids and polyphenols which have antioxidant and antimicrobial activity [3]. The sensation produced by consuming Andaliman feels bitter on the tongue which is caused by the presence of the compound hydroxyalpha sanshool. This plant has a soft citrus-like aroma that increases appetite. Most Andaliman fruits are rich in oils containing large amounts of alkaloids and unsaturated fatty acids that act as antioxidants [4].

Andaliman cultivation has not been intensively carried out because it requires a specific growing location. For seedlings, it is also very difficult, farmers usually take seeds that grow wild around the growing location. Usually, people use wild seeds from the forest or Andaliman plants that grow in fields to be maintained, this is because the sowing of Andaliman carried out by local farmers has not been effective [5]. Wild seeds of Andaliman plants in the forest or in residents' fields are known to come from birds that eat Andaliman and are also known to come from the remains of burning bushes in areas of old Andaliman plants [6]. The seeds produced from mature Andaliman plants are very numerous, but aspects of Andaliman plant cultivation are still difficult and very limited.

The results of observations in 2022 on Andaliman farmers around Lake Toba (Taman Eden 100) concluded that seeds were still difficult to obtain. Farmers are overwhelmed in preparing uniform andaliman seeds that are in accordance with expectations. They only hope for seeds that grow naturally around the growing location. To overcome this problem, researchers have conducted several studies on vegetative propagation of andaliman.

Andaliman vegetative propagation using grafting, stem cuttings, shoot cuttings (Basic Research 2023) and in vitro (Applied Product Research 2024) methods. In vitro propagation is carried out using auxin and cytokinin body regulators. The auxin growth regulators used are 2,4-Dichlorophenoxy acetic acid (2,4-D) and Naphthalene Acetic Acid (NAA), while the cytokinin growth regulator used is 6-Benzyl Amino Purine (BAP). 2,4-D (2,4-Dichlorophenoxy acetid acid) is a plant growth regulator from the auxin group that plays a role in inducing callus. Because 2,4-D has strong properties, it can stimulate callus formation. Lestari [7] stated that 2,4-D is a potent synthetic auxin and is widely used to stimulate callus formation in plant tissue. In several studies, 2,4-D was used to induce embryogenic callus, and the resulting callus was fragile, yellowish-white, and had a fairly high biomass. Meanwhile, BAP (6-Benzyl Amino Purine) plays a role in inducing callus with its role in triggering cell division. BAP has the same basic structure as kinetin, but despite its similarities, BAP is more effective because it has a benzyl group [8].

Plant Growth Regulators (PGRs) commonly used in tissue culture techniques are the auxin and cytokinin groups [7]. The compound 2,4-Dichlorophenoxy Acetic Acid (2,4-D) is an auxin group PGR that can stimulate callus growth. Meanwhile, the cytokinin group PGR that is commonly used is Benzyl Amino Purin (BAP). BAP generally functions to stimulate cell division, organogenesis, induce embryogenesis and increase chloroplast development [8][9] and is free from viruses. A balanced ratio of auxin and cytokinin in explants can produce callus growth [10].

The PGRs most often used in in vitro propagation are auxin and cytokinin. Commonly used auxins are IAA (Indole Acetic Acid), IBA (Indole Butyrate Acid), NAA (Naphthalene Acetic Acid) and 2,4-D (2,4-dichlorophenoxyacetic Acid) while cytokinins that are often used are Kinetin (Furfuryl Amino Purine), BAP/BA (Benzyl Amino Purine /

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Benzyl Adenine), 2i-P (2-Isopentenyl Adenine) [11]. Cytokinins play an important role in stimulating cell division, and auxins are widely used in tissue culture to stimulate callus growth, cell suspensions, and organogenesis [12].

Auxins (IAA, NAA, 2,4-D, or IBA) are needed by most plant cells for root division and initiation. At high concentrations, auxins can suppress morphogenesis. Auxin 2,4-D is widely used for callus induction: IAA, IBA, and NAA are used for root induction [13]. The main and most obvious function of auxins is to stimulate cell division. If high cell division activity is maintained for a long time, which usually prevents culture differentiation, then the highly metabolically stable 2,4-D is the appropriate auxin to use and if the aim of the experiment is to initiate a differentiation process that usually requires a short cell division time, then IAA and NAA are more suitable supplements [14].

Most media contain auxins, usually the compounds used are Naphthalene Acetic Acid (NAA) or 2,4- Dichlorophenoxyacetic acid (2,4-D). The natural auxin Indole Acetic Acid (IAA) is also sometimes used as a supplement. These three auxins are characterized by chemical and metabolic resistance to degradation or inactivation. IAA is characterized by its high instability. IAA is rapidly lost from the metabolic system, mainly through photooxidation and also through metabolic degradation. NAA has high stability and 2,4-D is the most stable used for callus induction [14].

Cytokinins play two important roles in in vitro proliferation, namely stimulation of cell division and stimulation of shoot and leaf growth [15]. BAP is a widely used cytokinin because it is the most effective in stimulating shoot formation, more stable and resistant to oxidation, and the cheapest among other cytokinins [16].

Materials and Methods

Location and Time of Research

The research was conducted at the Tissue Culture Laboratory of the Technical Management Unit of the Benih Induk Hortikultura (BIH), Gedung Johor, Department of Agriculture, North Sumatra. The research period was from March to November 2024.

Population and Sample

The population is all fruits, shoots, nodes and leaves of Andaliman in Taman Eden 100, Lumban Julu District, Toba Samosir Regency, then samples are taken from selected fruits, shoots, nodes and leaves with good criteria (meaty, red color, the same size and no defects, fresh shoots, nodes and leaves).

Tools and Materials

The tools that will be used are glassware such as culture bottles, petri dishes, beakers, measuring cups, Erlenmeyer flasks, measuring flasks, pipettes, stirring rods, hot plates, magnetic stirrers, pH meters, rulers, analytical scales, microscopes, cameras. The materials used in the study were Andaliman fruit, shoots, nodes and leaves, MS media (macro and micro elements), vitamins, myoinositol, agar (gelrite), amino acids, sugar/sucrose. Sterilization materials such as betadine, bycline, fungicides, alcohol.

Research Design

Sterilization of seed explants using formulation 1) bayclin 50% for 10 minutes, 70% alcohol for 5 minutes, betadine 50% for 5 minutes; formulation 2) bayclin 50% for 20 minutes, 70% alcohol for 5 minutes, betadine 50% for 5 minutes; formulation 3) bayclin 50% for 30 minutes, 70% alcohol for 5 minutes, betadine 50% for 5 minutes. Sterilization of shoot, node and leaf explants using formulation 1) bayclin 20% + Tween 80 as much as

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2 drops for 20 minutes, bayclin 10% for 10 minutes and bayclin 5% for 5 minutes, formulation 2) bayclin 20% for 20 minutes bayclin 10% for 10 minutes and bayclin 5% for 5 minutes. Finally, each formulation was rinsed 3 times with sterile water. Next, the explants were transferred to MS0 media for 4 weeks, sterile explants were subcultured into the propagation media, namely MS + BAP 2.5 mg + TDZ 0.1 mg + PVP 0.1 g/l and MS media + BAP 2.5 mg + PPM 0.1 g/l.

Parameter

The parameters observed were: number (%) of sterile seed explants, number (%) of sterile shoot, node and leaf explants, number of explants that grew and developed, number of shoots per explant.

Data Analysis

Data analysis by calculating the number (%) of sterile explants, the number (%) of growing and developing explants.

Results and Discussion

Sterilization of Seed Explants

The initial step in in vitro propagation of Adaliman plants is to find the right sterilant formulation, in this study there are several sterilant formulations used as shown in Table 1.

Table 1. Sterile formulation for in vitro propagation of Andaliman using MS0 media for 4 weeks.

No.	Formulation	Explant (amount/bottle)	Amount (bottle) Explant		Amount (%) Sterile
			Sterile	Contaminants	
1.	Bayclin 50% for 10 minutes, alcohol 70% for 5 minutes, betadine 50% for 5 minutes	300 (30)	30 (3)	270 (27)	30 (10.00)
2.	Bayclin 50% for 20 minutes, alcohol 70% for 5 minutes, betadine 50% for 5 minutes	300 (30)	130 (13)	170 (17)	130 (43.33)
3.	Bayclin 50% for 30 minutes, alcohol 70% for 5 minutes, betadine 50% for 5 minutes	300 (30)	280 (28)	20 (2)	280 (93.33)

Table 1 shows the amount (%) of sterile andaliman seeds that vary between the three formulations used, the lowest amount (%) was obtained in formulation 1, which was 30 (10%) and the highest amount (%) was obtained in formulation 3, which was 280 (93.33%). The varying amount (%) of sterile Andaliman seeds was due to the difference in soaking time in bayclin. The same concentration of bayclin with different times gave different results, the longer the soaking time, the higher the seed sterilization results. Furthermore, alcohol and betadine were given at the same concentration and soaking time. Bayclin is a chemical compound that is toxic and has the ability to kill microorganisms that are directly exposed. Therefore, bayclin is used as a disinfectant in explants that will be developed by tissue culture [17].

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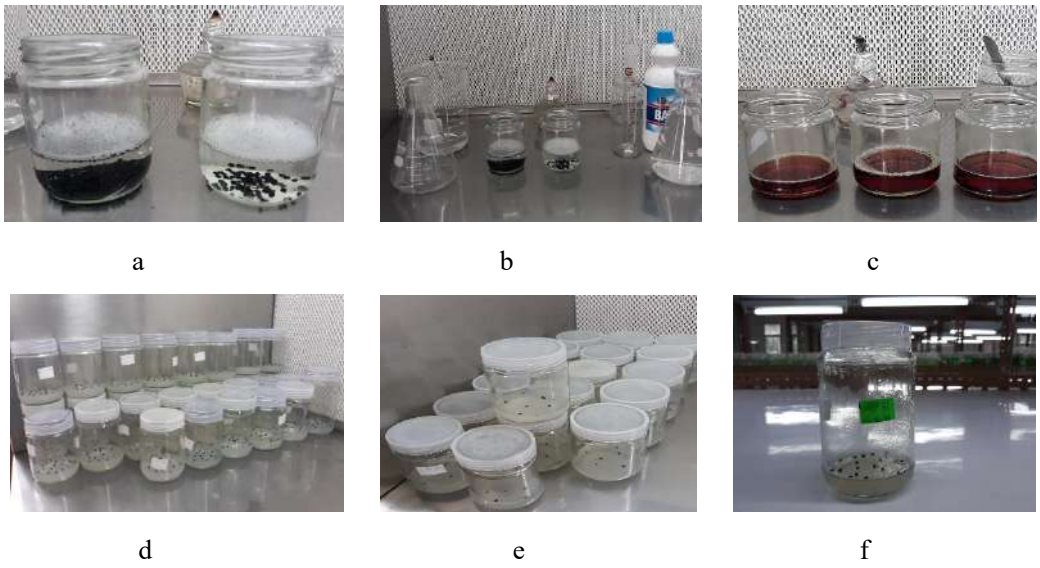
The sterilized seeds were transferred to MS0 media for 4 weeks to observe whether the seeds were truly sterile, then the seeds were transferred to the treatment media, namely MS + BAP 2.5 mg + NAA 1 mg and MS + BAP 2.5 mg + 2,4-D 1.5 mg media. Until the end of the study, namely mid-November 2024, the Andaliman seeds that were germinated in vitro only swelled, but none had grown as in Figure 1.



a b c d e f

Figure 1. Seed sterilization process (a, b, c), seed germination process on MS0 media (d,e, f)

Sterilization of Shoot, Node and Leaf Explants

Sterilization of shoot, node and leaf explants in vitro using two types of formulations as shown in Table 2.

Table 2. Sterile formulation for in vitro propagation of Andaliman using MS0 media for shoots, nodes and leaves

No.	Formulation	Explant (amount/bottle)	Amount (bottle) Explant		Amount (%) Sterile
			Sterile	Contaminants	
1.	• Bayclin 20% + Tween 80 as much as 2 drops for 20 minutes • Bayclin 10% for 10 minutes • Bayclin 5% for 5 minutes	(30): Shoot: 10 Node: 10 Leaf: 10	(21) 7 6 8	9	21 (70,00)
2.	• Bayclin 20% for 20 minutes • Bayclin 10% for 10 minutes • Bayclin 5% for 5 minutes	(30): Shoot: 10 Node: 10 Leaf: 10	(5) 2 2 1	25	5(16,67)

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Table 2 shows that the sterilant formulation number 1 is the best with a percentage of 70%. Furthermore, all sterile explants were transferred to media (1) MS + BAP 2.5 mg + TDZ 0.1 mg + PVP 0.1 g/l and media (2) MS + BAP 2.5 mg + PPM 0.1 g/l, as seen in Table 3. No. Origin of Media Explanation Number of Growing and Developing Explanations

Table 3. Number of explants growing and developing from the number of sterile explants for 2 media compositions

No.	Explant	Media		Number of Growing and Developing Explanations
		1	*2*	
1	Shoot	7	2	1 (from media 1)
2	Node	6	2	1 (from media 1)
3	Leaf	8	1	1 (from media 1)
	Amount	21	5	3 (from media 1)

Table 3 shows that the composition of the first media is better than the composition of the second media, this is indicated by the number of explants that grow and develop all from the first media. This is in accordance with the opinion of [18] which states that thiadiazuron (TDZ) plays a role in in vitro shoot multiplication. The addition of PVP will increase the success of sterile explants to grow and develop because the function of PVP binds phenolic compounds due to toxic tissue injury and inhibits plant growth [19][20]. Three explants that grow and develop can be seen in Figure 2.

a b c

Figure 2. In vitro propagation of Andaliman from different explants, a = shoot explant, b = node, c = leaf.

From Figure 2, it can be seen that explants originating from shoots and nodes are more developed when compared to explants originating from leaves. Furthermore, plantlets originating from shoot and node explants will be subcultured to be propagated and used as in vitro plant stock. As seen in Figure 3

a b c d

Figure 3. Propagation of Andaliman from various explant sources: leaves (a), shoots (b), stems (c) and nodes (d)

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The explants in Figure 3 were continuously incubated until plantlets were formed, the development of the explants towards plantlets was continuously observed. Figure 4 shows quite good explant development.

Figure 4. Development of Andaliman shoot explants to form plantlets

CONCLUSION

The best composition of sterilant materials for seed sterilization is: Bayclin 50% selama 30 menit, alkohol 70% selama 5 menit, betadine 50% selama 5 menit. The best composition of sterilant materials for shoot, node and leaf explant sterilization is: bayclin 20%, tween 80 sebanyak 2 tetes selama 20 menit, bayclin 10% selama 10 menit, Bayclin 5% selama 5 menit. The best propagation media is MS + BAP 2,5 mg + TDZ 0,1 mg + PVP 0,1 g/l. Explants that can grow and develop in vitro are shoot and node explants.

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Development of a contextual-based e-module using flip pdf professional in the animal structure course

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Abstract. This study aims to develop a contextual-based electronic module for the Animal Structure course in the Biology Department at Universitas Negeri Medan. The research method used for module development follows the ADDIE model, encompassing analysis, design, development, implementation, and evaluation stages. Flip PDF Professional software was utilized to present the module's interface. Instruments used in this study included tests, content feasibility assessment sheets, e-module presentation feasibility sheets, and evaluation questionnaires for both instructors and students.

The results of the study indicate that: (1) The e-module meets valid criteria in terms of content feasibility and presentation feasibility, achieving scores of 85.53% and 96.30%, respectively, both in the "highly feasible" category; (2) The e-module has proven practical based on feedback from instructors and students, with ratings of 94.25% and 96.50%, respectively, both falling under the "highly practical" category; (3) The e-module meets the criteria for effectiveness. Based on the analysis of student learning outcomes, with pretest and posttest scores, an N-Gain score of 0.75 was achieved, indicating a high category.

Keywords: e-module, Flip PDF Professional, ADDIE

Introduction

The rapid advancement in communication and information technology has transformed learning processes in schools and higher education institutions. As a result,

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educators, including both teachers and lecturers, are expected to master these technological skills to enhance the educational experience. Mastery in technology can be utilized to improve various learning components, including instructional materials. Teaching materials refer to a set of resources aligned with the curriculum, aimed at achieving specific competency standards and basic competencies [1] [2]. Teaching materials come in various forms, one of which is a module.

Observations and interviews with lecturers and students reveal that the use of e-modules as instructional materials remains limited. This may be due to the lecturers' heavy teaching schedules, leaving them with insufficient time to develop e-modules. Most lecturers rely on printed textbooks and scientific journals as reference materials. These textbooks typically provide only explanations and limited exercises, leading students to memorize course concepts without experiencing the meaningfulness of the material or its relevance to real life. Some online resources focus solely on concepts to be memorized, providing little practice for students in constructing knowledge or relating the content to their everyday lives. Furthermore, the online materials for animal structure courses are usually in English, which adds to students' difficulty in comprehending them. Developing a module with an appropriate approach could address these issues.

An electronic module is currently the most suitable option for students, as it is easily accessible at any location and time and allows for the inclusion of engaging media. Additionally, students tend to prefer self-study materials that include real-life examples, multimedia elements such as images and videos, and exercises to help address both technical and theoretical issues, especially when working on their final projects (theses). Such teaching materials, characterized by these features, are often referred to as contextual-based modules.

Contextual learning is an educational concept that links course content with students' real-life situations, encouraging them to connect theoretical knowledge with practical application in daily life. This approach enhances the meaningfulness of the learning material. Considerable research on the development of contextual-based e-modules has been conducted, ranging from primary schools to higher education. For example, [3] noted that e-modules enhance learning effectiveness compared to traditional textbooks. [4] also found that e-modules can boost learning motivation. Additionally, [5] reported that e-modules are suitable for students with special needs. However, no

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references were found specifically regarding the development of e-modules for the animal structure course.

This research is crucial for increasing students' motivation and interest in subjects such as animal structure, promoting independent learning, and providing both theoretical and practical inspiration for completing final projects. For instance, in studying the skeletal system, students are not merely tasked with memorizing bones; they are also informed of the significance of this knowledge. The skeletal system, for example, is essential for species identification, which is valuable for students interested in taxonomy and forensic science. Understanding skeletal structure is also beneficial for identifying abnormalities or disorders, which is vital for students interested in pathology. Furthermore, knowledge and practice in techniques related to studying the skeletal system equip students with essential skills for conducting research in biological sciences and biology education.

Based on this overview, this study aims to develop a contextual-based e-module for the Animal Structure course in the Biology Department at Universitas Negeri Medan.

Methods

Data Collection Techniques and Research Instruments

This study will be conducted in the Department of Biology at Universitas Negeri Medan from February to July 2024. It employs a research and development methodology using the ADDIE model. The subjects of this study include the lecturers teaching the Animal Structure course and students enrolled in the course, with the contextual-based e-module for the Animal Structure course serving as the research object.

Data will be collected through interviews, questionnaires, and tests. Interview and questionnaire results will guide the development of the e-module. Course instructors will validate the e-module's feasibility and practicality, while a media expert will validate its presentation. The questionnaire instrument for assessing content feasibility will be based on grids adapted from [6]. The response questionnaire for practicality assessment will draw from [7] for lecturers and [8] for students. The e-module validation instrument will be adapted from [9]. A multiple-choice test will be used to assess students' learning outcomes, particularly their higher-order thinking skills, before and after using the e-module.

Research Stages

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Analysis

This stage involves understanding the characteristics and needs of the Animal Structure course through interviews with instructors and students, along with an analysis of teaching materials and relevant scholarly articles. Both national and international standard tests will be reviewed to determine the depth of the material. Additionally, student characteristics will be analyzed, covering abilities, unique learning habits, learning styles, access to technology, and economic conditions. An assessment of the campus environment, classroom comfort, and available facilities will also be conducted.

Design

This phase defines the expected performance outcomes and appropriate testing methods. The design process begins by structuring the e-module, including initial design, module appearance, reference collection, and development of assessment instruments.

Development

Activities at this stage include compiling contextual-based e-module content, creating media elements, assembling material in PDF format, incorporating images, animations, and videos, creating exercises and evaluations, and defining course learning outcomes. The completed product will be validated by media, content, and instructional experts, with revisions made based on feedback before revalidation. Once approved, the module will proceed to the implementation phase.

Implementation

This stage involves setting up a learning environment with students and course instructors. A random sample will be selected for testing the module using a one-group pretest-posttest design. After completing the learning trial, students and instructors will respond to a feedback questionnaire. An evaluation phase will follow to assess the e-module's effectiveness.

Data Analysis

Data collected from questionnaires, along with evaluations of the e-module's practicality, feasibility, and effectiveness, will be analyzed using both qualitative and quantitative methods. Feasibility analysis will apply formulas and criteria based on [10]. Practicality criteria will be derived from [11] and achievement criteria for learning outcomes will follow standards set by Universitas Negeri Medan. The e-module's effectiveness will be measured using the N-gain formula.

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Results and Discussion

The course analysis revealed several key challenges faced by students in the Animal Structure course. Students experienced difficulties in building conceptual understanding, necessitating the use of visual aids such as images and videos. Additionally, the material's scope is closely related to real-life contexts, and some subtopics require direct observation, making contextual learning approaches particularly effective for enhancing comprehension.

An analysis of standard questions indicated that students are frequently required to engage in higher-order thinking, necessitating that material presentation and assessment methods be structured to foster critical thinking skills.

In terms of study habits, technology access, and backgrounds, students in the Biology Department at FMIPA UNIMED were found to regularly use devices like smartphones and laptops. However, they have not yet developed the skillset to efficiently search for credible scientific information online.

An analysis of the learning environment highlighted that the Biology Department at FMIPA UNIMED offers sufficient infrastructure in terms of technology and information access, as evidenced by the availability of computer labs, projectors, and internet access. Furthermore, the analysis of students' learning styles revealed that 46% have a kinesthetic learning preference, 31% are auditory learners, and 23% are visual learners.

The e-module design aligns with the syntax of contextual learning models, including principles such as constructivism, questioning, inquiry, learning community, reflection, and authentic assessment. Interactive media, including images, videos, and quizzes, are integrated using Flip PDF Professional. The e-module underwent content feasibility and presentation evaluations, as outlined in Tables 1 and 2. Overall, the assessments confirmed that both components met the criteria of "highly feasible."

Table 1. Results of Content Feasibility Analysis of the E-Module

Assessment Aspect	Item Number	Expert Evaluation	
		Percentage (%)	Criteria
Content Relevance	1, 2	81 %	feasible
Content Completeness	3, 4, 5	84,60 %	Very feasible
Content Accuracy	6, 7, 8	82 %	Feasible
Material Presentation Technique	9, 10, 11	85,60 %	Very feasible
Presentation Support	12, 13, 14	97 %	Very feasible
Language	15, 16, 17	83 %	feasible
Overall Score		85,53 %	Very feasible

Table 2. Results of the Presentation Feasibility Assessment of the E-Module.

Assessment Aspect	Item Number	Expert Evaluation	
		Percentage (%)	Criteria
Media Efficiency	1, 2	98 %	Very feasible
Presentation of Content	3, 4, 5	96,33 %	Very feasible
Graphics of Content	6, 7, 8, 9, 10	94 %	Very feasible

Utility of Media	11, 12, 13	97 %	Very feasible
Overall Evaluation		**96,30 %**	Very feasible

Despite the high feasibility rating, the validator provided specific corrections and suggestions for improvements that will be taken into account to enhance the e-module. The results of the e-module validation and test instrument validation by instructional experts are presented in Tables 3 and 4. All aspects of the e-module validation received a "very feasible" rating, while the test instruments received a "relevant" rating.

Table 3. Validation Analysis of the Teaching Module

Assessment Aspect	**Item Number**	**Learning Expert Evaluation**	
		Percentage (%)	**Criteria**
Module Identity	1	100%	Very feasible
Writing Systematics	2, 3, 4, 5, 6, 7, 8, 9, 10, 11	94 %	Very feasible
Teaching Content	12, 13, 14, 15, 16, 17, 18, 19, 20	83 %	Very feasible
Language Used	21, 22, 23	100 %	Very feasible
Overall Score		**94,25 %**	Very feasible

Table 4. Test Instrument Validation Results

Cognitive Dimension Evaluated	**Item Numbers**	**Test Instrument Expert Evaluation**
Analyzing (C4)	1, 2 , 3, 4	Relevant
Evaluating (C5)	5, 6, 7	Relevant
Creating (C6)	8, 9, 10	Relevant

The results of the practicality analysis based on the responses from lecturers and students are presented in Table 5, which received a "very practical" rating.

Table 5. Lecturer and Student Evaluation of the E-Module

Practicality Aspect	**Practicality Evaluation**	
	Percentage (%)	**Criteria**
Lecturer Response	96,50 %	Very Practical
Student Response	94,45 %	Very Practical

Based on the evaluation results, several improvements were made, including adjustments to the content in accordance with the contextual learning model, correction of writing errors, and refinement of the structure of the learning materials and instruments.

Students are considered to have mastered the material if they achieve a score of ≥ 65, in accordance with the standards of Universitas Negeri Medan. The data on learning mastery are

presented in Table 6.

Table 6. Results of Student Pretest and Posttest Scores

Assessment	Average	Passed
Pretest	48	8
Posttest	87	60

Table 6 presents the pretest and posttest scores of 65 students on the skeletal system material. The pretest results show that 8 students achieved learning mastery, while 60 students achieved learning mastery based on their posttest scores.

Based on the calculation of pretest and posttest scores from the field trial, students showed improvement through the implementation of the developed contextual-based e-modul, which was categorized as effective.

The n-gain scores are used to assess the effectiveness of the e-modul and are presented in Table 7.

Table 7. N-gain Scores of Student Learning Outcomes

Material	Average		
	Pretest	***Posttest***	***N-gain***
Skeletal System	48	87	0,75

Based on the analysis of the research results, the n-gain score obtained was 0.75, which falls into the high category. Therefore, the use of the contextual-based e-modul is effective in improving student learning outcomes. This is in line with the findings of [12], who revealed that contextual-based modules increase students' interest in learning, thereby enhancing their learning outcomes. Contextual-based modules are suitable for science education because they promote independent learning, capture students' attention by incorporating texts, images, videos, animations, and practice questions that are integrated with everyday life [13] [14]. Furthermore, contextual-based modules enable students to discover knowledge and concepts on their own, which helps the information received to last longer. By bringing real-world situations into the classroom, these modules encourage students to relate their knowledge to everyday life, thereby training their critical thinking skills also reinforce the idea that contextual-based modules improve students' ability to construct their own thinking based on real-life problems presented, making the material easier to learn because it is directly related to their daily lives [15] [16] [17].

CONCLUSION

Based on the results of the research, it can be concluded that (1) The content, presentation, and validity of the e-module meet the criteria of being very feasible; (2) The e-module is very practical to use based on the assessments of both lecturers and students; (3) The contextual-based e-module improves the higher-order thinking skills of Biology students at Universitas Negeri Medan, particularly in the course of Animal Structure, especially in the material of the skeletal system.

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The radulaceae family at sopotinjak, batang gadis national park, north sumatra, indonesia

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Abstract. The Radulaceae family is one of the most common liverwort families. Usually this group attaches to tree bark, decaying trees and epiphytes on leaves. This research was conducted in June - December 2022 at Resort 7 Sopotinjak Batang Gadis National Park, North Sumatra, Indonesia. The method used is the exploration method. 10 types of Radula were found, *Radula iwatsukii*, *Radula Formosa*, *Radula amoena*, *Radula anceps*, *Radula retroflexa*, *Radula sumatrana*, *Radula tjibodensis*, *Radula meyeri, Radula javanica*, dan *Radula companigera.*

Keywords: Diversity, Radulaceae, Sopotinjak, Batang Gadis National Park (TNBG), Liverwort

Introduction

The genus Radulaceae is a genus of liverwort groups spread throughout the world, ranging from tropical climates to warm climates. Radulaceae lives epiphytic on tree bark, weatherwood, leaves and stones [1]. Radulaceae has one genus, namely Radula. Members of this genus are clearly different from other families in that rhizoids emerge from their lobules and lack ventral leaves [2].

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Radula [3] is a genus that includes about 200 species worldwide, spread from the Arctic to Antarctica with the greatest diversity in the tropics and subtropics [2], [4], [5]. Members of this genus are usually found in bark, decaying wood, or live leaves, rarely on rocks or soils, inhabiting diverse environments, from sea level to altitudes of more than 4000 m [1], [5]. Morphologically, the genus has single characteristics such as (1) Radula-type branches (derived from stem epidermal cells and therefore associated with unmodified leaves), (2) incubated and lobed leaves, (3) absent lower leaves, (4) rhizoids in tufts on the lobule surface, and (5) tubular perianth, flattened in the dorsiventral portion [2], [5], [6]

Batang Gadis National Park is one of the conservation areas on the island of Sumatra. The area is divided into several sections, one of which is Sopotinjak. Sopotinjak is known as a humid area with a fairly high rainfall. This condition is a suitable habitat for moss growth.

In North Sumatra itself, research has been carried out on several liver mosses such as Ho et al. [7], Siregar [8], Siregar et al. [7], Siregar et al. [8], Siregar et al. [11], Kasiani et al. [12], Susilo et al. [13], Susilo et al. [14], and Damanik et al. [15]. Research on liver moss, especially about the genus Radulaceae, is still very limited. So it is necessary to conduct research to complete the data on the types in North Sumatra.

Method

This research will be conducted in Sopotinjak which is part of the Batang Gadis National Park and is located at 00o42'14" N – 99o13'9" E. Sopotinjak has a undulating to hilly land surface with a slope of > 40%, is an expanse of lower mountain forest with an altitude of 1,000 – 1,450 m above sea level. The average rainfall per month is 12-13 days so it is included in type A. The average temperature is 22-270C with a humidity of 80-91% [16]. Specimen collection was carried out by the exploration method. Collections were carried out on all Radulaceae families on various substrates (soil, rocks, tree trunks, leaves, weathered wood) using sharp knives. Moss sampling is attempted to be as complete as possible, which includes both vegetative and generative organs. All samples obtained are put into paper envelopes separately and assigned a collection number, collection date, and collector's name. Observed morphological characters from the samples and recorded directly in the field into the notebook including color, growth shape, substrate type, coordinates, humidity, light intensity and altitude. Observations were made using magnification lup 15-20 times. Moss specimens can be collected both dry and wet. Dry collection is carried out by inserting moss specimens obtained in the field into paper envelopes. Moss samples obtained in the field are then replaced with envelope paper, and dried by drying. This is done so that the sample is not damaged (damp/moldy). The dried specimens were then identified at the Medanese Herbarium, Department of Biology FMIPA USU Medan.

Result and Discussion

The research conducted in sopotinjak batang gadis national park found 10 types of radula that are epiphytic to tree bark, weathered wood and leaves. The 10 types are *Radula amoena, Radula anceps, Radula companigera, Radula javanica, Radula meyeri, Radula retroflexa, Radula tjibodensis, Radula sumatrana, Radula iwatsukii* and *Radula formosa.*

Kunci Identifikasi Radulacea di Sopotinjak

1. a. Plants have amentulose……. 2

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	b.	Plants do not have amentulose…….....	3
2.	a.	Amentulose longer than lobules…….....	*R. iwatsukii*
	b.	Amentulose shorter than lobules……	*R. formosa*
3.	a.	Lobule tips pointed to tapering……	4
	b.	Lobule tips blunt……..	5
4.	a.	Lobule shape square, 1/3-1/2 of lobule length……	*R. anceps*
	b.	Lobule shape ovoid, 1/4-1/3 of lobule length…….……	*R. amoena*
5.	a.	Lobules crescent-shaped…….……....	6
	b.	Lobules ovoid to square……...	7
6.	a.	Lobule edges curved……	*R. retroflexa*
	b.	Lobule edges flat……..….....	*R. sumatrana*
7.	a.	Lobule edges have gemma…….……	*R. tjibodensis*
	b.	Lobule edges flat……	8
8.	a.	Lobules are attached evenly……	9
	b.	Lobules are attached curved…….……...	*R. meyeri*
9	a.	Cell walls are thin, trigons are not clear……..	*R. javanica*
	b.	Cell walls are thick, trigons are clear……..	*R. companigera*

Deskripsi Jenis Radulaceae

1. *Radula iwatsukii* Yamada, *sp. nov.*

Epiphytes on tree trunks and leaves, stiff plants, reddish brown specimens, dense and irregular pinnate branches, spreading branches, have amentulose with 3-7 pairs of small leaves. The lobes are arranged very closely, oval, 0.7-0.9 mm long, 0.5-0.7 mm wide, rounded tips, ventral edges protruding towards the apex, dorsal base covering the stem, thin cells, clear trigone. Rectangular lobes, 2/3 of the length of the lobe, 0.3-0.5 mm, 0.2-0.3 mm wide, blunt tips, upper edge bordered by 2-3 rows of straight abaxial cells, bordered by 1-3 rows of cells, the lower part does not cover the stem, the base of the rhizoid attachment is slightly convex, few rhizoids, elongated keel forming an angle of 60o with the stem, 0.4-0.5 mm long, curved.

2. *Radula formosa* (Meissn.) Nees

Epiphytes on tree trunks, yellow to reddish brown plants in specimens, 9-16 mm long and 1.20-2 mm wide. Irregular branching. Has amentulose with 5-15 small leaves with a length of 0.3-0.5 mm. The lobes are oval to oblique, generally oval or rounded, the ventral and dorsal leaf edges are flat, the base of the dorsal edge covers the stem, the apex is rounded and bent clearly, the cell surface is smooth, the trigon is clear and large. Small rectangular lobules are elongated with a length of 1/3-1/2 of the length of the lobe with the widest part at the bottom, the tip is rounded with a slightly curved ventral edge, the dorsal edge curves to the tip of the leaf.

3. *Radula anceps* Sde. Lac

Epiphytes on leaves, yellow-brown specimens, 1.2-3 mm wide, Radula branching type. Lobes are densely arranged, oval shape, 0.6-0.9 mm long and 0.4-05 mm wide, flat attachment, flat dorsal base, flat ventral base, serrated edges, short to long and pointed teeth, 2-5 tooth lengths, pointed tip cells, round to square cell shape, thin walls, smooth surface, less clear trigonal shape, triangular shape. Lobules are rectangular, 1/3 of the length of the lobe, flat base, flat attachment, flat edges, pointed to pointed tips.

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4. *Radula amoena* Herz
Epiphytic on bark, dark green in dry specimens, 1.5-1.8 mm wide, branches irregular and tightly pinched. Lobes sparsely arranged, crescent-shaped to oblong, 0.6-0.8 mm long, 1.2-1.5 mm wide, margins flat or slightly serrated near lobe tips, dorsal margin base covering 1/2 of stem width, apex acute to tapering, not curved, cells thin-walled, trigon indistinct. Lobules rhomboid, 1/4-1/3 of lobe length, 0.1-0.3 mm long, 0.2-0.3 mm wide, apex blunt, axial margin straight, axial margin straight to slightly curved, covering 1/4 of stem width.

5. *Radula retroflexa* Steph.
Epiphytes on tree trunks and leaves, yellowish green, 1.5-1.8 mm wide. Irregular branching. Lobules are densely arranged, oval in shape, 0.7-0.9 mm long and 0.6-0.75 mm wide, flat attachment, curved dorsal base, flat edge, rounded tip, hexagonal cell shape, thick walls, smooth surface, clear trigonal trigonal. Lobules are crescent-shaped, 1/2 lobe long, covering 1/2 to the entire stem, flat base, flat attachment, curved edge, almost pointed tip. Oval shape, 3-4 on the edge of the cell.

6. *Radula sumatrana* Steph**.**
Epiphytes on tree trunks and leaves, yellowish green, 2-2.5 mm wide, irregular branching. Lobes are arranged sparsely to closely at the tip of the body, oval in shape, 1-1.3 mm long and 0.8-0.9 mm wide, flat to slightly curved attachment, dorsal base curved, ventral base flat, flat edge, rounded tip, thick wall, rough surface, triangular trigone. Lobules are square, 1/3-1/2 of the length of the lobe, curved base, curved attachment, flat edge, blunt to pointed tip.

7. *Radula tjibodensis* Goebel.
Epiphyte on leaves, green plants, yellowish in specimens, 1.5-1.7 mm wide, irregular branching. Lobes are densely arranged, oval shape, 0.5-0.8 mm long and 0.5-0.7 mm wide, curved attachment, curved dorsal base, flat ventral base, flat edges and gemma, rounded tips, round to hexagonal cell shape with thick walls, smooth cell surface, clear trigonal shape. Lobules are triangular, 1/3 of the length of the lobe, flat base, flat attachment, flat edges, prominent tips.

8. *Radula meyeri* Steph.
Epiphytes on tree trunks, wood and decaying leaves. The body of the specimen is yellowish green, 1.2-1.5 mm wide, irregular branching. The lobes are arranged overlapping, close together, oval, 0.5-0.7 mm long and 0.4-06 mm wide, curved attachment, curved ventral base, flat edge, rounded tip, round to hexagonal cell shape, thick walls, smooth surface, clear trigonal shape, triangular. The lobes are rectangular with a length of 1/3 of the lobe, flat base, curved attachment, flat edge, blunt tip.

9. *Radula javanica* Gott.
Epiphytes on tree trunks and decaying wood, dark green specimens, 1.2-1.9 mm wide, irregular branching. Lobes arranged with adjacent leaves, oval shape, 0.65-0.85 mm long and 0.4-0.5 mm wide, curved attachment, flat dorsal base, curved ventral base, flat edge, rounded tip, round to hexagonal cell shape, thin walls, smooth surface, unclear trigon. Square Lobules, 1/3-1/2 lobe length, curved base, curved attachment, flat edge, blunt tip. Oil body only 1, round shape, large size and located in the middle of the cell.

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10. *Radula companigera* Mont.

Epiphytes on tree trunks, yellowish green plant specimens, 1.2-2 mm wide, irregular branching. Lobes are arranged close together, oval shape, 0.7-0.95 mm long and 0.6-0.75 mm wide, flat attachment, flat base, curved ventral base, flat edge, rounded tip, round to oblong cell shape, thick cell wall, smooth cell surface, trigon is expanded and clearly visible. Lobes are oval to almost rectangular, 1/3 of the length of the lobe, flat base, flat attachment, flat edge, blunt to rounded tip. Oil body number 1, large, almost filling the entire cell.

Conclusion

Research conducted in Sopotinjak Batang Gadis National Park found 10 types of Radula that are epiphytic on tree bark, rotten wood and leaves. The ten types are *Radula iwatsukii, Radula Formosa, Radula amoena, Radula anceps, Radula retroflexa, Radula sumatrana, Radula tjibodensis, Radula meyeri. Radula javanica, dan Radula companigera.*

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The effect of project based learning model on obe toward student's achievemen

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Abstract. This research has the purpose to know the student's achievement in Acid-Base topic by implementing Project Based Learning model. The population of this research are all Senior High School students grade XI in Berastagi, which the samples are 2 classes XIth grade chosen by purposive sampling. The first as experiment class was taught by Project Based Learning Model while second class as control class was taught by Conventional model. The instrument test had been standardized by expert validator and empiric validity process. The result of test standardization is 20 multiple choice questions with reliability 0.865 . The research resulted that the data is normal distributed and samples are homogenous. The result data showed that student's achievement taught by Project based learning with Case method on OBE gave higher significance different compared with student's achievement taught by conventional model. The statement supported by the result of hypothesis testing is t_{count} (5.78) > t_{table} (1.67). The most cognitif aspect developed through Project Based learning is application aspect (C3).
Keywords : *Lesson Study, Project Based Learning, Student's Achievement*

Introduction

Based on the survey conducted by *United Nations Educational, Scientific and Cultural Organization (UNESCO)*, against quality education in developing countries in Asia Pacific, Indonesia ranked 10th out of 14 countries. As for the quality of teachers, Indonesia is at level 14 of 14 developing countries. In addition, the method lectures also often make students confused in learning a material which is indeed an abstract object or rarely encountered by students, as with teacher lecture methods tend not to be able to present the object into the classroom during the lesson. In learning with lecture method, students are not required to be more creative and critical thinking to what is learned, but the students only as a listener what is delivered the teacher without understanding it well [1].

The essence of education is essentially human interaction, coaching and developing human

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potential, lasting a lifetime, in accordance with the capacity and level development of students, and improving the quality of human beings. The quality of human resources (HR) can be improved by education. Improvement of HR through education objectives is clear, so that each generation can follow the development of science and technology and be able to anticipate changes

There are several aspects of education that have recently emerged in several discourses related to the problems of education in Indonesia, namely: (a) curricula whose implementation has not been relevant to the demands of society, (b) the cost of education is expensive, (c) the purpose of education in the process has been deviant, (d) the controversy over the implementation of the National Exam, and (e) many inadequate educational facilities. All these things are basically passed on to the honesty of education executors in carrying out this nation's education.

One way to overcome this problem is to change the learning strategies used by teachers in the classroom, ie from conventional learning into learning strategy that is to the activity of students. Based on that, the teacher is required to change the paradigm of teaching is just to deliver the subject matter into an activity to regulate the environment for students to learn. The primary objective of the action research study was to identify an alternate pedagogical approach to improve student engagement and academic performance in this researcher's psychology courses. These findings emphasized the importance of the student's perception of learning and its influence on academic performance and motivation. Based on the findings, PjBL has the potential to improve student engagement and their academic performance [2]

Chemistry is one of the subjects at High School level (SMA) in accordance with the principle of the Scientific Approach. Chemistry is *experimental science* means that in studying chemistry is not enough just to hear and read it, but it is necessary to do learning activities such as lab work that will help build students about the material being studied. As a result, students were unable to establish a fundamental understanding of chemical concepts at the beginning of their study of chemistry. Learning activities that can make students' memory of material last longer is a learning that makes students active in building and linking material concepts. Therefore, it is necessary to use instructional model supported by learning media that can actively involve students actively.

Learning model is one component of the defense system. Learning model that can make learners active or in accordance with the Scientific Approach such as *Inquiry* model , *Project Based Learning* (PjBL), *Problem Based Learning* (PBL) , and *Cooperative Learning.* Some of the learning models are government-emphasized learning models to be used in learning in the Curriculum 2013. However, the application of learning models is not merely to comply with the rules, but also needs to pay attention to several factors, including the material characteristics to be conveyed. The PjBL model is one of the suggested models applied in chemistry learning in the Curriculum 2013. In this PjBL model create projects that require students to (1) solve real problems and issues of interest to others; (2) actively engaging in their learning and choosing important matters during the project; (3) show clearly that they have learned key concepts and skills. The project provides an opportunity for students to produce observable evidence that they have mastered strict curricular standards as they apply their learning and solve problems at hand. By applying the PjBL model, the principle of learning activities can be achieved that is, (1) centered on the learner; (2) develop the creativity of learners; (3) to create favorable and challenging conditions; (4) having value, ethics, aesthetics, logic, and kines-tetika; (5) provide diverse learning experiences through the application of fun, contextual, effective, efficient and meaningful learning strategies and methods even though the time required is longer. [3]

Judging from my experience of a three-month integrated field experience program at SMA N 1 Berastagi, I observed that some teachers still apply conventional methods in the learning process,

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which leads to more teacher-centered learning, whereas in the 2013 curriculum it is emphasized that students who are centers of learning during the learning process. Based on interviews with chemistry teacher grade XI SMA N 1 Berastagi, acid-base material is less interesting material for students. This is because students are generally difficulty in understanding the concept of acid bases. So that required learning model and the right teaching materials to solve the problem faced by the student.

Based on the above problem, Based on the background above the writer identifies the problem as follows : The low quality of education and the quality of teachers in learning that can increase interest in student learning; Lack of variation of teaching methods which is conducted by teachers, in which teachers too dominate the learning process in the classroom that causes students become passive. The objectives of this study are to know :

The student's achievement in learning acid-base taught by project based learning model based on lesson study compared by student's achievement in acid-base solution taught by conventional model.

METHODOLOGY

Research Design

This research involves two classes of experimental class and control class which both of them are treated differently. Experimental class will be treated through project based learning model based on lesson study and other control class will be treated through conventional model.

Samples	Pre-test	Treatment	Post-test
Experiment Class	T_1	X	T_2
Control Class	T_1	Y	T_2

Description :
T_1 = pretest score of experimental class and control class
T_2 = posttest score of experimental class and control class
X = teaching treatment with PjBL model using animation based on lesson study
Y = teaching treatment with conventional model .

Techniques of data analysis that used are normalized gain, homogeneity test, normality test, and hypothesis testing.

Normalized Gain

An alternative is to normalize the gain score to account for the variance in pretest scores. Such a measure is *g*, the normalized gain, which is the absolute gain divided by the maximum possible gain:

$$g = \frac{post\ test\ score - pre\ test\ score}{maximum\ score - pre\ test\ score} \quad [4]$$

Where, the values of normalized gain are :

g> 0,7 = High
0,3≤ g ≥ 0,7 = Medium
g< 0,3 = Low

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Hyphotesis criteria that we used in research [5]. The value of t_{count} is compared with the value of t_{table} which is obtained from list. If $t_{count} > t_{table}$ at level a = 0.05 and degree of freedom (df) = (n1 + n2)-2 is meaning receives Ha or Ho rejected. Ha received or Ho rejected if the value of $t_{count} > t_{table}$ and Ha rejected or Ho received if $t_{count} > t_{table}$ at level a = 0.05.

Result and Discussion

Enhancement learning outcomes can calculated from average gain value all of student for each class that is enhancement learning outcomes control class is 0.52 or 52 % and experiment class is 0.70 or 70 %. Result of the gain obtained is difference between posttest and pretest. Based on learning outcomes data then obtained average, standard deviation, and variance from each class can seen in following table.

Table 2. Average, Standard Deviation, and Variance

Class	Average	Standard Deviation	Variance
Control class	0.523	0.125	0.016
Experiment class	0.708	0.129	0.017

Hypothesis testing was conducted to test the test hypothesis that has been done explained in chapter 2. This test will test the hypothesis whether the alternative hypothesis (Ha) is accepted or rejected. If Ha is accepted means Ho is rejected.

The hypothesis is tested by *t* – test one tail from the average of posttest of both classes. The result of the hypothesis in Table bellow

Table 3. Result of Hypothesis Testing

Class	Average	Standard Deviation	T_{count}	T_{table}	A	Description
Experiment class	0.708	0.1443	5.78	1.67	0.05	Ha is accepted and Ho is rejected
Control class	0.523	0.1241				

The result of calculation shows that $t_{count} > t_{table}$ (5.78 > 1.67) and it is up to standard it means that **Ha is accepted** and **Ho is rejected**. So, it could be conclude that the student achievement that be taught by PjBL model Based on Lesson Study is significant higher than student achievement that be taught by Conventional model.

Cognitive aspect improvement was measured in experiment class to know if the cognitive aspect of student will be improved. The average gain of cognitive aspect improvement in experiment class will be shown in bellow table.

Table 4. Average Gain of Cognitive Aspect Improvement Level of Cognitive Aspect

C1	C2	C3	C4
0.57	0.85	0.86	0.80
Medium	High	High	High

Discussion

After the research and doing analyzing data, its show the students achievement that taught by PjBL model based on Lesson Study is higher than students that taught by conventional model in Acid Base topic. The result can be obtained from the average of pre-test and the average of post-

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test that indicate the increasing of student's achievement before and after teaching treatment. The average of pre – test in control class (43.7) is not significant different with experiment class (42.2). Based on the pre – test value show that the students in SMA N 1 Berastagi are still not understood yet about the topic of Acid-Base. It's different with the value of average post – test that is 83.4 in experiment class is significant different average post – test of control class that is 73.7. From this value show that the students are understand the topic of Acid-base after giving the different teaching treatment for both of class. The result of calculation shows that $t_{count} > t_{table}$ (5.78 > 1.67) and it is up to standard. So, it could be conclude that the student achievement that be taught by PjBL model Based on Lesson Study is significant higher than student achievement that be taught by Conventional model. The analysis of gain in level of cognitive aspect is improved by conduct the PjBL model based on Lesson Study in experiment class and it is obtained C1 (Knowledge) aspect was 0.57 categorized as medium improvement, C2 (Understanding) was 0.85 categorized as high improvement , C3 (Application) was 0.86 categorized as high improvement, C4 (Analysis) was 0.80 categorized as high improvement. And in experiment class show that the most improve is in level of cognitive aspect of C3 (Application) with the average gain was 0.86. Project Based Learning on Students' Performance in the Concept of Classification of Organisms Among Secondary Schools in Kenya. This study revealed that project based learning technique enable students to improve in academic. The project based learning model has positive effect on student's attitude toward classification. The study recommends to the Ministry of education and its agencies to adopt project based learning technique among other student centred instructional techniques for teaching of practical oriented concepts like Classification of Organisms. (Wekesa and Ongunya, 2016)

Based on the relevant research that was done by [6]. was aimed to explore the effect of PjBL on learning motivation and problem solving ability of the vocational high school students. The treatment-group students are given project-based teaching method and control group students are given traditional teaching method during four week period of courses. The research results showed project based learning not only could enhance vocational school students' learning motivation, but facilitate their problem-solving ability. The contribution of the teachers a real exemplar of PjBL.

The relevan research aimed to determine the performance of the students on several measures and tested for the significant difference between the scores of the two groups. The findings of the study showed significant improvement on the performance of the two groups in their posttest, chapter test, and in the outputs. This implies that project-based learning is an effective approach in the teaching and learning of Chemistry [7].

. The hypothesis conclude that students' achievement which is implemented the inquiry strategy based on collaborative is higher significantly than direct instructional. In addition the cognitive aspect which is improved by implementing the inquiry strategy based on collaborative is C2 (Comprehension) is 0.76 included as high category [8]

Conclusion

Based on result of research obtained conclusion as follow :

1. The improvement of student's achievement in chemistry which is get project based learning model based is higher than the improvement in student's achievement which get conventional model learning on acid-base material. Learning taught by project based learning model based on lesson study more effective than learning taught by conventional model.

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2. The most developed cognitive domain in the experimental class, which is get project based learning based on lesson study is the cognitive domain of C3 (application).

Suggestion

As for suggestions that the writer can give are :

1. For teacher and prospective teacher, it is expected to be alble to use project based learning model based on lesson study to improve student's achievement of chemistry.
2. For students are expected to improve their learning experiences and interest using model and learning media so can improve their learning outcomes.
3. For further researchers who will conduct further research can make this research as a material for consideration and reference.

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Validity and practicality of STEM-PjBL based teaching materials on acid and base

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Abstract. *A high level of creative thinking is one of the factors that individuals must have in facing competition in the 21st century. However, the current condition is that the creative thinking skills of Indonesian students have not developed well and are still relatively low. In line with the observation results obtained during the lecture, students' creative thinking skills are still not optimal, this is indicated by the lack of creativity of students in doing the KKNI assignments given and still passive in discussions. Efforts to solve these problems are by using STEM-PjBl teaching materials in learning. The purpose of this study is to evaluate the usefulness and validity of STEM-PjBl-based instructional resources on acid and base solutions. This study was carried out at the State University of Medan's Chemistry Education Study Program, Department of Chemistry, Faculty of Mathematics and Natural Sciences. This research is an Research and Development study. The validity and practicality test instruments were assessed by lecturers in the form of a questionnaire The acquisition of material experts was 0.87 and media experts were 0.89, respectively, and the validity test findings showed an average kappa moment value of 0.88 with a very high category. The results of the lecturer's practicality test showed an average kappa moment value of 0.87 with a very practical category. It can be summarized that STEM-PjBL-based teaching materials on acid and base solution materials are valid and useful in the learning process.*

Keywords: (Validity, Practicality, STEM-PjBL, Teaching Materials, Acid, Base)

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Introduction

The learning of the 21st century is learning that prepares the 21st century generation and is relevant to everyday life which is closely related to the ability to think creatively, the ability to cooperate, the ability to solve problems, the ability to master technology, and the ability to communicate [1]. The learning of the 21st century can encourage people to think ahead. The Partnership for 21st Century Skills highlights that four competencies creativity, critical thinking, communication, and teamwork should be taught in 21st century education.

According to [2] creative thinking is the capacity to propose solutions to solve problems so as to create something new or different. to solve problems so as to create something new or different. This creative thinking ability aims to find solutions in solving a problem so that it can create something new or different. Creative thinking skills play an important role in preparing students to be able to solve problems in everyday life and adapt to the 21st century era [3].

A high level of creative thinking is one of the factors that must be possessed by individuals to face competition in the 21st century. However, the current condition of Indonesian students' creative thinking skills has not developed well and is still relatively low. This is in accordance with the results of the survey of the international institution Program For International Students Assement (PISA) in 2018 there was a decline from the results of 2015. In 2015, Indonesia obtained an average math proficiency score of 386 [4-5], while in 2018 the average score was 379 [4-6]. In addition, the Trends In International Mathematics And Science Study (TIMSS) results in 2018 Indonesia received an average score of 397 from the international average score of 500. The result of TIMSS and PISA shows low student creativity, because the characteristics of the questions in PISA and TIMSS are contextual questions, demanding reasoning, argumentation and creativity in solving problems [7-8].

This is also in line with the results of observations that have been made in the learning process. Students' creative thinking skills are still not optimal, this is characterized This is characterized by the lack of creativity of students in doing the KKNI assignments given by (Task Routine, Critical Book Report, Critical Journal Review, Idea Engineering, Mini Research and Project), there are still many who copy and paste from previous assignments, lack of student activeness in discussions, 50% of students still get low grades in UTS and UAS. The teaching materials used are books, modules that include exercises, articles, and video. However, the teaching materials used in the learning process have not been integrated with STEM.

The attempt to solve the problem is to use the right teaching materials. The development of this teaching material is expected to provide solutions in solving these problems. For that reason, there is a need for some innovation in the production of teaching materials that increase the ability to think creatively. The teaching materials will be very helpful in the learning process, but the preparation of these teaching materials will be more interesting if collaborated with the STEM-PjBl approach. The STEM-PjBL integrated teaching materials are teaching materials that contain a systematically organized material whose content integrates chemistry which is experimental science or project-based learning by applying various aspects of STEM, namely science, technology, engineering and mathematics where the problems taken are based on everyday life.

STEM is an acronym for Science, Technology, Engineering, and Mathematics [9-13]. According to [14], STEM is a learning approach that combines two or more of the disciplines included in STEM, or between several disciplines included in STEM and one or more other subjects. The STEM learning can improve learning outcomes and student motivation [15]. Student

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learning outcomes on the topic of colligative properties of solutions can be improved with the efficient use of instructional resources integrated with STEM [16]. Project-based learning (PjBl) is one of the learning paradigms that aligns with the use of STEM.

According to [17], the PjBL-STEM approach will help students develop higher order thinking abilities and think critically, creatively, and analytically. Students' enthusiasm to study about organic compounds and their science literacy can both be enhanced by STEM-PjBl integrated teaching resources [18]. The benefits of applying the STEM-PjBL learning model are not only proven to be able to foster science literacy skills, but also to build interactive and stimulating learning, helping to understand the subject matter, and forming an understanding of the subject matter. and energizing, helps in understanding the subject matter, and forms a creative attitude [19]. The implementation of project-based learning model STEM-integrated learning model is significantly effective in improving science literacy skills and creative thinking skills of students [20].

Beginning with the above description, students must take action to raise the standard of chemistry instruction in order to develop their capacity for creative thought. Creating instructional materials is one way to achieve this. The goal of this research is to develop STEM-PjBl-based instructional resources that are both legitimate and useful for enhancing students' capacity for original thought.

Method

Research and development, or R&D (Research and Development), is the methodology employed in this study. The 4D model is the development model that researchers employ in this development study [21]. Research and creation of instructional materials, including textbooks and LKS, frequently employ the 4D model [22]. The 4D development model is based on the work of Dorothy S. Semmel, Melvyn I. Semmel, and Sivasailam Thiagarajan from 1974. There are four phases in the model: define, design, develop, and disseminate.

The data collection techniques used in this study were instrument feasibility sheets, teaching material validation questionnaires, and practicality questionnaires. The types of data obtained in this study are qualitative and quantitative data. Qualitative data was obtained from the teaching material validation sheet, the results of the validation assessment and the responses of lecturers. Quantitative data in the form of suggestions, comments, results of validator reviews of product relevance, and lecturer response sheets to teaching materials are assessed descriptively. The results of the validation of material experts, media experts and the results of the practicality questionnaire were analyzed using the kappa moment formula.

Result

Define Stage

Front End Analysis

The front-end analysis was conducted by researchers through interviews with the lecturer of the capita selecta chemistry course. Based on the interview, it was concluded that students' creative thinking skills were still not optimal, this was indicated by the lack of creativity of students in working on the KKNI assignments given (Task Routine, Critical Book Report, Critical Journal Review, Idea Engineering, Mini Research and Project), many were still copy and paste from previous assignments, lack of student activeness in discussions, 50% of students still obtained low grades in UTS and UAS. The educational materials made use of include still textbooks, teaching materials that contain exercises, journals, and questions. questions, journals, and learning videos.

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However, the educational materials used in the learning process has not been integrated with STEM-PjBL.

Student Analysis

Student analysis was conducted by researchers through interviews with students related to the lecture process, their interest in acid-base solution material and the capacity of students to link acid-base material with STEM-PjBL. Based on the interview obtained the conclusion is that in lectures students are still required to do a lot of assignments, especially questions related to the material, there is still a lack of doing projects related to acid-base solutions, and they are still unable to relate acid-base solution material to other materials within the scope of STEM so that it results in low student creative thinking skills.

Task Analysis

Researchers carried out the task analysis by examining the learning results for the course, as indicated in table 1.

Table 1. Course Learning Outcomes

No	Course Learning Outcomes
1	Students can recognize acids and bases in a product correctly.
2	Students are able to analyze the differences in acid base theory according to arrhenius, bronsted lowry and lewis and their examples correctly.
3	Students are able to analyze the strength of acids and bases correctly
4	Students are able to calculate the pH of an acidic and basic solution correctly
5	Students are able to make balanced reaction equations for acid reactions with metals, carbonates or bicarbonates, and bases correctly.
6	Students are able to calculate the molarity or volume of acid or base solution from titration information correct
7	Students are able to design projects on acid and base solutions carefully

Concept Analysis

Concept analysis is carried out by researchers through sub-course learning outcomes analysis and continued by analyzing what concepts to be developed in teaching materials related to teaching materials. The results of the concept analysis consist of acid-base theory, acid-base strength, acidity (pH), acid-base reactions and acid-base titration.

Specification of Learning Objectives

The specification of learning objectives is carried out by researchers through analyzing learning objectives on acid-base solution material.

Design Stage

Test Preparation

Test preparation is based on the analysis of learning objectives. The test aims to determine the capacity of students' creative thinking towards learning chemistry, especially acid-base solution material. One of the assessment instruments that can measure creative thinking skills of students is an instrument of description questions (essays) that demand creative answers and are equipped with an assessment rubric that is in accordance with the components of creative thinking. Characteristics of creative thinking ability related to cognition as a process of constructing ideas that emphasize the aspects of fluency, flexibility, and originality elaboration [23]. After the

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creative thinking ability test questions have been compiled based on the grid, the test validation test is carried out to the material expert and declared feasible to be tested. The creative thinking ability test questions were tested on students who had learned the acid-base solution material, then analyzed so that the validity, reliability, difficulty index and differential power of the test questions were obtained. The test results were analyzed using the SPSS program. Validity and reliability tests on primary data test results obtained from 70 respondents with r table of 0.231 and sig of 5%. In the test validity test of 10 test questions that were tested, all questions were declared valid so that they could be used as pretest and posttest questions. Furthermore, the reliability test obtained a Cronbach's Alpha value of 0.753, so it was declared reliable. For the difficulty index test, it was found that the average question used had a medium difficulty index. Followed by a test of differential power, all data contained in the corrected item-total correlation table in the SPSS program shows a number greater than 0.3, so that all questions can be used because they have medium and high differential power.

Format Preparation

The format utilized in the instructional materials is Times New Roman and Adobe Hebrew for the title and text; the paper is sized to fit the UNESCO standard, which is 15.5 x 23 cm; the spacing between lines is 1.15 with a column format. With a white paper backdrop and a peach and blue color scheme that complements the educational materials' content, the items are organized methodically and progressively.

Preliminary design

The cover, preamble, introduction, STEM-PjBL components, usage instructions, course learning objectives, and concept maps make up the module's original layout, which is organized in a sequential fashion. Next, go on to the substance of the material related to other subjects (STEM), like the use of acid-base solutions in daily life or the application of technology, engineering, and mathematics. In the engineering section contains projects that students will work on along with several practicums related to the material. practicum related to the material. In addition there are mathematics problems, also equipped with creative thinking skills questions. The summary, competency exam, glossary, bibliography, and author biography make up the concluding portion. Figure 1 depicts the original layout of the instructional materials.

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(a)

(b)

(c)

(d)

Figure 1. (a) cover (b) introduction (c) science (d) technology

Development Stage

Validation and practicality tests are conducted throughout the development stage with the goal of creating instructional materials that are both legitimate and useful. Following the creation of draft 1 of the STEM-PjBL-based instructional materials, validation is conducted with the validator. Draft 2 teaching materials were created after the validators' comments and suggestions were taken into consideration. Assessment by instructors and students comes next.

Validation of Experts

Three validators, who were lecturers in chemistry, underwent material expert validation. Up to 28 assertions with a range of scores per item 1–5 are validated using a validation sheet in the form of a questionnaire. Curriculum conformity, accuracy, clarity of evaluation in the teaching materials, accuracy of presentation, languange compability, suitability for creative thinking skills, and relevance to the STEM approach are all factors that material experts consider when assessing the material. The validity level of the created teaching materials was ascertained by using the kappa moment formula to the findings of each validator's evaluation. Table 2 below displays the collected kappa moment data.

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Table 2. Material Expert Validation Assessment Analysis Results

Assessment Aspect	Kappa Moment		
	Expert 1	Expert 2	Expert 3
Curriculum conformity	0.94	0.87	0.87
Material accuracy	0.93	0.87	0.93
Clarity of evaluation	0.87	0.75	0.81
Accuracy of material presentation	0.90	0.95	0.90
Languange compability	0.90	0.85	0.80
Conformity with creative thinking skills	1	0.75	1
Material relevance with the STEM approach	0.81	0.87	0.81

The table indicates that each material expert evaluated seven assessment criteria, with a very valid category and an average kappa moment value of 0.87. This demonstrates that the STEM-PjBL-based instructional resources created are appropriate for usage in a very valid validity category.

At the next validation stage, teaching materials are also assessed in terms of media by media experts. by using a validation questionnaire instrument. The evaluation findings are derived from the media expert's completed questionnaire, and the kappa moment formula is then used to examine the assessment data. Table 3 displays the findings of three media expert validators' kappa moments.

Table 3. Media Expert Validation Assessment Analysis Results

Assessment Aspect	Kappa Moment		
	Expert 1	Expert 2	Expert 3
Cover	0.75	0.83	0.83
Layout	0.94	0.97	0.97
Picture and illustration	0.95	0.90	1
Colour	0.75	0.75	1

The table indicates that each media expert evaluated four assessment criteria, with a very valid category and an average kappa moment value of 0.89. This demonstrates that the acid-base solution STEM-PjBL-based instructional materials are appropriate for usage with a very valid valid validity category. Based on the assessment of material experts and media experts, the validity level of teaching materials based on STEM-PjBL-based teaching materials on acid solution material amounted to 0.88 with a very valid category.

Practicallity of Lecture and Student

The next step is for seven lecturers in the chemistry capita selecta course to evaluate STEM-PjBL-based instructional materials on acid-base solution content. The purpose of this step is to assess how useful the STEM-PjBL-based instructional materials are. A practicality questionnaire with up to 13 assertions and a score range for items 1–5 is used for assessment. Aspects of assessment by lecturers include aspects of ease of use, estimated learning time, and benefits. The results of the lecturer's assessment were analyzed using the kappa moment formula. The data on the results of the kappa moment for each aspect obtained can be seen in Table 4 below.

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Table 4. Lecturer Assessment Analysis Results

Assessment Aspect	Kappa Moment						
	Lecturer 1	Lecturer 2	Lecturer 3	Lecturer 4	Lecturer 5	Lecturer 6	Lecturer 7
Ease of use	0.92	0.92	0.95	0.87	0.87	0.96	0.87
Estimated Learning Time	0.87	0.75	1	0.87	0.87	0.75	0.87
Benefits	0.95	0.95	0.90	0.90	0.90	0.90	0.85

According to the table, the average kappa moment value for the three assessment criteria that the lecturer evaluated was 0.89, with a very practical category. This demonstrates that the STEM-PjBL-based instructional resources on acid-base solution materials are useful and fall into a very useful category.

After the teaching materials are declared valid and practical, the next trial is conducted to students. The trial was conducted using a creative thinking skills test. Test questions are given to students before learning and after learning. Furthermore, a student response questionnaire was also distributed to STEM-PjBL-based teaching materials. Benefits, presentation, and display of training materials are among the assessment features. The assessment employs a response questionnaire with up to 17 assertions and a score range for each item 1–5. The results of the student response questionnaire were examined using kappa moments to gauge the degree of use of the developed teaching materials. The findings of the kappa moment analysis of the student responses are shown in Table 5 below.

Table 5. Student Response Questionnaire Analysis Results

Assessment Aspect	Kappa Moment	
	Class A	Class B
Benefits	0.87	0.88
Presentation of Material	0.85	0.85
Display of Teaching Material	0.83	0.84

According to the table, the average kappa moment value for the three evaluation components of the student response questionnaire to the created instructional materials is 0.85, with a very practical category. This demonstrates how the STEM-PjBL integrated teaching resources enhance students' learning and foster their capacity for original thought.

Discussion

The purpose of this investigationis to produce a product in the form of STEM-PjBL-based teaching materials on acid-base solution material that is valid and practical. Teaching materials are prepared based on course learning outcomes. STEM-PjBL-based teaching materials are developed in order to improve students' creative thinking skills by linking chemistry material with other fields and applying it to the results of projects carried out in groups. The research method used is Research and Development with the 4-D development model from Thiagarajan. The stages of the 4D model consist of 4 stages, namely: (1) Define; (2) Design; (3) Develop; (4) Disseminate.

At the define stage, interviews were conducted with lecturers teaching the course to analyze what problems occurred in the lecture process, so that it was found that students' creative thinking skills were still not optimal, this was indicated by the lack of creativity of students in working on KKNI assignments given (Task Routine, Critical Book Report, Critical Journal Review, Idea Engineering, Mini Research and Project), many were still copy and paste from previous

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assignments, lack of student activeness in discussions, 50% of students still obtained low grades in UTS and UAS. The learning resources used are still textbooks, teaching materials containing practice questions, journals, and learning videos. However, the teaching materials used in the learning process have not been integrated with STEM-PjBL. Furthermore, student analysis is carried out through interviews with students, task analysis by analyzing course learning outcomes (CPMK), followed by analyzing Sub-CPMK and goal specifications by analyzing learning objectives on acid-base solution material.

Furthermore, at the design stage, test preparation, formatting and initial design were carried out. The test is prepared based on the test grid that has been made in accordance with the indicators of creative thinking skills, namely fluency, flexibility, novelty (originality) and elaboration. Before use, the test was tested first on 70 students who had received learning, so that valid and reliable test questions were obtained. Furthermore, the creative thinking ability test is given to students before and after learning is carried out. When preparing the typeface format used in the developed teaching materials, namely Times New Roman and Adobe Hebrew for the title and content of the teaching materials, the paper is adjusted to the UNESCO format, which is 15.5 x 23 cm, and the spacing between lines is 1.15 with a column format. The training materials' content is organized in a methodical and logical manner, with a white paper backdrop and a peach and blue color scheme. The color blue calms tense people and increases feelings of well-being. When individuals see the color blue the brain releases eleven neurotransmitters that are pleasant to the body, making it excellent in the learning process [24].

A cover, preamble, introduction, STEM-PjBL components, usage instructions, course learning objectives, and concept maps make up the module's basic layout. Next, go on to the substance of the material related to other subjects (STEM), like the use of acid-base solutions in daily life or the application of technology, engineering, and mathematics. The engineering section contains projects that students will work on along with several practicums related to the material. In addition to mathematics problems, it is also equipped with creative thinking skills questions. A summary, competency exam, glossary, bibliography, and author biography make up the concluding portion.

At the develop stage, validation of teaching materials is carried out to material experts and media experts, a total of 3 people each. Experts assess teaching materials in terms of material and media, this aims to see the feasibility of these teaching materials. Based on the results of expert assessments that have been analyzed using the kappa moment formula, the average is 0.87 for material experts and 0.89 for media experts. So it can be averaged that the validity assessment of the teaching materials that have been developed obtained a kappa moment value of 0.88 with a very valid category. We may infer that STEM-PjBl-based educational resources are appropriate for use in the classroom. The curriculum, the evaluation, the accuracy, the language rules, the ability to foster students' creative thinking, and the components of science, technology, engineering, and mathematics are all met by the instructional materials that have been developed.

Furthermore, the practicality test was carried out on 7 lecturers who taught the high school chemistry capita selecta course. The purpose of this practicality test is to evaluate the value of the lecture-based instructional resources. The kappa moment calculation was used to examine the scores of the seven professors who completed the questionnaire the average was 0.89 with a very practical category. This demonstrates that the STEM-PjBl-based instructional resources created are useful and fall into a very useful category. Student response questionnaires were also distributed to 60 students who had completed learning using STEM-PjBL-based teaching materials. Based on the results of student responses, the average kappa moment value is 0.85 with a very practical category. This demonstrates that the STEM-PjBL integrated teaching resources

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created help students learn and expand their capacity for creative thought. This is in line with several research findings stating that the application of project-based learning models integrated with STEM is significantly effective in improving students' science literacy and creative thinking skills [25]. Other research also shows that the combination of the STEM approach with the PjBL model can improve students' creative thinking skills [26].

In the teaching materials, several projects related to the material are presented, for example, making carbonated drinks from natural ingredients, namely galangal, Chinese lemon, red rosela flowers, nutmeg juice and clove leaves, and lime. The second project is making acid-base indicators from natural materials such as turmeric, hibiscus flowers, roses, and others. The third project contained in the teaching materials is the manufacture of environmentally friendly detergents made from used cooking oil. Students' comprehension of increasingly difficult information is enhanced by this endeavor, which also helps them become more cooperative and think creatively. Besides that, the teaching materials also present acid-base solution material and are associated with other sciences such as technology, engineering and mathematics. The link between the concept of acid-base solution and other sciences will improve students' creative thinking skills. To hone students' creative thinking skills in teaching materials are also presented questions of creative thinking skills.

Conclusion

The following conclusions can be drawn from the research findings:

1. The value of the kappa moment is 0.87 for material experts and 0.89 for media experts, so the STEM-PjBl-based teaching materials on acid-base solution material are considered very valid. The average validity of the two experts is 0.88.
2. The average kappa moment of the lecturer is 0.89 and the average value of the student response questionnaire is 0.85, so the STEM-PjBl-based teaching materials on acid-base solution materials are included in the very practical category.

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Development of a STEM-based electrochemistry e-module

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Abstract. *Education in the era of the industrial revolution 4.0 must be able to equip graduates with 21st century skills (21st Century Skill) such as critical thinking skills in solving problems, creativity and innovation as well as communication and collaboration skills. The STEM (Science, Technology, Engineering and Mathematics) approach in chemistry learning can stimulate students to actively participate and be able to integrate various disciplines in solving various challenging problems faced. One way to do this is by integrating STEM into the Electrochemistry e-module. The purpose of this study is to produce a valid (feasible) and practical electrochemistry e-module. This study is a development research with the ADDIE model, conducted in the Chemistry Education Study Program in the Selected Chemistry Capita course. The results showed that the STEM-based electrochemistry e-module developed was declared very feasible with a feasibility percentage of 89.441 and an average practicality value of 85.56 with a very good category.*

Keywords: *Development, E-Modules, STEM, Electrochemistry, Feasibility*

Introduction

Education in the era of the industrial revolution 4.0 must be able to equip graduates with 21st Century Skills. These skills include critical thinking in solving problems, creativity and innovation as well as communication and collaboration skills. This is stated in the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 49 of 2014 concerning National

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Standards for Higher Education Article 6 which states that graduates of the Bachelor's Program must have general skills, namely being able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that pays attention to and applies humanities values that are in accordance with their field of expertise [1].

Science learning with the Science, Technology, Engineering and Mathematics (STEM) approach is one way out to improve graduate skills in the era of the 4.0 revolution. Through this concept, it is possible to combine four branches of science, namely Science, Technology, Engineering and Mathematics into learning that focuses on problem solving. The STEM approach can play a role in expanding students' skills in producing more creative ideas or ideas [2].

Based on the results of observations that have been carried out in the Kapita Selekta lecture, the learning process uses textbooks, journals, and learning videos, the teaching materials used have not been integrated with STEM and only contain materials and practice questions. Students have difficulty in understanding the material which is characterized by a lack of critical thinking skills in connecting chemical concepts with everyday life phenomena during the learning process so that many students still get low scores.

In chemistry learning, the quality of learning and the achievement of learning objectives are greatly influenced by several factors, one of which is the use of teaching materials. Through teaching materials, lecturers and students will find it easier and more helpful in carrying out the learning process. One of the teaching materials that can be developed by lecturers is a module. Modules that follow the development of information and communication technology really need to be developed. According to Nasution (2020) E-module is an innovation that has a very large contribution to changes in the learning process, where the learning process is no longer just listening to the lecturer's explanation of the material but students also carry out other activities such as observing, doing, demonstrating and others [3].

STEM (Science Technology Engineering and Mathematics) based e-modules are innovative teaching materials presented in digital form that can be easily accessed. E-modules can be created using the kvisoft flipbook maker application. This application is known as a professional software for converting PDFs into double-sided flash books. This software can create HTML5 and flash double-sided books from all types of files: PDF, images, Word, PowerPoint, Excel, and others [4]. STEM-based e-modules are modules that are systematically compiled and developed whose content integrates chemistry (science) with technology, engineering and mathematics where learning is combined with the real world as an application of these fields which are developed with the help of kvisoft flipbook maker in digital form that can be accessed by students independently. In addition, STEM integrated teaching materials are also effectively used in the learning process which can improve student learning outcomes [5].

Based on the background that has been described, it is necessary to conduct a study on "Development of STEM-Based Electrochemistry E-Modules". The purpose of this study is to produce electronic teaching materials in the form of STEM-based electrochemistry e-modules that are feasible and practical.

Methods

The type of research used in this study is Research and Development (R&D), which is a research method used to produce certain products and test the effectiveness of the product. The development model used in this study is the ADDIE model. The ADDIE model consists of 5 stages including Analysis, Design, Development, Implementation and Evaluation [6], but the discussion of this study only goes as far as the feasibility and practicality test of the e-module. This research was

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conducted at the Chemistry Department, Faculty of Mathematics and Natural Sciences, State University of Medan. The respondents in this study were chemistry lecturers as validators, and lecturers in the Chemistry Education study program who taught the Selected Chemistry Capita courses. The data collection technique in this study used a feasibility instrument and a practicality questionnaire, where feasibility was determined from the validator's assessment while practicality was determined from the lecturer's response to the e-module being developed.

Results and Discussion

Analysis Stage

The analysis stage is an initial identification of how the performance, needs and characteristics of Chemistry Education Study Program students are as a reference for the background of the research through observation and reflection from the previous selective capital lecture process. Observation activities through observation during the lecture process. The aspects observed include the use of media, learning resources, methods, and learning models.

Based on the results of observations in the selective capital lectures, it is known that there are no teaching materials specifically for selective capital materials in printed or electronic form, most lectures use lecture methods, questions and answers and focus on solving practice questions. Although in lectures, case method and project assignments are given, students have not been fully able to integrate the concept of chemical material with technology and engineering, this causes the learning outcomes obtained by students to be still low. Therefore, the development of STEM-based electronic modules needs to be carried out to optimize the lecture process and direct students in understanding chemical material and being able to relate the concepts to everyday life.

Material analysis is carried out by looking at the lecture devices, especially the Semester Learning Design (RPS) for Selected Chemistry Capital. This analysis aims to obtain information and become a basis for detailing the content of the developed e-module. The formulation of learning outcomes for the course is: 1) Able to explain the concept and analyze oxidation-reduction reactions in electrochemical cells, 2) Able to write electrolysis reactions in metal plating and refining a metal and, 3) Able to apply Faraday's law for electrolysis of electrolyte solutions.

Design Stage

The product design stage is the initial design stage of STEM-based e-modules on Electrochemistry material, determining the format/systematics of the e-module, determining the outline of the material content based on the curriculum analysis that has been carried out, searching for and determining STEM-related content from various sources such as journals and textbooks, determining aspects of validation instrument assessment, practicality, student response questionnaires and test instrument indicators. To compile the e-module, a systematics consisting of: cover, foreword, introduction, table of contents, module usage instructions, module description, course learning outcomes, concept maps, electrochemistry material (integrating material with science, technology, engineering and mathematics), equipped with sample questions, practical activities, brief information, summary, self-reflection, competency test, answer key, glossary, bibliography and author biography is used.

Development Stage

This stage is the process of making the design a reality. The resulting product is a STEM-based electrochemistry e-module using the kvisoft flipbook maker application. The development process goes through the following stages: 1) creating an e-module that has been designed based on a

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predetermined systematics, 2) after the module has been designed, it is exported or published in the form of swf and exe with the kvisoft flipbook maker application so that an electronic module is produced, 3) then the e-module is validated by a team of experts, namely media experts and material experts to determine the feasibility of the developed e-module, 4) revision of the e-module based on the assessment results of the validator, namely material experts and media experts.

The validation stage of the e-module that has been developed by conducting a feasibility test of the e-module to 3 validators (material and media experts). In the material validation instrument there are 3 components, namely, 1) the suitability of the material with the Course Learning Outcomes (CPMK), 2) the relationship between the material and STEM, and 3) integrated critical thinking skills. Based on the questionnaire that has been filled by the material experts, the assessment results are obtained, then the data is analyzed to determine the feasibility criteria of the developed e-module. The following is a recapitulation of the feasibility data by 3 material experts presented in table 1.

Table 1. Recapitulation of Material Feasibility

No.	Material Feasibility Aspect	Validator 1	Validator 2	Validator 3	Average	Criteria
1	Material Compliance with CPMK	100	100	87.5	95.833	Very fesiable
2	Relationship with STEM	92.857	89.286	85.714	89.286	Very fesiable
3	Integrated Critical Thinking Skills	100	75	100	91.667	Very fesiable

The validation results showed a positive assessment of the STEM-based electrochemistry e-module that had been developed from the material aspect with an average feasibility value of 92.262 with the criteria of Very Feasible. The developed module was also assessed from the media aspect by media experts using the media feasibility instrument.

The media aspects assessed were the presentation, language, and graphic components. Based on the media feasibility questionnaire sheet that had been filled out by 3 validators, the assessment results were presented in table 2.

Table 2. Recapitulation of Media Feasibility

No	Media Feasibility Aspect	Validator 1	Validator 2	Validator 3	Average	Criteria
1	Presentation Component	98.75	91.25	82.5	90.833	Very fesiable
2	Language Component	100	75	75	83.333	Very fesiable
3	Graphic Component	97.727	93.454	65.909	85.697	Very fesiable

The validation results showed a positive assessment of the STEM-based electrochemistry e-module that had been developed from the media aspect with an average feasibility value of 86.621 with the criteria of Very Feasible. Thus, it can be concluded that the feasibility value of the STEM-based electrochemistry e-module based on the material and media aspect values obtained an average feasibility value of 89.441 with the criteria of very feasible.

In addition to providing an assessment of the e-module being developed, the validator also provided suggestions for several shortcomings in the e-module being developed so as to produce good teaching materials that are feasible to be used in learning electrochemistry material. Based on several suggestions given by the validator to the e-module, a revision stage was then carried

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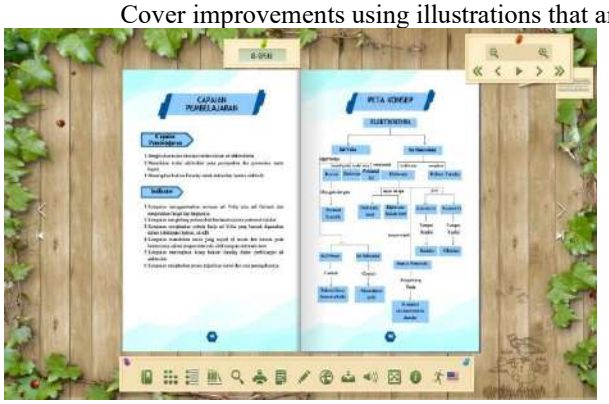
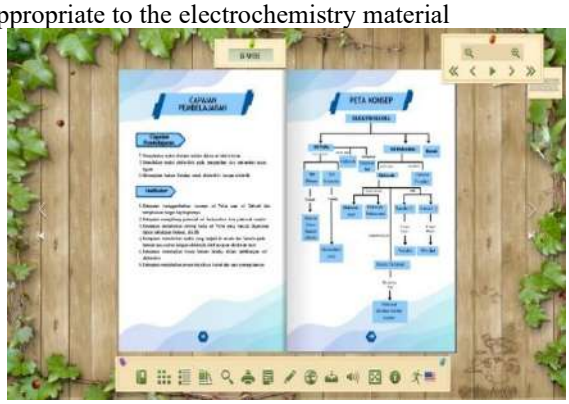
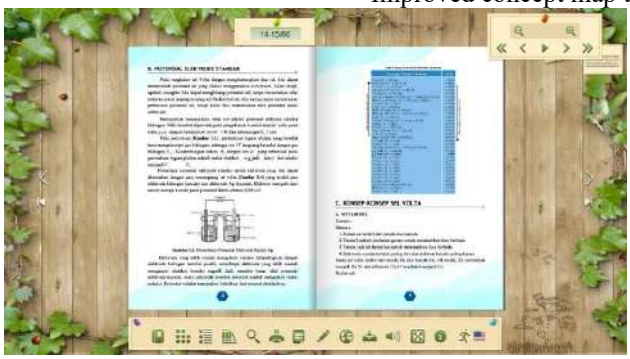
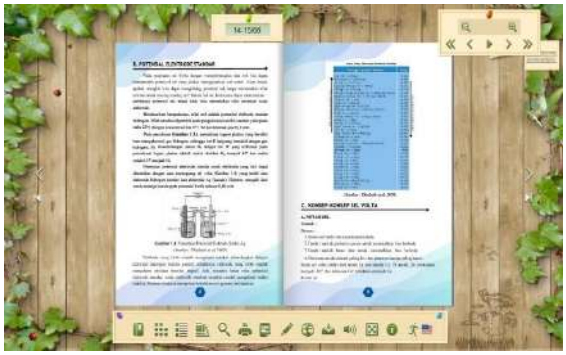
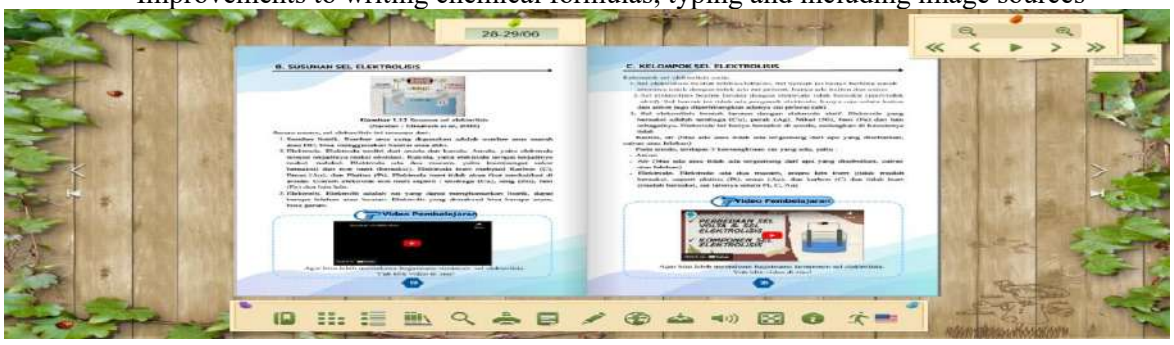
out to perfect the e-module. Several changes in the appearance of the STEM-based electrochemistry e-module can be seen in table 3.

Table 3. Changes in E-Module Appearance

Before Revision	After Revision
Cover improvements using illustrations that are appropriate to the electrochemistry material	
	
Improved concept map to be more structured	
	
Improvements to writing chemical formulas, typing and including image sources	
	
Improvements by adding learning videos that are appropriate to the material	

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The next stage is the assessment of the e-module by 3 lecturers of the Chemistry Selective Chapter course. The purpose of this assessment is to determine the level of practicality of the STEM-based Electrochemistry e-module that was developed. The following is table 5 which contains a recapitulation of the lecturer's practicality assessment based on the results of the practicality questionnaire consisting of 11 questions with a score range per item of 1-5.

Table 5. Recapitulation of Practicality by Lecturers

No	Assessment Aspects	Lecturer 1	Lecturer 2	Lecturer 3	Average	Criteria
1	Ease of Use	90	86.67	90	88.89	Very good
2	Estimated Learning Time	80	90	80	83.33	Very good
3	Benefits	86.67	86.67	80	84.45	Very good

The results of the practicality by the lecturer showed a positive assessment of the STEM-based electrochemistry e-module that had been developed with an average practicality value of 85.56 with the criteria of Very Good.

Conclusion

Based on the results and discussions that have been described above, it can be concluded that the validity of the STEM-based electrochemistry e-module is stated as very feasible with an average feasibility value of 89.441, where the average feasibility value of the material aspect is 92.262 with very feasible criteria and the average feasibility value of the media is 86.621 with very feasible criteria. The average practicality value of the e-module is 85.56 with very good criteria, thus producing a STEM-based Electrochemistry e-module with very feasible and very good criteria (practicality).

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Development of storyboard media in learning chemistry on colloid materials to increase students' creativity

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Abstract. This research aligns with the advancements of 21st-century technology in society 5.0, where learners are encouraged to use web-based learning media. The study aims to enhance students' creativity in chemistry education, particularly in the topic of colloids, utilizing technology-based teaching through the Storyboard media. This research employed the Research & Development (R&D) method with a 4-stage model: define, design, develop, and disseminate. Conducted at the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, the study utilized questionnaires and tests to assess students' learning improvements. The research findings indicate that the validation of the questionnaire instrument by experts yielded highly satisfactory results: the questionnaire format, content format, as well as language and writing were deemed suitable with respective ratings of 100%, 88%, and 100%. The overall validation rate for the creativity instrument questionnaire is 96.4%., the validation results of the test instrument by expert validators confirmed its validity. Furthermore, the presentation of media validation results by expert validators yielded the following data: material aspect, illustrations, quality and appearance, and attractiveness were rated at 100%, 100%, 90%, and 90%, respectively. Overall, the feasibility score reached 95.50%, indicating that the instrument is considered suitable for use. After validating the media, it was implemented with students to assess their creativity levels, the average percentage score was 86%, indicating a very good category. Thus, it can be concluded that the Storyboard Media developed in this study is suitable for use.

Keywords: Development, Storyboard, Creativity, Participants, Validation

Introduction

The description that has been described above, is necessary to conduct research on "Development of Storyboard Media in Learning Chemistry on Colloidal Materials to Increase Students' Creativity". The purpose of this study is to produce learning media.

The society 5.0 era has changed the global perception of politics, social, economy, and also the scope of education. Educational adaptation in the face of society 5.0 which emphasizes the development of character values, empathy, and tolerance in line with the development of competencies that think critically, innovatively, and creatively [1]. Integrating virtual space and physical space into one makes it easier for educators by utilizing the *Internet of Things* (IoT), *Virtual/Augmented reality*, and *Artificial Intelligence* (AI). These media have paved the way for unlimited learning potential. The world of education in the era of Evolution 5.0 plays a role in improving the quality of Human Resources (HR) by revolutionizing and orienting towards more

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modern learning. [2] Higher Education (PT) plays a role in preparing competent graduates for the world of work that is needed today [3], [4], [5].

The 21st-century life skills, the 4Cs, namely *Creativity, Critical Thinking, Communication*, and *Collaboration* are one of the answers in facing the challenges of the 4.0 revolution era and society 5.0 in preparing competent graduates [6]. However, in fact, based on the results of several studies that have been carried out, the level of creativity of students in Indonesia is very low [6], [7], [8]. Observations have also been made on chemistry learning with the aim of finding solutions to improving learning outcomes and students' creativity. The results of the observation found that it is necessary to develop learning media based on theories, concepts and follow the rapid development of science and technology, in order to increase students' enthusiasm, creativity and interest in learning. This is by several studies, including the use of technology-based learning media that has a positive impact on changes in education in the era of society 5.0 [9]. Learning media is needed by educators to be applied during learning to students [10]. In addition, the use of digital media in learning can increase the interaction between educators and students, because it takes place on reciprocity during learning [11], [12].

One example of technology-based learning media that is in great demand in chemistry learning is computer-based interactive learning media, such as *Adobe Flash CS6, digital comics, e-books, flipbooks, and augmented reality* [13]. Based on the results of the research, the use of interactive media in learning can improve critical skills [14], Creativity [15], and learning outcomes [16],[13], [17]. In this study, the interactive media to be developed is *storyboard interactive media. Storyboard* is an interactive learning media that uses storylines to convey information in learning. The results of the study showed that the use of storyboard media in learning buffer solutions was more effective in mastering students' material [18]. There is an effect of the use of storyboard media learning on students' learning creativity in cultural arts lessons [19].

Based on the description that has been presented, it is necessary to conduct research related to the "Development of Storyboard Media in Chemistry Learning on Colloidal Materials to Increase Students' Creativity". The purpose of this study is to produce learning media and measure the increase in students' creativity.

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Method

This research was conducted at the Department of Chemistry, Universitas Negeri Medan (State University of Medan), to use valid storyboard media applied to chemistry learning to increase students' creativity in colloidal materials. The research population is all students majoring in chemistry, with a research sample of 150 students. This research uses the Research and Development (R&D) method with the 4-D model (Define, Design, Develop, and Disseminate) as the research design.

The implementation of storyboard media on colloidal materials is carried out for students. Then, students are given learning materials and interactive media that are developed, followed by increased student creativity during learning activities. Expert validators carried out a feasibility analysis of storyboard media using questionnaire instruments. This questionnaire uses a Likert scale with a score criterion range of 1 = very bad; 2 = not good; 3 = good; and 4 = very good. The research instrument used in this study is a student creativity questionnaire.

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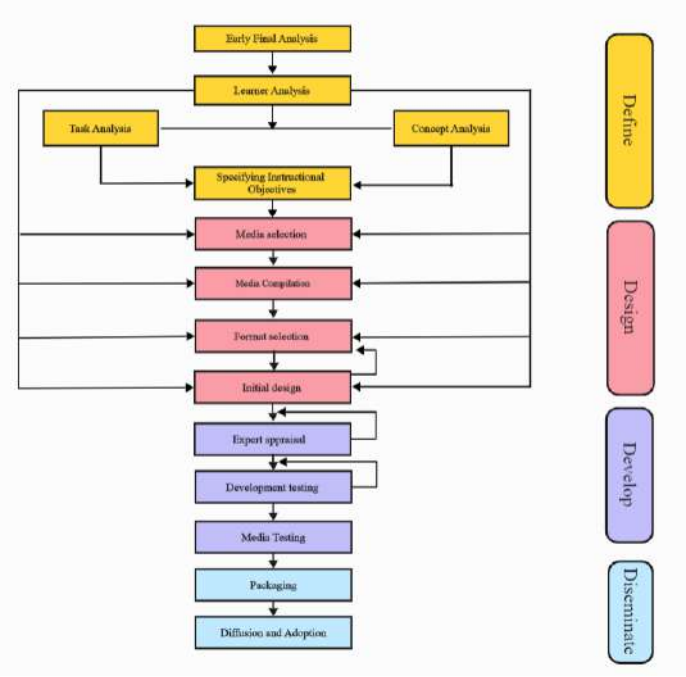

Figure 1. 4d Model Development Design

Result and Discussion

Media Validation by Expert

Learning media plays a very important role in achieving a goal that has been set in the learning process [20][21]. Good learning media requires validation stages to ensure that the content, methods, and designs are effective in achieving learning objectives and in accordance with student standards and needs.

Validation of learning media is crucial in ensuring that the learning tools developed meet the quality and effectiveness standards needed to support the teaching and learning process. This process involves an assessment from experts or validators who assess various aspects of learning media, the assessment aspects include material, illustrations, attractiveness, quality and appearance. To ensure that the media is in accordance with the desired educational objectives. This validation includes checking 1) Material, 2) Illustration, 3) Quality and appearance, and 4) Attractiveness with the aim that the media can increase students' creativity and learning outcomes. And if the results of the validation process contain feedback that is important to improve and improve the learning media, then input will be accepted so that the media can be perfected so that the media can be widely applied in the context of education.

The media that has been designed is validated by expert validators using a questionnaire, where the expert validator is a lecturer from the Department of Chemistry, State University of Medan and the following results are obtained:

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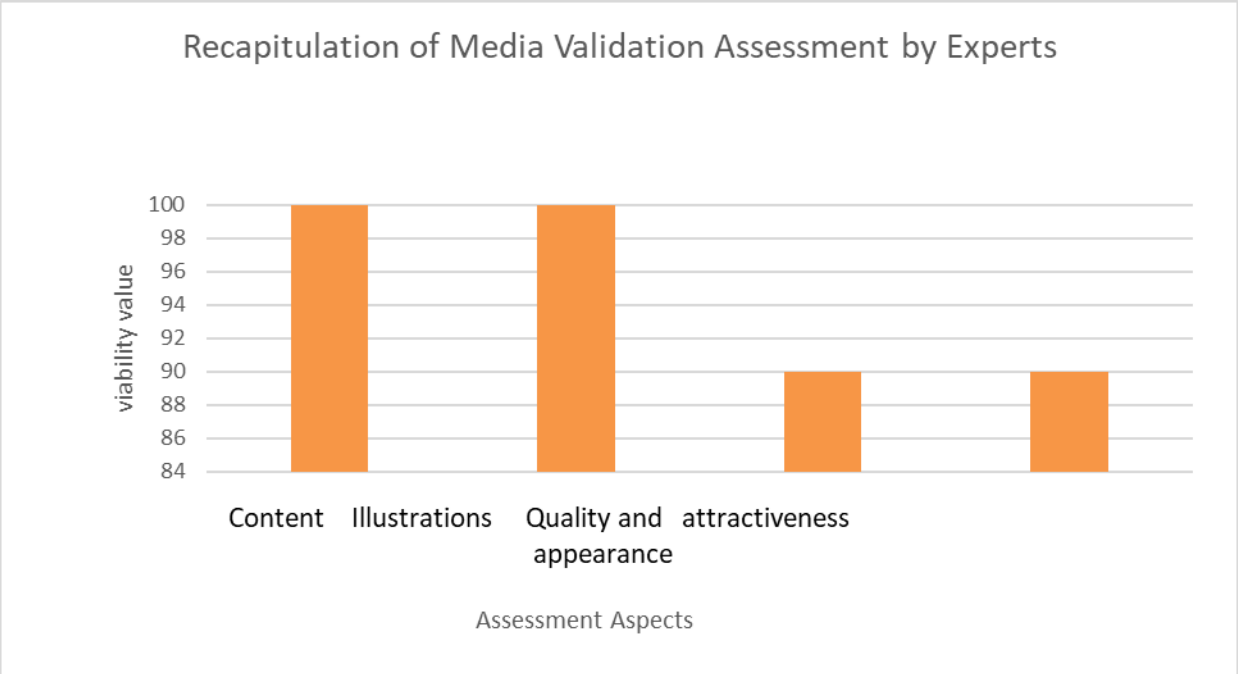

Figure 2. Results of Media Validation Assessment by Experts

Based on Figure 2. above the results were obtained that from 4 aspects of the assessment got very good results where the presentation of the results of media validation by expert validators showed the following data: material aspects, illustrations, quality and appearance, as well as attractiveness were assessed 100%, 100%, 90%, and 90%, respectively. The average percentage value of the result is 95%, so based on [22], the range of 90-100 is stated to be very feasible and does not need to be revised so that the designed storyboard learning media is feasible and can be implemented for students. After an expert validator validates the learning media, the next step is to test the learning media on students. The test was carried out to see the effectiveness of storyboard learning media in increasing students' creativity.

Student Creativity Asessment

Storyboard media on colloidal material that has been validated is taught to students. Furthermore, observations were made on the increase in students' creativity by measuring using a creativity questionnaire that had been validated by expert validators and obtained the following results:

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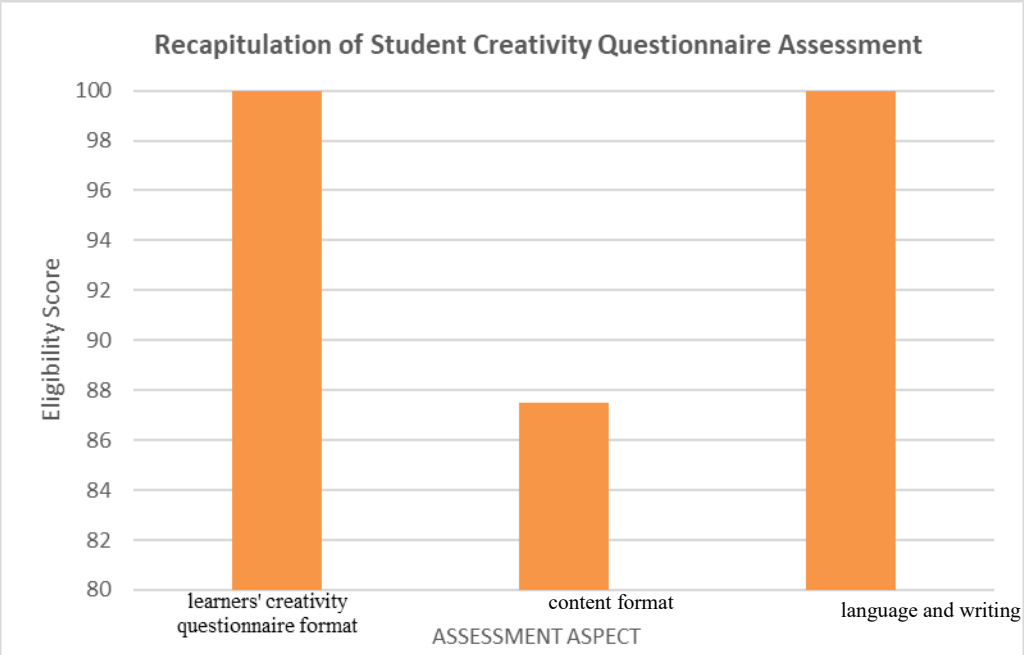

Figure 3. Student Creativity Questionnaire Assessment

Based on Figure 3. above, it can be concluded that based on the assessment, includes 3 aspects, that is: the format of the questionnaire for students' learning creativity, the format of the content and also the language and writing. The questionnaire that has been developed has an above-average feasibility of 96.4% with a very feasible category, this is supported by Sugiono's (2016) research that the questionnaire is valid and very feasible to be implemented for students [23].

After an expert validator validates the questionnaire and is suitable for implementation, the next stage of the questionnaire is distributed to students to be filled out according to the results of their learning experience obtained during learning using *Storyboard media*. After the learning is complete, students are directed to fill out a creativity questionnaire containing 24 questions that students can access through a google form, where the results of the answers that students have filled in will be used to measure the level of creativity of students who have been taught storyboard media. From the results of the data collection that has been filled in, the value of the presentation of students' creativity in each question item is obtained as follows:

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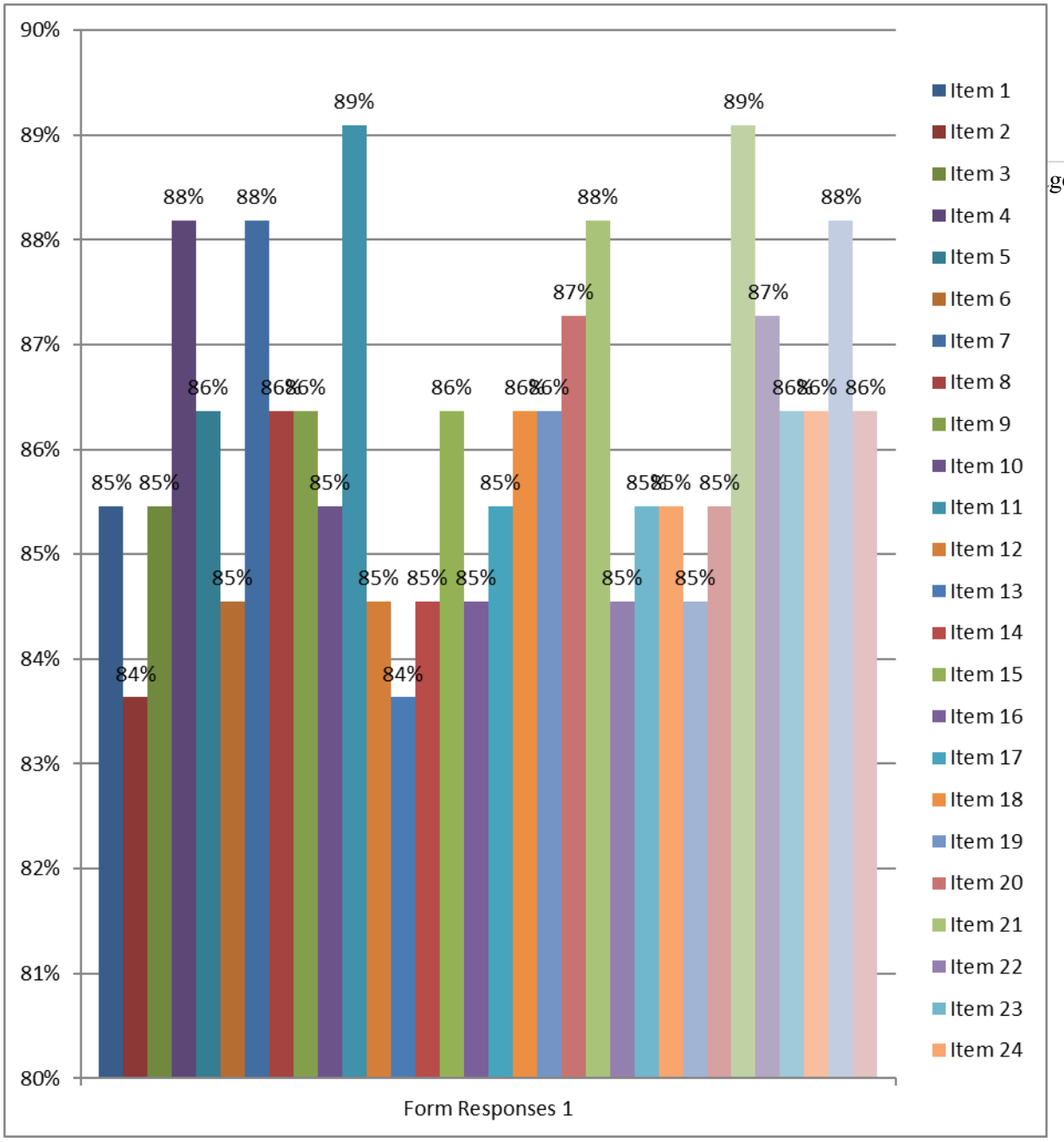

Figure 4. Student Creativity Questionnaire

Based on graph 4.4 above, it can be concluded that after learning using storyboard media, there is an increase in students' creativity with the average score of the percentage of students reaching 86% and included in the good category.

Based on the data obtained, it can be concluded that Storyboard media is very suitable to be used as a learning medium for students on colloidal materials. Other research also supports the feasibility of using storyboards as a learning medium that is very suitable for increasing participants' creativity and making the learning process more relaxed and interesting [24]. Learning with storyboard media has been proven to direct students to be more creative, active, and make learning activities more enjoyable [25].

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Conclusion

Based on the research results regarding the use of storyboard media for colloidal material, the feasibility score reached 95.50%, indicating that the instrument is considered highly feasible for use. Additionally, the implementation results show an increase in student creativity, with a percentage of 86%, which is categorized as very good. Therefore, it can be concluded that the storyboard media for colloidal material developed in this study is suitable for enhancing student creativity in learning.

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Development STEM-PBL based teaching module integrated with scientific literacy in electrochemistry material

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Abstract. *Ability to think creatively is one of the skills expected in education in the 21st century. However, students' creative thinking ability is still in low category. This is due to the lack of stimulus in generating new ideas and students' scientific literacy abilities. One effort to improve creative thinking skills is by implementing integrated STEM-PBL learning in scientific literacy. The research was carried out in the Chemistry Education Study Program, Department of Chemistry, for one semester. The aims of this research are: (1) develop a STEM-PBL learning plan integrated with scientific literacy to stimulate student activity in learning to improve students' creative thinking abilities, (2) develop and standardize test instruments to measure students' creative thinking abilities, and (3) determine the effectiveness of integrated scientific literacy STEM-PBL learning on students' creative thinking abilities. This research is development research by adopting the Plomp development model which consists of 4 stages: the planning, design, realization and testing, evaluation and revision stages. Data were analyzed using descriptive statistics (average scores and percentages). The results of development module had been created, the module was validated with 3 expert validators so that the results obtained from validator I was 3,67, validator II was 3,5 and validator III was 3,6. These three results are categorized as very valid, this shows that the use of a STEM-PBL learning model integrated with scientific literacy in Basic Chemistry learning can improve students' creative thinking abilities so that this makes students think more actively and increase their creativity in implementing learning.*

Keywords: Creative Thinking, Learning Model, STEM-PBL, Scientific Literacy

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Introduction

Learning chemistry is one of the lessons that has its own characteristics and requires skills in solving chemical science problems in the form of theories, concepts, laws and facts [1]. One of the learning objectives of chemistry is for students to understand chemical concepts and their interrelationships and applications in both everyday life and technology [2]. Therefore, students are expected to be able to understand and master chemical concepts.

Chemistry is a science that studies everything such as the structure, composition, properties and changes of matter and the energy associated with it. Chemistry is quite difficult to learn, this is because there is some coverage of teaching material in the form of concepts that are abstract and complex, so students find it difficult to understand the representation of things that are abstract and cannot be directly observed by students, so a change is needed in the learning process so that students can more easily understand chemistry material [3].

In order to master a course, various facilities or tools in the form of teaching materials are needed to facilitate the teaching and learning process. One of the most important of these is the teaching module, which is useful for helping students to understand the material and practices to be studied in specific courses [4]. Teaching modules are the smallest teaching and learning programme units that students can study independently or that students can teach themselves (self-instruction) [5]. Chemistry teaching modules that are more varied, innovative, and practical will certainly greatly help students to understand chemistry courses. This will also affect the success of the learning process [6].

An indicator of the success of educators in the learning process is the change in attitude or knowledge of students who have experienced the learning process [7]. A learning method that can activate students in the learning process is the use of the discovery or inquiry method. This inquiry learning model emphasizes more on learning activities, namely the process of critical thinking and analysis to find answers to the problems posed [8].

The Chemistry Module integrated with STEM (Science, Technology, Engineering and Mathematics) and PBL (Problem-Based Learning) is a module that has a high criterion of 0.75 so that this module is effectively used in the learning process as a learning resource [9]. According to Suryaningsih [10] and Adhelacahya [11] STEM-PBL in chemistry material is able to build students‘ creative thinking skills and also become a module that can increase students’ understanding of chemistry material because students become interested in the modules that have been given this is also a passion in learning.

The initial analysis of the learning module used so far has not had the aim of improving students' science literacy, which means that it has not explained the scientific role of science material for society and has not explained the role of material technology for society. In addition, the module that has been used also has not answered questions about the study of material based on the data presented, has not presented material based on student exploration and observation to find new information related to the material. The teaching materials that have been used so far also have not presented examples of material applications in everyday life so that they have not been able to describe experiments that are in accordance with the material and do not motivate problem solving based on scientific evidence. For this reason, an innovation is needed, one of which is the development of a STEM-PBL-based module, where this module is designed so that students have the knowledge, attitudes, and skills to identify questions and problems in their life situations, explain natural phenomena, design, and draw conclusions from the material that has been taught. At the same time, students become constructive, caring, and reflective human beings using ideas

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of science, technology, engineering, and mathematics [12].

Methods

This research was conducted at the Chemistry Education Study Programme, Faculty of Mathematics and Early Sciences, Medan State University, and this research began in May - September 2024. The research conducted included research and development (R&D) using the ADDIE type of development model. The background in choosing the ADDIE model as a development model is because the stages are simple, and very suitable for problem based learning models. The ADDIE model has five stages, namely (A)nalysis, (D)esign, (D)evelopment, (I)mplementation, and (E)valuation, but in this article only until the development stage.

The instruments used in this research are product validation questionnaires by experts and product practicality questionnaires by lecturers. The data analysis technique in this study is that after collecting data, the next stage is analysis. In this study, the data analysis techniques used were qualitative data analysis techniques and quantitative data analysis techniques to describe the validity and practicality of STME-PBL integrated chemistry e-modules with valid criteria Hinton, McMunay & Brownlow [13] as shown in Table 1.

Table 1. Average Score Conversion to Validity

Score X	Description
1,00 - 1,99	Not Valid
2,00 – 2,74	Less Valid
2,75 – 3,49	Valid
3,50 – 4,00	Very Valid

Result and Discussion

This research is a research and development (R&D) that produces products in the form of STEM-PBL-based chemistry learning modules that are suitable for use as teaching materials and handbooks for students so that they can overcome students' weaknesses in understanding electrochemical concepts. The steps are as follows:

Data Collection

The data collection stage is carried out to obtain the information needed in order to achieve the research objectives. The steps taken at this stage are needs analysis is to analyze course learning outcomes that are used as a reference in developing modules, literature review is to review previous studies related to the development of learning modules based on multiple representations, problem identification is to analyze the factors that cause problems so that there needs to be module development.

Planning

After identifying the problems encountered, then analyze solutions to solve these problems. There is some planning that is done, namely: Determination of product design, formulation of learning objectives, and preparation of Rencana Pembelajaran Semester (RPS).

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Module Development

Through this stage, the initial design of a STEM-PBL-based chemistry learning module that can improve students' science literacy is prepared, so that this teaching module can be used as one of the student learning resources. The design for STEM-PBL-based teaching modules is presented in table 1 below.

Table 2. Design of teaching materials based on science literacy components

Number	Components of Science Literacy	Teaching Materials Design
1	Science as a body of knowledge	Display theories, concepts, principles according to the material presented
2	Science as a way to investigate	Answering questions about the application of the material Answering questions regarding the study of material based on the data presented Presenting material based on student exploration and observation to find new information related to the material.
3	Science as a way of thinking	Presents examples of material applications in everyday life Presenting an overview of experiments that are in accordance with the material Motivate problem solving based on scientific evidence
4	The interaction of science, technology and society	Describe the role of material science for society Describe the role of material technology for society

Based on the initial design of the teaching module that has been made consisting of the components of Science as a body of knowledge, Science as a way to investigate, Science as a way of thinking and the interaction of science, technology and society. Then below is also presented a table for the description and description of Electrochemical material, namely in the following table 2.

Table 3. Description of material in teaching materials Electrochemistry

Number	Material/ Sub-materials	Materials presented in the e-module
1	Foreword	A general description of the material, a brief explanation of STEM-PBL and the purpose of writing the e-module.
2	Preface	Description of STEM learning model, expected learning outcomes, learning indicators and concept map of electrochemistry.
3	Redox Reactions	Explanation of teaching materials, integration of Science (Corrosion Events) and Technology (Paint Coatings)-PBL in the material, presentation of summaries, example problems and their solutions, and competency tests giving questions related to the material.
4	Electrodes and Electrolytes	Explanation of teaching materials, integration of Science-PBL Lithium Ion Batteries, presentation of summaries, example problems and their solutions, and competency tests giving questions related to the material.
5	Electrochemical Cell	Explanation of teaching materials, integration of Science (Metal Plating)-PBL, presentation of summaries, example problems and their solutions, and competency tests giving questions related to the material.
6	Electrolysis Cell	Explanation of teaching materials, integration of Engineering (Key Gilding with Copper Metal)-PBL, presentation of summaries, example

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problems and their solutions, and competency tests giving questions related to the material.

Based on the design of the teaching module and the description of the material that has been presented above, the resulting module is a STEM-PBL-based teaching material on Electrochemistry material designed to build students' concept understanding so that it can improve students' science literacy. To obtain a learning module that meets the criteria of feasible/valid and builds students' understanding of concepts, researchers follow development procedures and analyze research results. In meeting these objectives, researchers developed learning modules using the ADDIE model through a series of development stages, namely the analysis stage, design stage, development stage, implementation stage, and evaluation stage. With the results of the feasibility assessment of the development results that have been filled in by content/material experts. Then at this stage, the module that has been developed and compiled based on the material description, the next step is validation by a team of experts in their fields, namely 3 validators with 4 aspects of assessing the feasibility of content, presentation components, language components and graphic components presented in table 3.

Table 4. Table of expert validators

Number	Assessment Aspect	Score			X	Description
		V 1	V 2	V 3		
1	Components of Content Appropriateness					
	1) Suitability of Material with Learning Outcomes	3,75	4	3,75	3,83	VV
	2) Link to Science, Technology, Engineering and Mathematics (STEM)	3,75	3,75	3,75	3,75	VV
	3) Integrated Critical Thinking Skills	3,2	3,2	3,2	3,2	V
2	Presentation Component					
	1) Presentation Technique	3,2	3,6	3,2	3,33	V
	2) Supporting Material Presentation	3,75	3,75	3,75	3,75	VV
	3) Presentation of Learning	3,2	3,4	3,4	3,33	V
	4) Completeness of e-module elements	3,57	3,57	3,57	3,57	VV
3	Language Component					
	1) Readability	3	3	3,3	3,1	V
	2) Coherence	4	3	3	3,33	V
	3) Use of terms and symbols	3	3	3	3	V
4	Graphics Component					
	1) Size of Module	4	4	4	4	VV
	2) Design of e-module cover	3,5	3,5	3,5	3,5	VV
	3) Module Content Design	4	3,3	4	3,76	VV
	4) Typography of the module content	4	4	4	4	VV
Rata-rata		**3,67**	**3,5**	**3,6**	**3,59**	VV

Description: Rating categories: 1.00-1.99 = invalid (IV); 2.00-2.74 = less valid (LV); 2.75-3.49 = valid (V); 3.50-4.00 = very valid (VV).

Based on the results of module validation to 3 validators, the STEM-PBL-based teaching module on electrochemical material was obtained with an average of validator 1 with a value of 3.67 (with

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a very valid category), validator 2 with a value of 3.5 (with a very valid category) and an average validator 3 with a value of 3.6, so that the average obtained from the three validators was 3.60 (with a very valid category). Based on Table 4, the information obtained on average with very valid criteria, but there are several subcomponents with valid criteria, namely the criteria for critical thinking skills, presentation techniques, presentation of learning, coherence and use of symbols, this is because the subcomponents are less than optimal presentation but this e-module is very feasible to use in the learning process. The following are also presented some pictures for teaching modules that have been made in Figure 1. STEM-PBL Based Teaching Module on Electrochemistry material

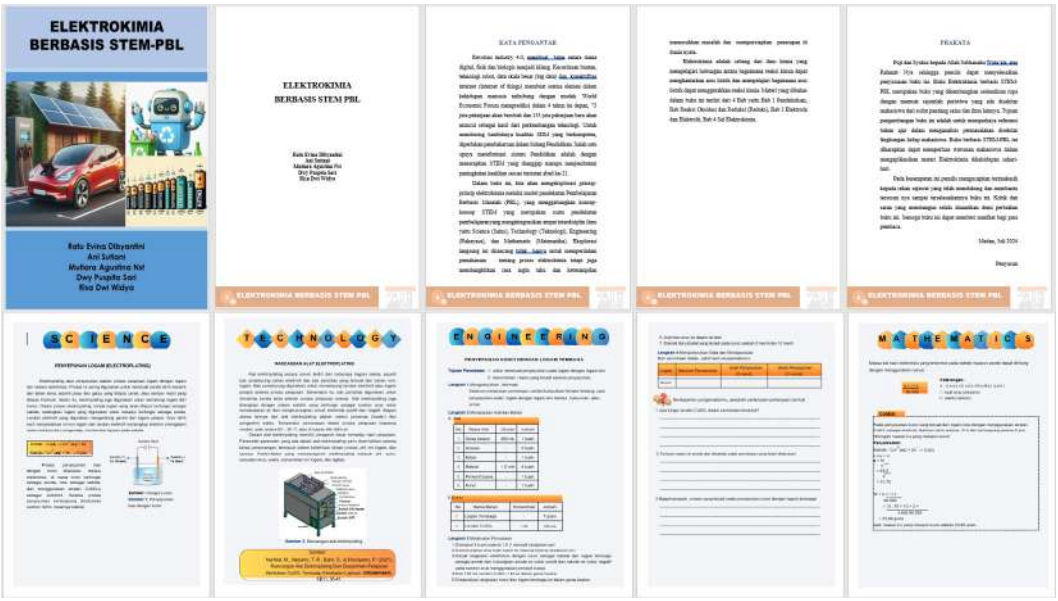

Figure 1. Module STEM-PBL in Electrochemical Material

The module developed has the advantage of being based on STEM-PBL, where Science is an activity that involves understanding and applying about natural phenomena and the state of social behavior using a systematic methodology, and based on evidence through observation and experimentation, in this module given examples such as metal plating (eletroplating), lithium ion batteries and corrosion. Technology is the knowledge and skills to design and construct machines, systems, materials and processes that benefit humans in an economical and environmentally friendly manner, in this module examples are given of the design of electroplating equipment, electric cars, and corrosion prevention techniques. Engineering is a variety of innovations to modify nature to meet human needs and desires and mathematics is everything related to patterns, relationships, numbers, quantities, and space and provides a language for technology, engineering and science, in this module given the calculations that exist in electrochemical material and experimental data collection.

Based on the explanation above, the STEM-PBL-based module on electrochemical material can be used as one of the student learning resources so that it can further add insight and knowledge about electrochemical material, especially can improve students' science literacy skills so that in the future students have high competitiveness in the world of work [14].

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Conclusion

The STEM-PBL teaching module is a new innovation in learning electrochemistry courses which is expected to increase the activeness and science literacy skills possessed by students to find and solve problems systematically, logically, and analytically. The validation results with an average validator of 3.59 with a very valid category so that this module is very good to use as one of the electrochemistry learning resources so that students can improve their science literacy skills which will also have an impact on increasing higher order thinking skills.

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Development of project based learning teaching (PjBL) materials based on the outcome based education (OBE) curriculum on the topic of acid-base solutions to improve students' collaboration skills

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Abstract. *Collaboration skills are essential for students to cultivate, as they play a critical role in facilitating success across educational settings, professional environments, and societal interactions. Collaboration skills can be trained through the learning process by applying the Project Based Learning (PjBL) learning model as a real implementation of the Outcome Based Education (OBE) curriculum. The application of PjBL learning to develop student collaboration skills must be supported by appropriate teaching materials. This study employs a development research approach utilizing the Plomp model. The validity assessment involved three validators, each an expert in their respective fields, whereas the practicality assessment was conducted with a group of 25 students. Teaching materials developed by PjBL-OBE on the topic of Acid-Base Solutions obtained a score of 91.5% with a very valid category and a score of 90.5% with a very practical category.*

Keywords: Project Based Learning (PjBL), Collaboration skills, Outcome Based Education (OBE), Acid-Base Solutios, Plomp

Introduction

Outcome-Based Education (OBE) serves as a pedagogical framework that prioritizes the attainment of defined learning outcomes as the central objective of the educational process. This

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approach shifts the focus from traditional teaching methods to student-centred learning, where the emphasis is placed on what students are expected to learn and demonstrate after completing a course or programme [1]. OBE focuses on the outcomes of the learning process, rather than on the process itself. OBE is characterised by clearly defined learning outcomes, which guide the design of curriculum, instructional strategies and assessment methods. [2], [3], [4], [5]. In OBE, alignment of assessment methods with learning outcomes is critical. This alignment ensures that assessments accurately measure whether students have achieved the desired competencies. For example, Crespo et al. highlight the importance of aligning assessment with learning outcomes to ensure that educational objectives are effectively achieved [6].

One of the outcomes that students are expected to have is having good collaboration skills. Collaboration skills are skills that must be developed in students. Collaboration skills are useful to support success in continuing education, in the world of work and in life in society, in addition to being used to learn various concepts and solve various natural science / science problems. Therefore, in the learning process, efforts need to be made to develop students' collaboration skills.

Project Based Learning (PjBL) is characterised by a student-centred approach, where students engage in projects that require them to investigate authentic problems and develop solutions that can be applied in real-life contexts. PjBL not only increases student engagement but also promotes collaboration and communication skills [7], [8]. According to Meti et al., the integration of PjBL in an OBE framework allows for continuous assessment of student performance, ensuring that learning objectives are achieved at every stage of the educational process. [9]. The integration of PjBL and OBE fosters the enhancement of higher-order thinking skills. When students work on complex projects, they are required to apply their knowledge creatively and critically, which aligns with OBE's goal of producing competent graduates who can fulfil industry demands. [10]. The connection between PjBL and OBE creates a systematic and adaptable learning environment that responds to the unique requirements of each learner. PjBL is frequently combined with OBE, as it offers a practical framework for students to utilize their knowledge and skills in real-world situations. PjBL emphasises active learning and collaboration, which allows students to engage deeply with the material while working towards specific outcomes. [11], [12]. This synergy between OBE and PjBL increases student engagement and motivation, as students see the relevance of their education in addressing real-life problems [12], [13]. [13], [14].

The implementation of PjBL with OBE necessitates a detailed framework that encompasses the creation of teaching materials and assessment strategies designed to effectively evaluate student performance in relation to established outcomes. The teaching materials employed should align with PjBL-integrated OBE (PjBL-OBE). Consequently, this study aims to develop PjBL-OBE teaching materials focused on acid-base solutions to enhance students' collaboration skills.

Method

This research uses development research introduced by Plomp which consists of five stages, including the prelimenary investigation phase; design phase; the realization/construction phase; the test, evaluation, and revision phase and the implementation phase [1]. After the teaching materials were developed, the teaching materials were validated by three expert validators who were selected based on their fields of expertise. The questionnaire used to test the validity of PjBL-OBE teaching materials is seen from three aspects. The first aspect is the content aspect of the teaching materials developed, in this case related to the topic of acid-base solutions. The second aspect is the linguistic aspect (the use of good and correct language) used in the developed PjBL-

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OBE teaching materials. The third aspect is the graphic aspect to see the structure and layout of the developed teaching materials.

The process of developing a textbook consists of five distinct stages, which are as follows: The Prelimenary Investigation Phase is conducted to define the problem and plan activities for the development of coursebooks focused on Acid-Base Solutions. This phase involves a thorough examination of the shortcomings of current teaching materials, alongside a critical evaluation of the principles that define effective teaching resources, which will be incorporated into the literature review. In this phase, the activities carried out by researchers are analysing the parts that must be improved from the pre-existing teaching materials as well as analysing the teaching materials. In this phase, problem definition and planning of research activities were carried out. Researchers conducted analyses related to the problems that exist in the available teaching materials, especially on the topic of Acid-Base Solutions. Alongside the benefits of current teaching materials, there are also notable shortcomings, such as the content of the material that is less complex and systematic, teaching materials also do not contain information about the application of Acid-Base solution material in everyday life, inadequate examples of problems and discussions, and the most important thing is that in existing teaching books there are no *projects* that students must do as a bill in learning. Based on the identified issues, the researcher will outline the subsequent steps, specifically focusing on the creation of teaching materials for Acid-Base solutions within the Capita Selecta Chemistry Course, using PjBL as an implementation of the OBE curriculum. The strategy developed by researchers is to add material about acid-base solutions to make it more complex and systematic, add information related to the application of each material discussed in everyday life to add insight to students, present various examples of relevant problems as well as detailed and systematic discussions, and present various *Project* tasks relevant to acid-base solution material that can be carried out by students in groups as course bills.

During this phase, researchers developed multiple designs to address the issues identified in the investigation phase. Researchers developed designs for teaching materials focused on Acid-Base Solutions within the framework of the Project-Based Chemistry Capita Selecta Course (PjBL). The curriculum focused on Outcome-Based Education (OBE). The implementation plan for teaching materials consists of several components: (a) the design of teaching materials, (b) the design of images included in the teaching materials, and (c) the design of content [1]. Researchers developed research instruments to gather data regarding the process and outcomes of teaching material development, ensuring that the resulting materials are valid, practical, and effective. The designed instruments consist of four types: validity instruments and practicality instruments.

The Realization Phase serves as a subsequent step following the design phase. During this phase, the product takes the form of a textbook on Acid-Base Solutions, developed through Project Based Learning (PjBL) aligned with the Outcome-Based Education (OBE) curriculum and its accompanying resources. Once the design phase is complete, the subsequent step will involve production or fabrication. The realisation phase can be characterized as the product manufacturing phase. Products that have been developed in alignment with the design are subsequently classified as prototype 1.

The Test, Evaluation, and Revision Phase involves the validation of the developed teaching book by expert validators. Currently, the evaluation of both the advantages and disadvantages, along with insights from expert validators, is observed to enhance teaching materials. Following the validation of the teaching materials and tests were conducted on a limited scale involving 25 students. Following the completion of a series of tests, the subsequent phase involves evaluation. Following the completion of the evaluation stage, additional revisions will be implemented.

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Revisions are conducted through a careful examination of the evaluation results. Revisions are conducted to ensure that the developed products meet the necessary suitability criteria for use. The final phase is the implementation phase, during which trials of the developed textbooks are conducted. The trial involved students serving as research subjects, specifically those enrolled in the chemical education program at Medan State University who participated in the Kapita Selekta course.

Result and Discussion

Validity of Teaching Materials

The assessment of teaching materials for Acid-Base Solutions utilizing Project Based Learning (PjBL) in accordance with the Outcome-Based Education (OBE) Curriculum encompasses three critical dimensions: content accuracy, linguistic clarity, and graphic effectiveness. Validation is conducted by three validators, each aligned with their respective areas of expertise. The scoring system consists of four categories: 4 represents strongly agree, 3 indicates agree, 2 signifies disagree, and 1 denotes strongly disagree. The instrument for validating the teaching material is presented in table 1.

Table 1. Teaching Material Validation Questionnaire for Acid-Base Solutions based on PjBL-OBE

No.	Aspects assessed	Score			
		1	2	3	4
	A. Content				
1	Topics presented in the teaching materials are in accordance with the Capita Selecta Course Learning Outcomes.				
2	The content of the acid-base solution material is outlined systematically.				
3	The description of acid-base solution material, along with the provided examples, effectively engages learners' interest and maintains relevance.				
4	The teaching materials include supplementary information that aligns with the description of the learning materials related to acid-base solutions.				
5	Teaching materials are developed in alignment with Project Based Learning, following the principles of an Outcome Based Education curriculum.				
6	*Project* tasks in the teaching materials are in accordance with PjBL learning based on the OBE curriculum				
7	Illustrations of issues and dialogues aligned with chemical education research can enhance students' comprehension of the subject matter.				
8	The example questions and discussions presented serve to facilitate the attainment of learning objectives while also enhancing student motivation to engage in the learning process.				
9	The references contained in the PjBL-OBE-based acid-base solution teaching materials are clear.				
10	References originate from textbooks and other relevant and reliable sources.				
	B. Language				
1	The language employed adheres to the established rules of Indonesian grammar effectively.				
2	The terminology employed is suitable and precise.				
3	Language use is developmentally appropriate				

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4	There is a steady application of terminology that accurately represents various material concepts.
	C. Graphical
1	Teaching materials for acid-base solutions are interestingly designed
2	Teaching materials for acid-base solutions are designed using the appropriate font and size so that they are easy to read
3	The placement of the image layout on the acid-base solution teaching materials is appropriate.
4	The arrangement of the text in the teaching materials for acid-base solutions is noteworthy.
5	The colors employed in the educational resources for acid-base solutions are suitable and visually appealing.
6	Acid-base solution teaching materials have an organised layout
7	The preparation of teaching materials for acid-base solutions is systematic

The data is processed and examined based on the completed questionnaire sheet provided by expert validators. Figure 1 illustrates the results obtained.

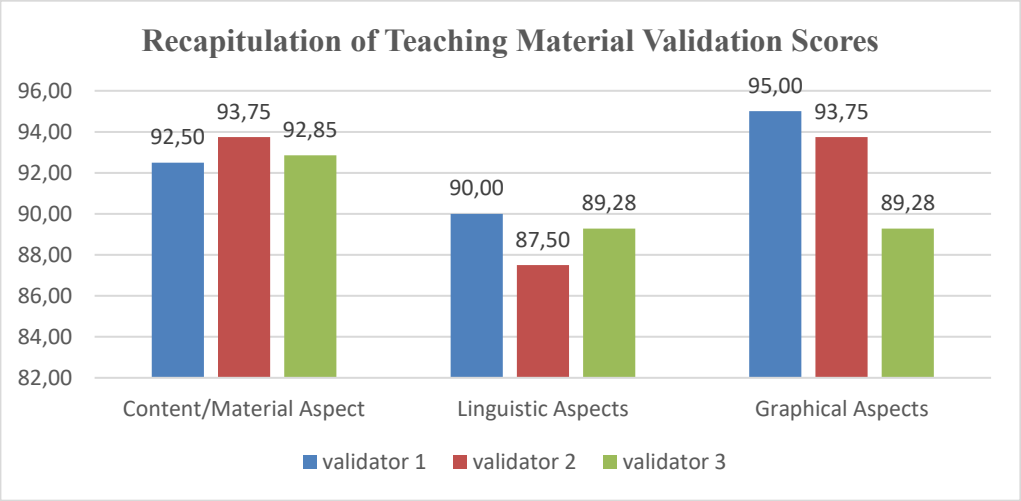

Figure 1. Recapitulation of Validity Score

The average validation value, derived from the data across three aspects of the validation assessment evaluated by each validator, stands at 91.54%. The statistical teaching materials developed for various test materials demonstrate that they meet a key requirement for the feasibility of teaching materials, specifically validity, achieving a classification of very valid. The validator's input involves incorporating project assignments into each chapter and including acid-base titration graphs for each type of titration.

Practicality of Teaching Materials

This study evaluates the practicality of teaching materials for Acid-Base Solutions designed around Project Based Learning (PjBL) within the Outcome-Based Education (OBE) Curriculum. The assessment focuses on three key aspects: ease of use, presentation attractiveness, and perceived benefits for student users. The teaching material underwent testing with a cohort of 25

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students enrolled in the Chemistry Education S1 study programme. The testing instrument comprises a questionnaire featuring 20 closed statements. The scoring system consists of four categories: 4 indicates strong agreement, 3 signifies agreement, 2 represents disagreement, and 1 denotes strong disagreement.

The practicality value is measured for each aspect based on the results of the questionnaire given to students. The acquisition of the aspect of ease of use of teaching materials for acid-base solutions was 90.63%. The acquisition of aspects of the attractiveness of teaching materials for acid-base solutions was 90.00%. The acquisition of aspects of the benefits of teaching materials for acid-base solutions was 90.63%. The acquisition of practicality aspects for each part can be seen in Figure 2.

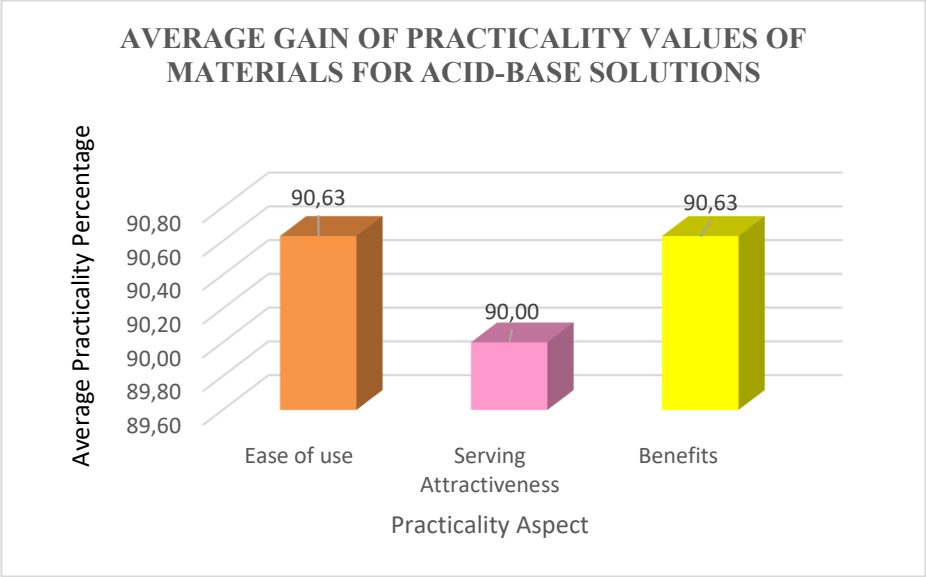

Figure 2. Recapitulation of Practicality Score

The average value of practicality, based on the three aspects assessed by students, is 90.5%. The teaching materials for Acid-Base Solutions, developed through Project Based Learning (PjBL) in alignment with the Outcome-Based Education (OBE) Curriculum, are classified as highly practical.

Conclusion

1. The acquisition value of the validity teaching materials for Acid-Base Solutions in the Capita Selecta Chemistry course based on PjBL-OBE is 91.5% (very valid).
2. The acquisition value of the practicality of teaching materials for Acid-Base Solutions in the Capita Selecta Chemistry course based on PjBL-OBE is 90.5% (very practical).

Acknowledgments

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Solvent optimalization for styrax benzoin frankincense alkaloid isolation

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Abstract. This research aims to determine the optimal solvent for the isolation of alkaloid compounds in Toba benzoin resin. Alkaloids are known to have a wide range of significant biological activities, making it important to develop efficient and effective isolation methods. In this research, various solvents such as methanol, ethyl acetate and n-Hexane were tested to isolate alkaloids from Toba benzoin resin. Each extract was analyzed using thin layer chromatography (TLC), vacuum liquid chromatography (KVC) and gravity column chromatography (KKG) to identify and measure the alkaloid content. The results showed that the methanol solvent produced alkaloid isolates with the highest purity and RF compared to other solvents. These findings provide a strong basis for the development of more efficient and environmentally friendly extraction methods for alkaloid compounds from Toba benzoin latex, which has the potential to increase the added value of this commodity.

Keywords: Frankincense, *Styrax benzoin*, alkaloid, isolation, solvent, chromatography

Introduction

North Sumatra is known as the largest incense producing area in Indonesia. The incense production area is in the North Tapanuli, Dairi, Toba Samosir, and Central Tapanuli regions. North Tapanuli Regency is the center of frankincense production in North Sumatra, with an area of 22,670 hectares of frankincense plantations with an annual production of 2,000 tons. In this area, there are 14 thousand farmers spread across 8 sub-districts and 161 villages (Waluyo et al.). The area of frankincense forests in North Sumatra is as wide as 23,017.42 hectares and the production is 4,978.48 tons per year (BPS North Sumatra

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Province, 2013). The production capacity of frankincense from this region can only meet 41% of the world's demand for frankincense sap which reaches 92,000 tons/year [1] The production of frankincense both in quantity and quality is still low. This is due to the lack of interest of farmers to improve the quality and management system that is still traditional. Research on improving the quality of frankincense is still not widely done. In fact, in terms of the many benefits, this commodity deserves to be looked at for development. The smell is very distinctive and is not only used in certain tribal rituals, but also used as a raw material for cosmetics and as a binding material to fragrances so that the smell does not disappear quickly. In addition, it is also useful as a preservative and raw material for medicine [2].

Cynamic acid and its derivatives are substances with a high composition (19-30%) in frankincense, have diverse pharmacodynamic effects and can be used as medicinal raw materials. Several studies show that cinnamic acid is a compound that has the potential to overcome dermatophytosis. In addition to its beneficial pharmacological effects, frankincense has no toxic effects on the body [3]. One of the secondary metabolites in frankincense sap is alkaloid compounds, where this organic compound is important to use in pharmacy because phytochemical studies prove that alkaloid compounds are very effective as medicinal ingredients because they have a very good effect on the body, this is because the typical structure of alkaloids can interact with enzyme systems that participate in important pathways in the body and are able to produce *polypharmacological* properties that are efficient [4].

Based on previous research, Susanti et al. (2021) showed that the active ingredients of cinnamic acid (54.42%) and benzoic acid (45.58%) can be obtained by soaking using ethanol solvents. This study also showed the content of alkaloids, flavonoids, saponins, tannins and terpenoids in frankincense sap ethanol extract. According to Simatupang (2021), frankincense sap is less soluble in water solution but soluble in organic solvents.

Although there have been several studies that have been conducted on this frankincense sap, research on alkaloid isolation is still relatively limited, due to the lack of literature sources on the isolation of this alkaloid such as the selection of the optimal solvent to use. Therefore, more in-depth information is needed regarding the selection of the optimal solvent for the isolation of this alkaloid. Based on the above information, the researcher is interested in conducting a study entitled Selection of Optimal Solvent for the Isolation of Alkaloid Compounds in Frankincense Sap (*Styrax benzoin*) Toba

Experimental

Chemicals, Equipment and Instrumentation

The materials used in this study are frankincense sap powder size 80 mesh from the parsoburan area, Ethanol 96% (C_2H_6O), N-Hexane (C_6H_{14}), ethyl acetate ($C_4H_8O_2$), Methanol (CH_3OH), silica gel (SiO_2), dragendorff reagent, Wagner, Mayer, KLT silica gel plate 60 F254 (E. Merck.Art 554). The equipment used in this study is an inert maceration container, a 250 ml glass beaker (pyrex), Erlenmeyer 250 ml (pyrex), analytical balance, 100 ml measuring flask (iwaki), measuring cup 100 ml, vial bottle, droppipette, 10 ml and 25 ml measuring pipette, spatula, filter paper, test tube (pyrex), rotary evaporator, 254 nm UV lamp and 365 nm, one set of liquid vacuum chromatography, one set of KLT, one set of KKG.

Extraction

The extraction of frankincense sap is carried out by maceration. Frankincense sap powder was weighed as much as 120 grams, then macerated with 96% ethanol solvent. The sample was soaked for 3 times 24 hours while stirring. Then the solution was filtered using filter paper with the help of a buncher and a vacuum pump, then the extract was subjected to phytochemical screening tests to determine the group of secondary metabolites it contained. The liquid extract obtained is evaporated using a rotary evaporator with a solvent

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boiling point temperature of 78°C for 4-5 hours and then continued using a water bath until a thick extract of frankincense sap is obtained [5].

Alkaloid Test

Alkaloid compounds were identified using Dragendorff, Mayer and Wagner reagents, the formation of brick red deposits, yellow deposits and white deposits showed positive alkaloid tests [5].

Preliminary Test by KLT

The preliminary test by KLT was carried out by comparing the spectral pattern of the standard solution of the extract using KLT-spectrodensitometry. This analysis aims to determine the composition of eluene with the best comparison. The phase of motion used is a mixture of n-hexane solvents: ethyl acetate, ethyl acetate: methanol with a ratio of 10:0 9:1 8:2 7:3 6:4 5:5 4:6 3:7 2:8 1:9 0:10. After being bleached, it is observed with 256nm UV light. The composition of the eluents with the best ratio is marked as producing the largest number of spots and separate. If the stain is still tailed, it is modified into 3 solvents [6].

Fractionation by Vacuum Liquid Method

Ethanol extract of frankincense sap as much as 100 mg added silica gel as much as 200 mg was ground until a dry powder was obtained. Silica that has been mixed with ethanol extract of frankincense sap is inserted into the column and covered with a G3 strainer. After that, the column is dissolved with a motion phase according to Table 1. The fractionated eluat is evaporated until dry [7] .

Table 1. Motion Phase for KVC

Fraction	Motion phase			
	N-Hexane – Ethyl acetate		Ethyl acetate – Methanol	
1	100%	0%	100%	0%
2	90%	10%	90%	10%
3	80%	20%	80%	20%
4	70%	30%	70%	30%
5	60%	40%	60%	40%
6	50%	50%	50%	50%
7	40%	60%	40%	60%
8	30%	70%	30%	70%
9	20%	80%	20%	80%
10	10%	90%	10%	90%
11	0%	100%	0%	100%

Thin-Layer Chromatography (KLT)

All fractions were reconstituted with 2 mL of methanol, then dosed using capillary tubing on a GF254 silica gel AL-TLC plate. Furthermore, the AL-TLC silica gel GF254 plate is dissolved with a phase best movement in the preliminary KLT. After being analyzed, the Rf value is calculated [8]

Gravitational Column Chromatography (KKG)

The combined fractions of the KVC results were further separated using gravity column chromatography (KKG) by using silica gel 60 F254 as the stationary phase and the motion phase using the best eluene in the separation of the isolate stains used. Silica gel 60 F254 is weighed and activated in an

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oven at 110°C for 2-4 hours. Then the silica is soaked using n-Hexane to remove the air trapped in the silica, then the silica immersion is slowly inserted into the column and then n-Hexane is inserted into the column up to 2-3 cm above the silica at the top of the column is tightly closed and left for 24 hours to ensure the density of the silica and prevent the formation of cracks. After that, the KVC isolate is impregated and put into a column, then elution is carried out by adding eluence continuously while rotating the bottom faucet and eluent is accommodated in a vial of 10 ml in each vial. The results of the collection are then in the KLT, if there is a similarity of stains, then the compounds have the same indication of structure and properties so that they can be combined. The results of the combined KKG fraction whose alkaloids will be characterized using FTIR [9].

Results and discussion

Sample Preparation

Frankincense sap comes from Toba Regency, Habinsaran District in the Parsoburan Area. Samples of frankincense obtained from Toba were dried. This drying aim to remove the moisture content contained in it which can cause enzymatic reactions and damage the sample. After drying, aerate the frankincense sap sample and then mash it into a dry powder (simplisia). The purpose of smoothing this frankincense sap is to improve the efficiency and quality of the extraction of the desired compounds and the extraction process can run well.

Extraction of Frankincense Saps

Extraction was carried out by the maceration method. The reason for choosing this maceration as the stage of the extraction process is because the target active compound, namely alkaloids, has non-heat resistant properties [10]. The compounds contained in frankincense sap are overall polar compared to semipolar and nonpolar. Ethanol can dissolve frankincense because it is polar and its chemical structure is similar to the compounds contained in frankincense sap. Ethanol was chosen as a solvent in this study because it has the ability to interact with polar bonds in frankincense sap so that it can dissolve frankincense well. 120 g of frankincense sap powder is extracted using 600 ml of ethanol, 96% using the boiling point of ethanol which is 78°C. Extraction is carried out for 3 x 24 hours (until it is completely cleared). The evaporation process is carried out using a rotary evaporator with a temperature of 69-75°C to keep alkaloid compounds from being damaged due to the properties of alkaloid compounds that are not heat-resistant. This process produces a viscous extract of colored frankincense sap brownish-red (Figure 1.). The extract is weighed and then the yield is calculated. The calculation of this yield was obtained from the comparison of the mass of ethanol extract of frankincense sap used in the extraction process. The percentage of ethanol extract obtained from frankincense sap (yield) with the comparison of frankincense sap powder with ethanol (1:5) was 85.56%.

Alkaloid Test of Frankincense Sap

The alkaloid test was carried out with the addition of Dragendorff, Wagner and Mayer reagents by 2-3 drops each where each reaction would produce a different color. Results obtained from the alkaloid test presented in Figure 1.

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a b c

Figure 1. Results of identification alkaloid test : (a) Test Dragendorff the results is brick red precipitate, (b) Test Wagner the results is light brown precipitate, (c) Test Mayer the results is White Deposits

The alkaloid test with the addition of Dragendorff reagent as much as 2-3 drops, the positive results were shown by the formation of brick red deposits. The existence of this precipitate is due to a reaction between K^+ metal ions from potassium *tetraiodomercury* (II) and nitrogen compounds in alkaloids that form potassium alkaloid complexes [11].

The alkaloid test with the addition of Wagner reagent as much as 2-3 drops showed positive results by the formation of light brown to yellow precipitates. The formation of this precipitate is due to the presence of free electron pairs in nitrogen that make up alkaloid compounds and in the Wagner reagent there are iodine and potassium iodide. The free electrons of the nitogen atoms in the alkaloids will form a coordinate covalent bond with the K^+ metal ion potassium *tetraiodomercury* (II) from the Wagner reagent, resulting in a reddish-brown to yellow potassium-alkaloid complex in the extract [12]

The alkaloid test with the addition of Mayer reagent as many as 2-3 drops of positive results was shown by the formation of white precipitate. The formation of this white precipitate is due to the presence of a potassium-alkaloid complex. Where the complex can be formed due to the reaction of nitrogen atoms found in alkaloids with K^+ metal with potassium *tetraiodomercury* (II) found in Mayer's reagent. This is because there are free electrons in alkaloid nitrogen atoms that can form coordinate covalent bonds [13].

Thin-layer chromatography Introduction

The separation of alkaloid compounds in frankincense sap (*Styrax benzoin*) was carried out by liquid vacuum chromatography (KVC) method. Before the separation process with the KVC method, Therefore, a preliminary analysis was carried out using the thin-layer chromatography (KLT) method, the purpose of this preliminary analysis was to determine the right eluent and ratio that was able to show good separation through the pattern of separation of the resulting dye stains. The ethanol extract of frankincense sap is analyzed with KLT to determine the best eluene composition and comparison. The solvents used are methanol, ethyl acetate and n-hexane. Modified eluene by making a mixture of two solvents, namely: methanol; ethyl acetate and ethyl acetate; n-heksan. With a ratio of 10:0 ; 9:1 ; 8:2 ; 7:3 ; 6:4 ; 5:5 ; 4:6 ; 3:7 ; 2:8 ; 1:9 ;0:10. The chromatogram profile of the extracted extracts that had been diluted with various eluents was observed under UV 254 light. The best eluents are the ones that produce the largest number of separate spots. As shown in Figure 2.

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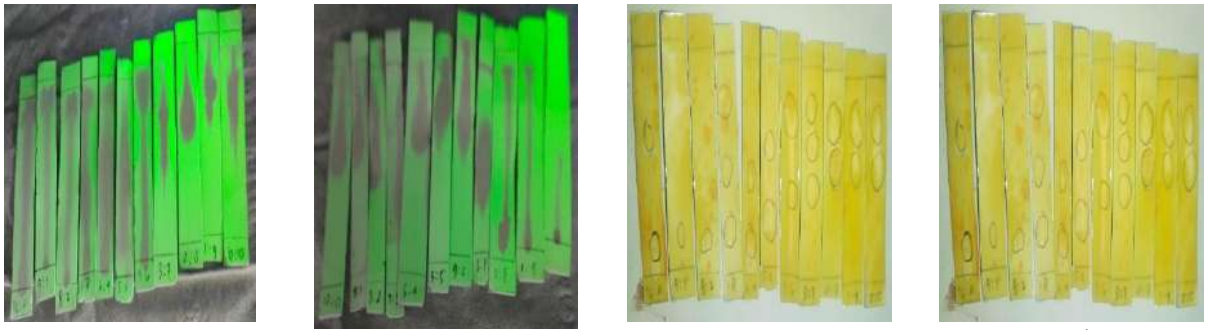

a b c d

Figure 2. KLT Introduction; (a) Methanol:Ethyl Acetate (b) Ethyl Acetate:n-Hexane (c) Identification with Polar Spot Dragendorff Reagent (d) Identification with Non Polar Spot Dragendorff Reagent

Based on the results of the modification, it is known that ethyl acetate:methanol with a ratio of 3:7 and n- Hexane:ethyl acetate 4:6 shows the highest number of stain spots and is separate.

Liquid Vacuum Chromatography

Initial separation of frankincense sap viscous extract compound (*Styrax benzoin*), using liquid vacuum chromatography (KVC) method. The principle of this KVC method is the separation of compound mixtures based on the difference in solubility in the stationary phase and the motion phase. Where the stationary phase will be held and the motion phase will flow through the column with the help of a vacuum. In this method, the sample is flowed through a column using vacuum pressure. Dilution starts from non-polar eluene (n-hexane: ethyl acetate) to polar eluene (ethyl acetate: methanol). The purpose of using eluents from non-polar to polar is to increase the polarity properties of the target compound so that the resulting fraction has purer and better separate properties. The eluen used is a ratio adjusted eluen.

The resulting fractions are stored in glass bottles, then each bottle is evaporated with a rotary evaporator to obtain a thick compound. The factions that have been evaporated are then grouped into non-polar fractions and polar fractions.

a b

Figure 3. (a). Faction 1-11 Non-Polar KVC Results (b) Polar KVC Results Faction

In the non-polar and polar fractions, namely fractions 1-11 and 12-21, 5 factions were selected each that had a fairly clear pattern of stains. Then identification and monitoring were carried out using the KLT method on the comparison of eluene n-hexane: ethyl acetate (4:6) and ethyl acetate: methanol (3:7). The use of this comparison aims to see the similarity of stain patterns on the chromatogram.

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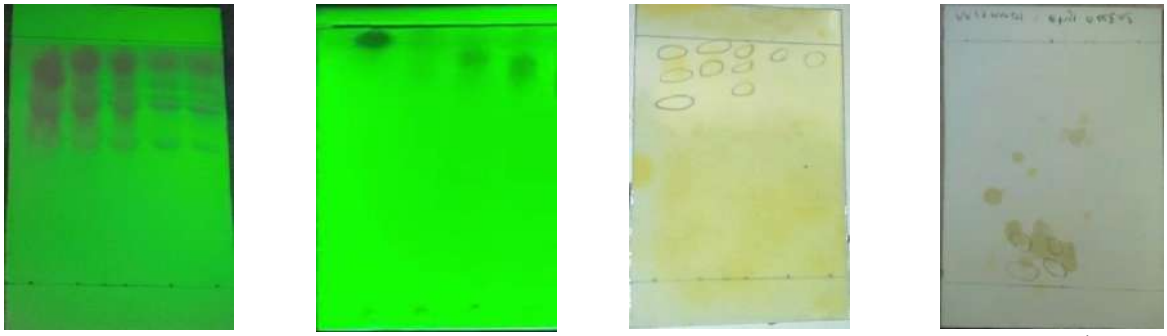
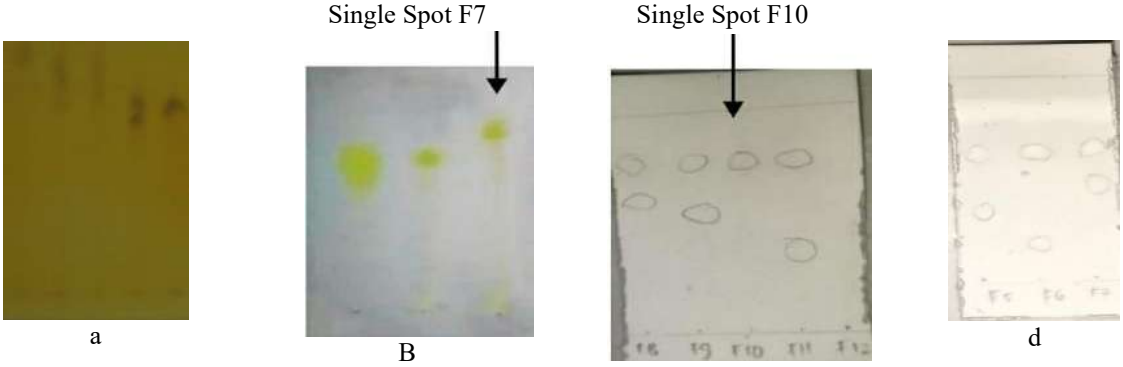


a b c d

Figure 4. KLT KVC Results;(a) Visualization of KLT 5 Selected Fractions of n-Hexane:Ethyl Acetate with 254 nm UV Light (b) Visualization of KLT 5 Selected Fractions of Ethyl Acetate:Methanol with UV Light 254 nm (c) Plate a After Wagner Spraying (d) Plate b After Wagner Spraying

Gravitational Column Chromatography (KKG)

Fractionation of frankincense rubber ethanol extract by gravity column chromatography (KKG) with silica gel 60 (0.063-0.200 nm) as the stationary phase and n-hexane:ethyl acetate as the moving phase with a ratio (4:6). The ratio between the moving phase and the stationary phase is 30:1 which means 30 grams of silica gel for coulomn chromatography and 1 gram of sample. This research was carried out by the wet method, meaning mixing the sample with the motion phase, then putting it into a column. Fractionation with columns produces fractions that are accommodated in vial bottles as many as 21 vials with a size of 10 ml. Furthermore, in the KLT again each fraction contained in the vial, the same stain pattern is then combined to produce 8 stain fractions as shown in Figure 3.5



a B c d

Figure 5. Spot 8 Joint Faction of KKG; Remarks (a), (b) visualization of plates sprayed by Dragendorff, (c), (d) visualization of Mayer sprayed plates

Based on observations with the spraying of Mayer reagent, the stain pattern obtained produced F10 has a single stain. Based on the results of the modification, it is known that n-Hexane:ethyl acetate (4:6) indicates the number of single spots, to ensure further modification is carried out, namely KLT is carried out with 3 types of solvent systems, namely methanol, ethyl acetate and n-Hexane.

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Figure 6. Single spot KLT F10 from KKG with 3 solvent motion phases i.e. with methanol, ethyl acetate and n-Hexan and identified with Wagner reagent, respectively.

The motion phase of 3 types of solvent systems, namely methanol, ethyl acetate and n-hexane, showed a single stain pattern with RF 0.5, 0.91 and 0.2, but in semi-polar solvents (ethyl acetate) still produced tail spots. In this case, further analysis was used to determine the structure and functional groups contained in the transformate in the fractionated sample of frankincense sap using *Fourier Transform Infrared Spectroscopy* (FT-IR).

Figure 6 Single spot KLT F10 from KKG with 3 solvent motion phases i.e. with methanol, ethyl acetate and n-Hexan and identified with Wagner reagent, respectively. Methanol also provides good extraction efficiency and is environmentally friendly, making it a suitable choice for industrial applications. These findings could provide further ease of pharmaceutical and industrial applications

Conclusion

This study shows that methanol is the optimal solvent for the isolation of alkaloid compounds from sap, styrax benzoin because it produces the highest yield compared to other solvents. Methanol also provides good extraction efficiency and is environmentally friendly, making it a suitable choice for industrial applications. These findings could provide further ease of pharmaceutical and industrial applications.

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Development of project-based interactive teaching materials and obe integrated case methods in qualitative analytical chemistry learning to improve student learning outcomes and science process skills

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Abstract. *This research is a development interactive electronic module Qualitative Analytical Chemistry teaching materials based on the case method and project integrated Outcome Based Education using the ADDIE model with research subjects of 30 students. Research data were obtained from a validation questionnaire for media experts, material experts, linguists and student responses to the developed e-module with BSNP criteria. Material expert validation obtained an average content feasibility of 3.78, language eligibility 3.65 and presentation feasibility 3.65, graphic feasibility 3.76. Respondent's level of achievement 93%, increasing learning outcomes 75%, percentage of student project activities is 85,92, average science process skills 71,41% and Respondents' satisfaction with learning with electronic modules is 92.33%.*

Keywords: case-method, project, OBE, valid and effective e-modules, qualitative analytical chemistry

Introduction

The development of human resources for the 21st century in the era of the Industrial Revolution 4.0 must include the learning concept established by UNESCO in the framework of the World Educational Forum in the form of four pillars of education. namely learning to know, learning to do, learning to be, and learning to live together. By implementing this pillar, it is hoped that educators (teachers/lecturers) can encourage students to become quality human resources, create

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a learning environment that needs to be updated and think scientifically, critically, systematically, logically and creatively.

Law Number 14 of 2005 concerning Teachers and Lecturers regulates that teachers and lecturers have an academic background, competence, educational certificate, are physically and mentally healthy, and meet other qualifications required by the university where they work. A teacher has several educational competencies including educational, personal, social and professional skills acquired through vocational training. Teacher competency standards are indicators that can be used as a measure of the characteristics of teachers who are considered professionally competent. To improve teacher competency, preservice chemistry teacher needs to implement innovation and reform [1].

Based on the results of case studies at universities in North Sumatra, qualitative analytical chemistry lectures in the last two years have not been optimal. This is known from the final exam scores of preservice chemistry teacher students who got an A grade of only 12.62%, 10.19% a C grade and 4.85% an E grade. In this regard, efforts are needed to improve the quality of learning with a capable learning model. equip and activate knowledge in prospective teacher students so that they can develop thinking abilities and strengthen concepts to achieve basic competency in Qualitative Analytical Chemistry material. Thus, the creative, critical, collaborative and communicative thinking skills of prospective teacher students can be trained in a scientific attitude when discovering facts, concepts and theories as well as Outcome-Based Education [2- 4]. Obtaining chemistry scores that are not yet optimal is also a challenge for teachers to increase student scores until they reach the specified KKM.

For this reason, it is necessary to increase the chemical competence of prospective teacher students in producing superior, tough and professional teachers. One strategy that can be implemented is through updating learning scenarios that are interactive, practical and effective. Apart from that, there is also a need for interactive teaching materials, e-modules in the form of virtual-digital based on case methods and integrated OBE projects [5- 6]. With electronic media, teachers/lecturers will easily carry out learning activities even though they are in different places from the students [7].

With project-based interactive teaching materials and case methods according to the concept of an integrated Outcome-Based Education (OBE) curriculum that is valid, effective and practical, students will be motivated to be more proactive in interacting, collaborating and innovating in constructing their knowledge and skills, so that student competence is expected to increase with superior, qualified, productive, capable and skilled graduate resources to manage learning with a responsible attitude in the world of work to become a professional teacher [8].

The aims of this research were (1) To obtain interactive e-Module teaching materials based on the case method and OBE integrated projects in learning Qualitative Analytical Chemistry courses that are valid, effective and practical; (2) To determine the science process skills and learning outcomes of the Qualitative Analytical Chemistry course of prospective teacher students in achieving graduate standards in CP-MK through the application of case method-based interactive e-module teaching materials and OBE integrated projects.

Methodology

The type of research is educational research and development, using the ADDIE method [9]. The research was carried out in the even semester of the 2024 academic year at the Chemistry Department, FMIPA, Medan State University.

The procedure for developing teaching materials refers to the Borg & Gall development model which was adapted from the Dick & Carey model using steps one to step nine [10]. So the

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procedure for developing teaching materials in this research consists of 2 (two) stages, namely the pre-development stage and the development stage. The pre-development stage includes: 1) needs analysis stage which consists of: analysis of teaching materials; identification of objectives for developing teaching materials; and analysis of student characteristics and the context of the teaching materials needed for learning; 2) product design stage which consists of: formulating CPL and CPMK courses integrated with the OBE curriculum; formulate and organize discussion points according to the OBE integrated curriculum; Formulate case method and project based learning; design of learning flip videos for each subject; and 3) realization stage. Meanwhile, the development stage includes: 1) the trial and evaluation stage which consists of feasibility testing, one-on-one trials, small group trials, and large group trials, 2) the final product stage, namely producing case-based Qualitative Analytical Chemistry electronic teaching materials. method of development results that are feasible and effective.

The test site for research on the development of electrical teaching materials for Qualitative Analytical Chemistry based on the case method and OBE integrated projects was carried out in the Chemistry Department, Medan State University. The subjects of the feasibility trial (expert test) were experts within the Medan State University. The selection of experts is carried out purposively by considering competency, ease of communication and experience in their respective fields. Meanwhile, the subjects for testing the effectiveness of the research product were 30 students from the Chemistry study program at Medan State University who taught the Qualitative Analytical Chemistry course and 2 lecturers who taught the Qualitative Analytical Chemistry course.

The research instruments used in this research were first validated by expert validators, namely: (1) Validation Questionnaire Instrument, (2) Learning Activity Instrument, (3) Observation Sheet Instrument, (4) Student satisfaction response questionnaire instrument. application of interactive Qualitative Analytical Chemistry electronic teaching materials based on the case method and OBE integrated projects resulting from the development of (5) Learning Outcome Test Instruments. All collected data is collected and distributed into a frequency distribution table to be processed and analyzed descriptively.

Testing of the impact or learning effects of the product is carried out using small group trial data and large group trials of student learning outcomes based on learning outcomes in the cognitive domain. This research used a one group pretest-posttest design. This one group pretest-posttest design consists of one predetermined group. In this design, the test is carried out twice, namely before being treated, it is called a pre-test and after being given treatment, it is called a post-test. The research pattern of the one group pretest-posttest design [11].

Finally, the test results of the sample population were tested using a t-test for two paired samples. Critical area of acceptance of H_0: $-t_{table} \leq t_{count} \leq -t_{table}$ or p-value (sig.) $> \alpha$ and critical area of rejection of H_0: $t_{count} < -t_{table}$ and $t_{count} > -t_{table}$ or p-value (sig.) $< \alpha$ [12].

To determine the effectiveness of the interactive Qualitative Analytical Chemistry electronic teaching materials developed, it can be determined using the Gain normality test (N-Gain). The N-Gain test is obtained from calculating the difference between the pre-test and post-test scores. The results of the N-Gain test are then calculated as the average value to be able to conclude whether it is in the high, medium or low category [13].

Effectiveness of the application of integrated interactive Qualitative Analytical Chemistry electronic teaching materials OBE product development is a measure related to the level of success of the learning process. The effectiveness criteria in this research refer to the average normalized gain value which is at least in the medium category. The analysis tools used are Excel and SPSS

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for Windows 24 software.

Results and Discussion

Result

Analysis stage

At the the analysis stage there are three types of activities that researchers must carry out, namely competency analysis, student characteristics and instructional. In competency analysis, also called curriculum analysis, the curriculum must be analyzed carefully, trying to understand and measure the level of depth of competency required by the curriculum. Analysis of student characteristics means knowing exactly the conditions of students who will use the product being developed. Thus, you must know in detail the student's initial level of ability, their learning ability and other important aspects. Meanwhile, instructional or learning analysis is describing the general competencies in the curriculum into specific competencies and then determining the order of priority.

Design stage

At the design stage there are three types of specific activities, namely preparing the structural framework(outline) of the product to be developed, determining the systematic development and designing the evaluation tools (instruments) that will be used.

Development stage

At this stage the product begins to be developed according to what has been determined in the design. Implementation of the system to be used and paying attention again to the principles of product criteria developed to improve the product.

Implementation stage

The product developed is associated with students based on the instructions for use that have been prepared.

Evaluation stage

Evaluation is to measure the extent to which students master the product being developed. Evaluation is also feedback in the learning process and measures achievement through indicators and learning objectives.

Results of e-module Product Validation by Material and IT Experts

Validation of electronic teaching materials for interactive Qualitative Analytical Chemistry based on case methods and assessment development projects using questionnaire instruments with valid BSNP standards based on validation results by expert validators according to the OBE integrated curriculum concept. Validation of the developed interactive electronic teaching materials is carried out by providing an assessment in the form of a score based on a standard BSNP questionnaire including appropriateness of content, appropriateness of language, appropriateness of presentation, and appropriateness of graphics. Scoring is determined by referring to the Likers scale, namely: score 4 (strongly agree), score 3 (agree), score 2 (disagree), and score 1 (strongly disagree).

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Based on the results of validation by expert validators, the following are the average scores from media expert validators, linguists, material experts, and expert chemistry practitioners/lecturers on case method-based interactive Qualitative Analytical Chemistry electronic teaching materials and development project results presented in Table 1, following.

Table 1. Average value of expert validators for electronic teaching materials for interactive Qualitative Analytical Chemistry based on the case method and OBE integrated projects developed

No	BSNP Criteria	Average expert validator scores				Average	Validation Criteria
		Media Expert	Linguist	Materials Expert	Practitioner Expert		
1	Eligibility fill	3.75	3.81	3.80	3.77	3.78	Very valid and does not need revision
2	Language Eligibility	3.52	3.61	3.76	3.74	3.65	Very valid and does not need revision
3	Feasibility of presentation	3.61	3.73	3.55	3.72	3.65	Very valid and does not need revision
4	Graphic Eligibility	3.72	3.89	3.74	3.72	3.76	Very valid and does not need revision
Overall grade average						**3.71**	**The criteria are very valid and do not need to be revised**

Based on the data in Table 1, it can be seen the average validation value by validators, media experts, linguists, material experts and expert practitioners/lecturers on case method-based interactive Qualitative Analytical Chemistry electronic teaching materials and integrated OBE project development results. The average score from media experts is 3.65; linguist 3.76; material expert 3.71; practitioner expert 3.73; and the overall average score is 3.71; with very valid criteria and does not need to be revised. For language appropriateness, the average score obtained from media experts was 3.52; linguist 3.61; material expert 3.76; practitioner expert 3.74; and the overall average score is 3.65; with very valid criteria and does not need to be revised. For presentation feasibility, the average score obtained from media expert validators was 3.61; linguist 3.73; material expert 3.55; practitioner expert 3.72; and the overall average score is 3.65; with very valid criteria and does not need to be revised. Meanwhile, for graphic feasibility, the average value obtained from media expert validators was 3.72; linguist 3.89; material expert 3.74; practitioner expert 3.72; and the overall average score is 3.76; with very valid criteria and does not need to be revised. Furthermore, the overall average score was obtained at 3.71 with very valid criteria and no need for revision.

Obtaining this data shows that the validators, media experts, language experts, material experts, and practitioner experts/lecturers have given positive opinions regarding the case method-based interactive Qualitative Analytical Chemistry electronic teaching materials and the OBE integrated projects developed. Overall, the average final score for interactive Qualitative Analytical Chemistry electronic teaching materials based on the OBE integrated project case method as a result of the development was 3.71 with very valid criteria; This means that it meets BSNP standards according to the OBE integrated curriculum concept, and is suitable for students to use in learning the Qualitative Analytical Chemistry course.

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In the effectiveness trial of small group (10 people) and large group trials carried out on 30 chemistry education students. The effectiveness of interactive Qualitative Analytical Chemistry electronic teaching materials based on the case method and OBE integrated projects, the results of the development were obtained from learning results and analyzed using SPSS for Windows 24. Data from large group trials are presented as in Table 2, below.

Table 2. Data on improving student chemistry learning outcomes

Increased learning outcomes in testing electronic teaching materials for Interactive Qualitative Analytical Chemistry based on the case method and integrated OBE projects developed				
No	**Sampel**	***Mean Pre-test***	***Mean Pos-test***	***N-gain***
1	Small group (10 students)	39	82	71
2	Big group (30 students)	40.50	83.50	80

Based on the data in Table 2, it is known that the N-gain in the small group trial was 71, which means there was an increase in student chemistry learning outcomes in the small group trial by 71%. Meanwhile for the large group the N-gain was 80, which means there was an increase in learning outcomes chemistry students in large group trials 80%. Graphically it can be seen as presented in Figure 1 below

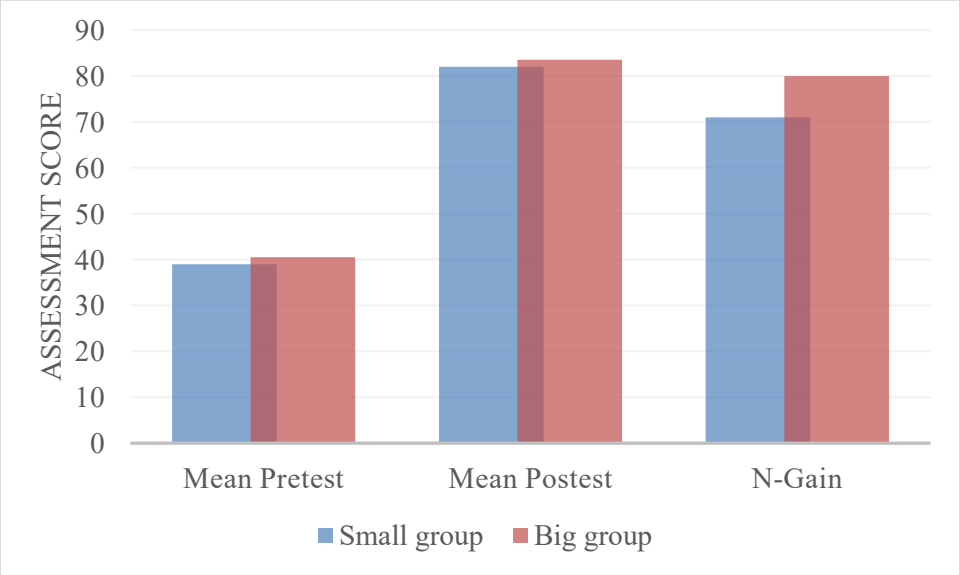

Figure 1. Increased learning outcomes in testing electronic teaching materials for Interactive Qualitative Analytical Chemistry based on the case method and integrated OBE projects developed

Observation Results of Science Process Skills in Students Who Were Studying with Product Development.

At the practicum meeting using developed electronic teaching materials, the meeting begins with conditioning students in the laboratory to sit in their groups to then provide motivation and apperception about the objectives of the practicum/mini research such as: Flame test, anion identification reaction, identification reaction for group I to V cations. contained in the teaching materials developed and filled in the LKM that has been provided. For example, in LKM 01

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entitled Preliminary Tests of Samples (Organoleptic), students are guided to find the relationship between the presence of metals and their compounds in nature, industrial waste which does not receive strict supervision and the importance of being able to understand test reactions such as flame tests or wet analysis reactions. Furthermore, questions and answers related to the material being practiced were carried out to ensure that all students understood the activities. In the closing section, students are guided to draw conclusions from the practicum activities [14]. Figure 2 shows students' science process skills while conducting qualitative analytical chemistry practicum research in the laboratory.

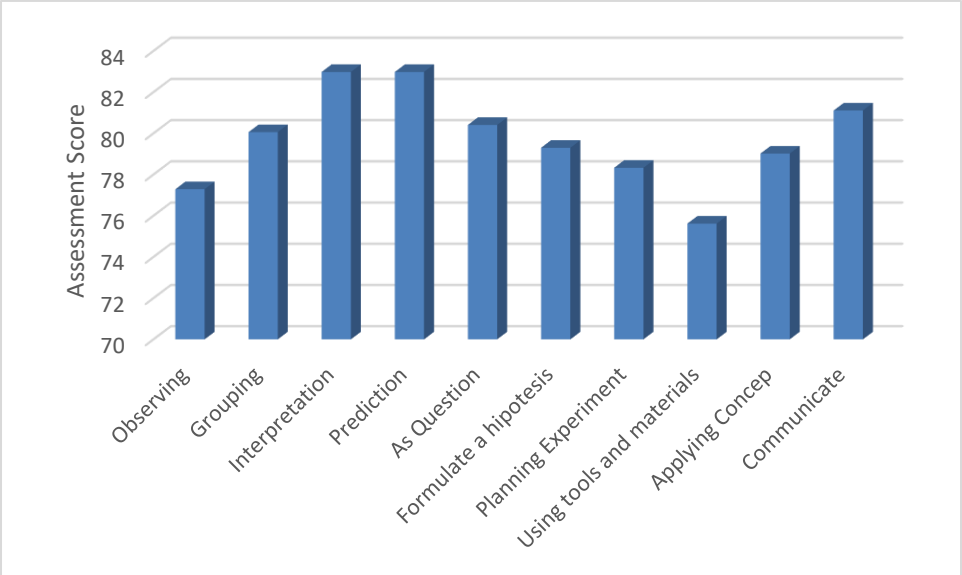

Figure 2. Graph of the average science process skills of students during do practicum

In Figure 2 it can be seen that interpreting and predicting aspects are the highest science process skills. During the practicum activities, two graduates of Chemistry Education from Medan State University assisted in the research by observing aspects of the science process skills achieved by students according to the assessment rubric that had been prepared. As a consideration for assessing the achievement of aspects of science process skills, the results of student worksheets can be used as a reference [15]. The results of observations of students' science process skills in the form of average observation scores include: observing 77.29; grouping 80.06; interpreting 82.98; forecast 82.98; asking questions 80.41; formulate a hypothesis 79.3; planning experiments 78.33; using tools and materials 75.62; applying concepts 79.02 and communicating 81.11. Science Process Skill is the ability of student apply scientific method to understand, develop and discover science [16-17] and [6].

Student performance assessments are carried out by three observers using performance assessment instruments. Assessments are carried out during the process of carrying out mini-research experimental projects in the laboratory and making learning flip videos. Each observer assessed 10 students. Performance assessment includes 3 (three) components; namely the pre-employment stage, implementation of learning and implementation of performance practices. Percentage of student performance scores in project work on learning overall grade average is 85.92%.

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The average percentage of student performance scores in planning and implementing project activities obtained an average score of 85.92%. Based on these results, it can be concluded that the performance product of student project activities in learning is in the good category and shows the reachability of graduate learning achievement standards (CPL) and course learning achievements (CP-MK) in Qualitative Analytical Chemistry.

Conclusion

Interactive Qualitative Analytical Chemistry electronic teaching materials based on case methods and OBE integrated projects which are designed and developed according to the OBE integrated curriculum concept and can be accessed from the internet are in very valid criteria with an average validity value of 3.71. Application of interactive Qualitative Analytical Chemistry electronic teaching materials based on the case method and integrated OBE projects developed can increase student chemistry learning outcomes in small group trials by 71% and large group trials by 80% with an average increase in learning outcomes for both test groups try at 75%. The performance product of student project activities in case method and project-based learning is in the good category and shows the reachability of standard learning outcomes (CPL) and course learning outcomes (CPMK) with an average percentage score of 85.92. The scientific process skills developed are observing: 77.29; group:80.06; interpreting and forecasting: 82.98; ask a question:80.41; formulate a hypothesis: 79.3; planning an experiment:78.33; using tools and materials: 75.62; apply concept:79.02 and communicate.

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Development of lecture guidelines using the case method and team-based projects in the department of chemistry

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Abstract. *The main performance indicators (IKU) of universities, according to the Minister of Education and Culture's Decision No. 753/P/2020, represent a performance contract between the Minister and the Rector. The 7th of the 8 IKUs is collaborative and participatory classes. Under this IKU, universities are required to implement lectures using the Case Method and Team-Based Projects, with evaluation criteria contributing 50% to the final grade. This IKU is cascaded down to the faculties, departments, and study programs. This policy research aims to develop lecture guidelines using the Case Method and Team-Based Projects in the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan. The research utilizes a 4D development model—define, design, develop, and disseminate. The product developed is a lecture guideline for the Case Method and Team-Based Projects, which was rated as good by two validators and deemed suitable for use, consisting of five assessment aspects: content feasibility at 91.67% with a very valid category, technical feasibility at 100% with a very valid category, language and writing style at 87.5% with a very valid category, usage effectiveness at 81.25% with a very valid category, and evaluation and feedback aspects at 75% with a valid category. In addition to the guidelines, this research also produced a Semester Learning Plan (RPS) as an example for lecturers, which received a validation score of 95% in the very valid category.*

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Keywords: case method, team-based project, research and development, validation

Introduction

A very important aim in problem-solving and developing critical and creative thinking ability is obviously stated as a goal of national education. Graduates are going to enter the real world where surprises and novelties await them. For such a reason, education should so equip students with the capability of adapting and even outdoing the problems: not just solving problems but mastering them-to turn challenges into inspiring opportunities that yield benefits. Two of the significant skills that modern education graduates are expected to master will be critical and creative thinking. Both are basic competencies with which learners can solve problems. [1]

Ministry of Education and Culture Regulation No. 3 of 2020 and Decree No. 753/P/2020 stipulated that all IKU to be implemented by the universities were eight in all. The seventh KPI demands each faculty to implement Case Method and Team-Based Project as an active learning method. Besides, 50% of the evaluation should be done through Case Method and Team-Based Project. These KPIs of the university are then cascaded into faculties, departments, and study programs. In the 2023 performance agreement between the Head of the Chemistry Department and the Dean of FMIPA, it was recorded that 26% of courses must be based on Case Methods and Team-Based Projects; it is expected to increase in 2024. Although this quantitative target has been reached, further review for quality is highly in need. Apart from that, the existence of various lecturers for the subject means a different personal interpretation of how the Case Method and Team-Based Project is conducted. Ultimately, it leads to an inconsistency in the evaluation of and quality within courses, specifically between courses delivered by different lecturers.

Case analysis and solving are in close relation to the lessons of chemistry, and by the method of case study, the students learn how to solve a problem [2, 3]. Some studies carried out on the case method came out to be extremely effective in learning many different topics. It has the ability to enhance cognitive learning outcomes, such as conceptual understanding, affective aspects, and broader learning benefits, including thinking and communication [4, 5].

The implementation of the case method is highly compatible with the program MBKM. This will provide a very good opportunity to enhance students' skills in 4Cs, namely Creativity Skills, Critical Thinking Skills, Communication Skills, and Collaboration Skills, and finally, it will create better quality graduates, which in turn reduces unemployment waiting times for graduates [6]. The Case method or case study learning model activates students to be more creative and critical in thinking while solving cases from different angles and perspectives in order to arrive at the optimum solution [7]. Application research has been taken in terms of improvement in learning enhanced by the Team-based project or project-based learning model for the current generation of students [8].

Team based projects represent one of the learning models that might enhance the cognitive ability and critical thinking skills in students. Equally, project methods improve the students' academic performance and competence in science learning compared to those with lecture and discussion methods. This is a team-based project method whereby the students are allowed to engage in problem solving to develop their competencies. This study is conducted in order to explain the feasibility of developing a lecture guideline by using Case Method and Team-Based Project in the Department of Chemistry.`

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Method

This research has been carried out at Universitas Negeri Medan, Jalan Willem Iskandar/Pasar V, Medan, North Sumatra, in 2024. Its focuses on the development of Lecture Guidelines Using the Case Method and Team-Based Projects in the Department of Chemistry. The study is conducted using the Four-D (4-D) model. The four successive stages of the 4-D model are define, design, develop, and disseminate [11].

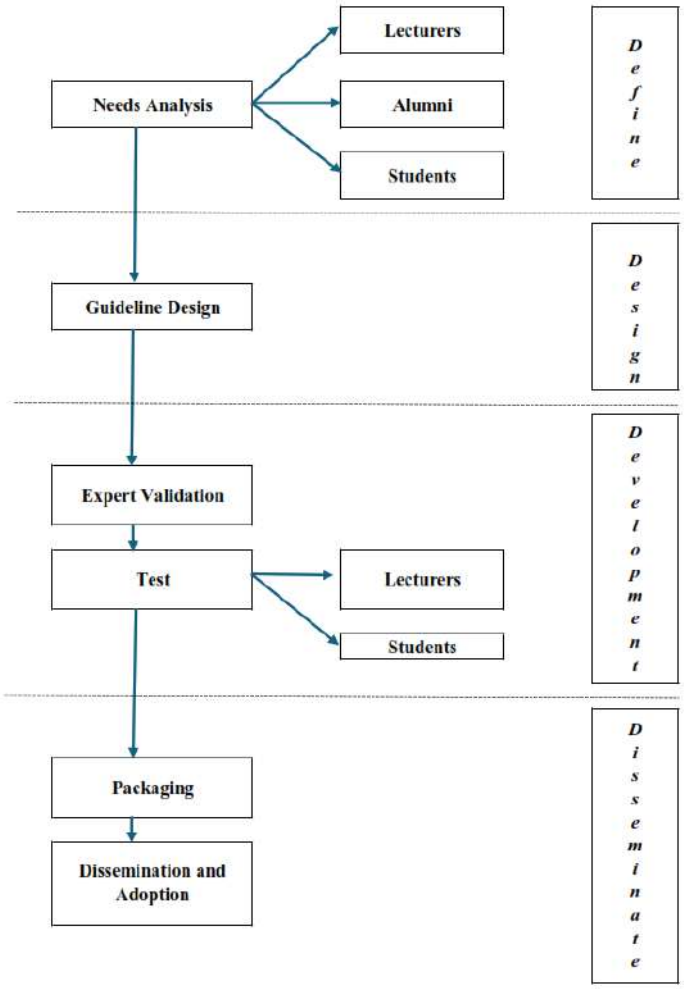

Figure 1. 4D Model Development Design

This research is conducted to explain the feasibility by expert validators of developing a lecture guideline using Case Method and Team-Based Project in the Department of Chemistry. The validation test analysis of the guidelines was conducted by expert validators using a questionnaire instrument. The questionnaire employs a Likert scale with a scoring range of 1 = very poor; 2 = poor; 3 = good; and 4 = very good [12]. The validation aims to determine the feasibility of the developed product. The expert team that performed the validation was further analyzed descriptively in qualitative terms for feedback and suggestions.

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Result and Discussion

Validation by Experts

The design of the guidelines developed in this stage included an example of the Semester Learning Plan (RPS) and served as a reference for lecturers in the Department of Chemistry in implementing lectures with the Case Method and Team-Based Project. This design began by articulating the background, legal bases, objectives, and benefits of the developed guidelines. It then presented a detailed explanation of learning-centered students coupled with a model of learning. Then, an explanation on problem-based learning/case method and team-based project learning method followed suit.

In addition to drawing up the guidelines, the researcher also produced an RPS sample which lecturers within the Department of Chemistry could refer to when developing their respective RPS. The course sampled for this example of RPS was General Chemistry, because it is a compulsory course for both programs within the Department of Chemistry.

The product was further validated by expert validators using the instrument of assessment questionnaire, where the expert validators consist of two members from the Quality Assurance Task Force of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, and the Coordinator of the General Chemistry course of the Department of Chemistry, Universitas Negeri Medan. From this, the following results can be seen in the Tabel 1.

Tabel 1. Recapitulation of validation results

Validation type	Average	Percentage	Category
Content	3.7	91.67%	Very valid
Technical	4.0	100 %	Very valid
Language	3.5	87.5%	Valid
Effectiveness	3.3	81.25%	Valid
Evaluation and Feedback	3.0	75%	Valid

Referring to the validity category of a product, the validation test result on the developed product gave most aspects a rating of valid to highly valid from the validators. It showed that the product was adequately qualitative and hence suitable for implementation within the context of its intended use. The details can be seen in Figure 2.

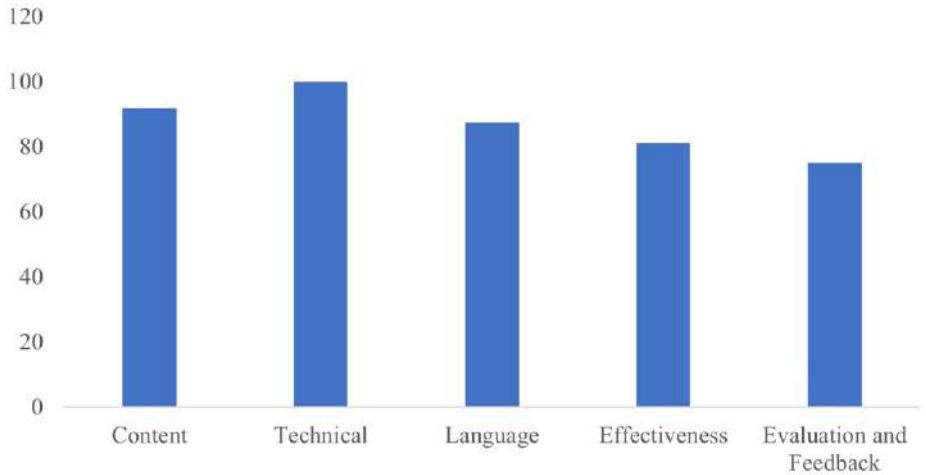

Figure 2. Summary of validity results

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From the developed product, namely Lecture Guideline in the Department of Chemistry using Case Method and Team-Based Project, it appears from the validation result that the highest score is in the technical aspects, nearing 100. It can thus be said that technically this product is well-structured and user-friendly, with its layout and format supporting the smooth running of its implementation. The scores for content and language aspects were also high, about 90, meaning the material is relevant for the chosen learning methods and the language used is clear enough.

The effectiveness aspect receives a mark of about 85, indicating that this teaching guide is effective in helping students achieve learning outcomes but may be further enhanced for more student participation in case studies and team projects. The lowest score was about 80 from the evaluation and feedback aspects. This implies that the assessment mechanism and flow of feedback between lecturers and students are still in need of improvement to facilitate more explicit assessment rubrics or deeper ways of assessment.

This lecture guideline is in general highly feasible, though improvements in the evaluation part and partly in content and language would fully optimize the product for support in case-based and project-based learning within the Department of Chemistry.

Assessment of the Semester Learning Plan (RPS) by Validators

The product developed was the RPS, and this is a model to be applied by lecturers within the Department of Chemistry. This will also form part of the guide for lectures using the Case Method and Team-Based Project approaches. The instrument the researcher uses to assess the RPS developed is an adoption of the RPS assessment conducted by the GPM of FMIPA Universitas Negeri Medan. This RPS is part of the guide currently under development. Expert validation results are presented below.

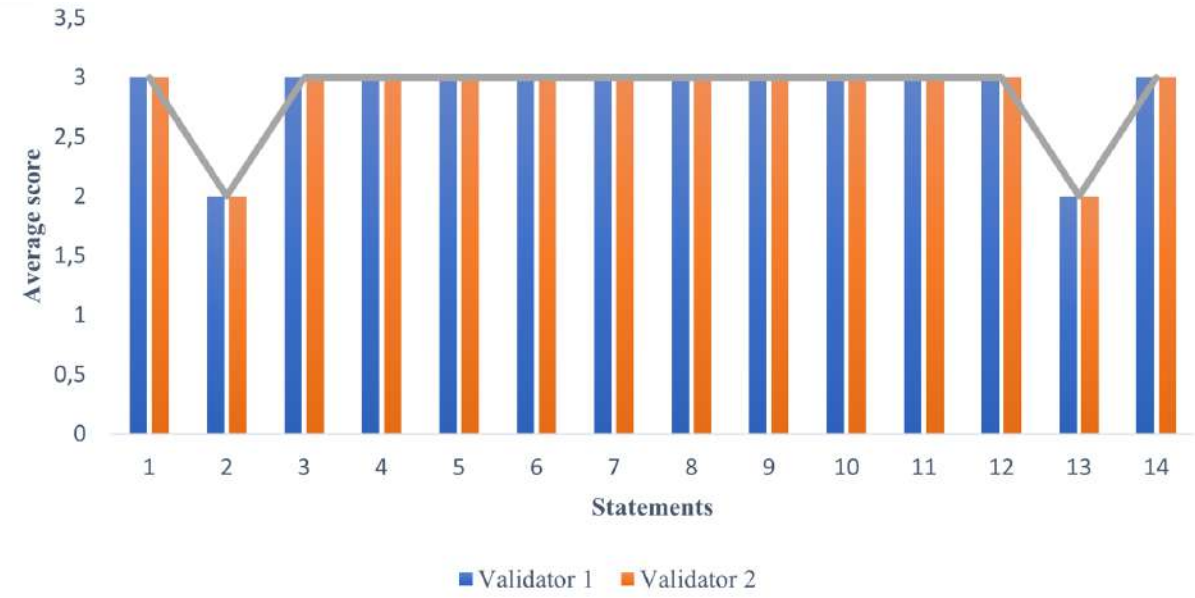

Figure 3. Summary of Assessment of the Semester Learning Plan (RPS) by Validators

Based on Figure 3, from this it can be concluded that RPS which was made as an example in the lecture guideline through the Case Method and Team-Based Project approaches had been commented on positively by both validators. One of the improvements was adding in the

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naming of the practitioner; previously, only the term "practitioner" was shown. This was addressed by enumerating the name of the practitioner. The RPS, used as a model for the lecturers then obtained from the validators an assessment score of 95%, which falls under the "highly feasible" category.

Universitas Negeri Medan opened our general chemistry program by establishing links with practitioners and professional experts in various industrial fields to promote relevance and quality of learning. We proudly introduce Mr. Indra, S.Si., Quality Analyst at PT Unilever Oleochemical Indonesia, who is going to share his experiences and expertise directly with the students in this 6th meeting.

Coming with a strong background and rich experience in the oleochemical industry, Mr. Indra will present practical insights and industrial case studies relevant to the course and thus help the students bridge the gap between what is theoretically taught in class and what is practiced in reality. His presence is bound to enrich not only the understanding of the students but also inspire them towards pursuing careers in related fields.

Conclusion

Based on this research result, implementation of a lecture guideline in Case Method and Team-Based Project with their developed Semester Learning Plan-RPS will be worth trying in the General Chemistry course of the Department of Chemistry. The approach shall contribute to solid improvement in teaching methodology and also make learning more interactive.

Acknowledgments

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Development of a higher order thinking skill (HOTS) chemical module based on science, technology, engineering, and mathematics (STEM) on thermochemistry materials

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Abstract. *This research aims to develop a module that can improve students' high-level thinking skills so that they are able to think critically, creatively, innovatively and are able to solve the problems they face. The chemistry module that has been developed is combined with the application of the Science, Technology, Engineering, and Mathematics (STEM) learning model as well as questions that have Higher Order Thinking Skill (HOTS) reasoning on Thermochemistry material in the general chemistry course. The Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM) which was developed is expected to improve students' high-level thinking skills, especially in thermochemistry material in general chemistry courses. Therefore, a Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM) was developed on Thermochemistry material. Research on the development of this chemistry module has been carried out using a 4-D development model which consists of 4 development stages, namely define, design, development and disseminate. This research was carried out in the chemistry department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan. The feasibility test for the chemistry module that has been developed has been validated by two expert lecturers and obtained results that fall into the very feasible category. This category includes the appropriateness aspect of the content in this module, namely obtaining a percentage of content appropriateness of 82.5%, in the appropriateness aspect of presentation 91.7%, in the appropriateness aspect of language 91.7% and in the aspect of appropriateness of graphics obtaining 86% where the average from all these aspects it falls into the very feasible category with several improvements suggested by expert validators for product improvement.*

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Keywords: *higher order thinking skill, module, stem model, thermochemistry.*

Introduction

Education is very much needed by students to be able to improve their competence so that in the end they can produce graduates who are competitive in the world of work. The education process can be carried out in a directed manner by looking at the basis of the students' competency needs [1]. The competencies needed by students today include high-level thinking skills of students which include critical thinking skills, being able to solve problems they face, being creative and innovative. Thinking skills like this will make students more qualified in doing every job or activity because students will be able to communicate and cooperate well with each other [2].

High-level thinking skills will direct students to be able to analyze to be able to synthesize which in the end is able to create new ideas that are creative and innovative [3]. Higher Order Thinking Skill (HOTS) is the ability of students to think to be able to process their thoughts to lead to something creative and innovative through the scientific facts they obtain [4]. High-level thinking skills are a complex thinking process in describing material, making conclusions, building representations, analyzing, and building relationships by involving the most basic mental activities [5].

Students' high-level thinking skills can be supported by using modules containing Higher Order Thinking Skill (HOTS) questions so that students are accustomed to dealing with problems or Higher Order Thinking Skill (HOTS) questions that require longer reasoning with a minimum cognitive level of C4 (Analysis). In addition, this high-level ability also needs to be supported by the right learning method so that it is very appropriate if combined with the Science, Technology, Engineering, And Mathematics (STEM) learning model. Science, Technology, Engineering, And Mathematics (STEM) aims to demonstrate holistic knowledge so that it can prepare quality and competitive students [6]. STEM education means providing practical reinforcement of education in STEM fields separately, while developing an educational approach that integrates science, technology, engineering, and mathematics, by focusing the educational process on solving real problems in everyday life or professional life [7]. According to Pfeiffer, Ignatov, and Poelmans (2013) also stated that in STEM learning skills and knowledge are learned simultaneously by students [8].

The application of chemistry is widely used for the needs of human life both in the fields of health, industry and in other fields of life. One of the chemical materials that is widely applied in life is Thermochemistry. Thermochemistry is closely related to human life. An example of the application of thermochemistry in life is the basic concept of using batteries. Batteries are materials that can store electrical energy and the electric current contained in the battery can be distributed to power electrical equipment in the home. The facts of the application of chemistry in human life are the starting point for students to be able to think at a high level related to Thermochemistry in general chemistry courses so that students are able to apply chemical concepts, analyze and create something new that is useful for the lives of living things. Therefore, the Science, Technology, Engineering, And Mathematics (STEM) learning model is the right model to be able to study and explore contextual chemical material.

Based on the results of the author's observations of the lecture process on Thermochemistry material in general chemistry courses, the Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, And Mathematics (STEM) used in the lecture process is still minimally available. In general, students use teaching materials that have

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not integrated Higher Order Thinking Skill (HOTS) questions and are not integrated with the Science, Technology, Engineering, And Mathematics (STEM) learning model. Therefore, there is still a need for additional Higher Order Thinking Skill (HOTS) chemistry modules that are integrated with Science, Technology, Engineering, And Mathematics (STEM).

Based on the explanation, it is very important to conduct research on " Development of A Higher Order Thinking Skill (HOTS) Chemical Module Based On Science, Technology, Engineering, And Mathematics (STEM) on Thermochemistry Materials " so that it is expected to meet the needs of Higher Order Thinking Skill (HOTS) chemistry modules based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry Material.

Methodology

The research method used in this study is the Research and Development (R&D) method with the 4-D model. Research and development according to Gall & Borg (2003) [9] is a process to develop and validate a product. Research and development is also a process to develop a new product or improve an existing product [10]. The 4-D development model consists of four stages, namely define, design, develop, and disseminate [11].

Results And Discussion

This research was conducted to develop a Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry Material using the 4-D development model from Thiagarajan which goes through 4 stages, namely: (1) Define, (2) Design, (3) Development and Dissemination. Based on the development research that has been carried out, the following results were obtained.

Define Stages

At this definition stage, an analysis has been carried out regarding what is needed to be used as a basis for compiling the development of a Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry material, namely as follows.

Initial Analysis

The initial analysis was conducted by interviewing 3 lecturers of general chemistry courses at the Chemistry Education Study Program, Chemistry Department, FMIPA Universitas Negeri Medan and data processing was carried out on the data so that data was obtained that on average lecturers use the case method/PBL and PjBL learning models in the learning process of general chemistry courses and accompanied by an evaluation test instrument that is Higher Order Thinking Skill (HOTS). Based on these data, it can be concluded that there is still a lack of STEM implementation by lecturers in the lecture process in class when teaching general chemistry courses. In fact, this STEM learning model is one of the right learning models in improving students' high-level thinking skills [12].

Curriculum Analysis

In the curriculum analysis section, an analysis of the Lesson plan for the General Chemistry course has been carried out and the results obtained are that the average test instrument used is included in the test instrument with the Higher Order Thinking Skill (HOTS) level of thinking ability. In addition, the models generally used are PBL and PjBL. Therefore, there is still a need

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for variations in chemistry learning models, including the STEM learning model that links theoretical knowledge with contextual events/facts that occur so that it will be able to direct the way students think to have high-level thinking skills.

Concept Analysis

In the conceptual analysis section, an analysis has been carried out on each sub-material in the Thermochemistry material studied in the Thermochemistry course so that several sub-materials are obtained that require more specific and more complete explanations in order to understand them. In addition, based on the results of the analysis of the material and sub-materials that have been carried out, the researcher connects each material and sub-material with contextual events that occur both in the industrial world, education and in community life. Furthermore, the sub-materials are arranged systematically in a chemistry module that has been developed and integrated with HOTS test instruments and STEM learning models so that they are able to produce quality teaching material products

Purpose Specification

At this goal specification stage, the formulation of learning objectives is carried out based on an initial analysis related to the Thermochemistry material that has been integrated into the Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM), namely: a) being able to explain the definition of thermochemistry, energy and its relationship in the field of Science, Technology, Engineering, and Mathematics (STEM), b) being able to analyze the application of thermochemistry concepts in the field of Science, Technology, Engineering, and Mathematics (STEM), c) being able to apply thermochemistry concepts in the field of Science, Technology, Engineering, and Mathematics (STEM), d) understanding and explaining the process of exothermic and endothermic reactions in the field of Science, Technology, Engineering, and Mathematics (STEM), e) being able to design exothermic and endothermic reactions and implement them in the field of Science, Technology, Engineering, and Mathematics (STEM), f) being able to create thermochemical reaction equations and analyze their application in the field of Science, Technology, Engineering, and Mathematics (STEM), g) being able to analyze the types of thermochemical reactions that occur and their relationship in the field of Science, Technology, Engineering, and Mathematics (STEM), h) being able to formulate, analyze, determine the values of enthalpy changes in thermochemical concepts and their relationship in the fields of Science, Technology, Engineering, and Mathematics (STEM).

Design Stage

Modification of Basic Concept of Material

At the stage of modifying the basic concept of this material, the researcher has modified the sub-material to be integrated into the chemistry module based on the analysis of thermochemistry material in several reference sources so that the researcher creates material in the chemistry module that is developed divided into three sub-materials that focus on understanding the concept of thermochemistry and energy, types of thermochemical reactions that occur, and determining the enthalpy that occurs in thermochemical reactions and its application in the fields of Science, Technology, Engineering, And Mathematics (STEM).

Media Selection

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The creation of chemistry modules uses two applications to design chemistry modules, namely Microsoft Word and Canva. Based on the collaboration of Word and Canva, it will maximize the design of quality modules and also be integrated with attractive images and color designs to increase reader motivation and not bore module readers. In addition, we also integrate with barcodes and video links on the application of thermochemical concepts in the fields of Science, Technology, Engineering, and Mathematics (STEM) which will also make it easier for students to understand the material and its application in life

Format Selection

The chemistry module developed consists of several important parts to make it easier for readers to use and understand the contents of the developed module, including cover, foreword, table of contents, Module Usage Guide, Learning Objectives, Concept Map, Material and its application in the field of Science, Technology, Engineering, And Mathematics (STEM) which is integrated with the HOTS test instrument, Summary, Evaluation Question Answer Key, Glossary, Bibliography, Summary of Book Contents. The systematics are arranged in Times New Roman writing format with font size 12.

Development Stage

At this development stage, a Higher Order Thinking Skill (HOTS) chemistry module based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry Material has been created in accordance with the design that has been designed and then validated by 2 expert validators and revised by researchers to produce a chemistry module that is suitable for use. The results of the feasibility validation by expert validators are as follows.

Feasibility Test Results of the Developed Chemistry Module

The feasibility test of the developed chemistry module has been validated by two expert lecturers and based on the feasibility according to BSNP and obtained feasibility results consisting of 4 indicator aspects. In the aspect of content feasibility, the percentage of content feasibility was 82.5%, in the aspect of presentation feasibility 91.7%, in the aspect of language feasibility 91.7% and in the aspect of graphic feasibility obtained 86% where all of these aspects are included in the very feasible category with several improvements suggested by expert validators for product improvement. The feasibility of the developed teaching materials can clearly be seen in Figure 1. Feasibility Graph of the Higher Order Thinking Skill (HOTS) Chemistry Module Based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry Material.

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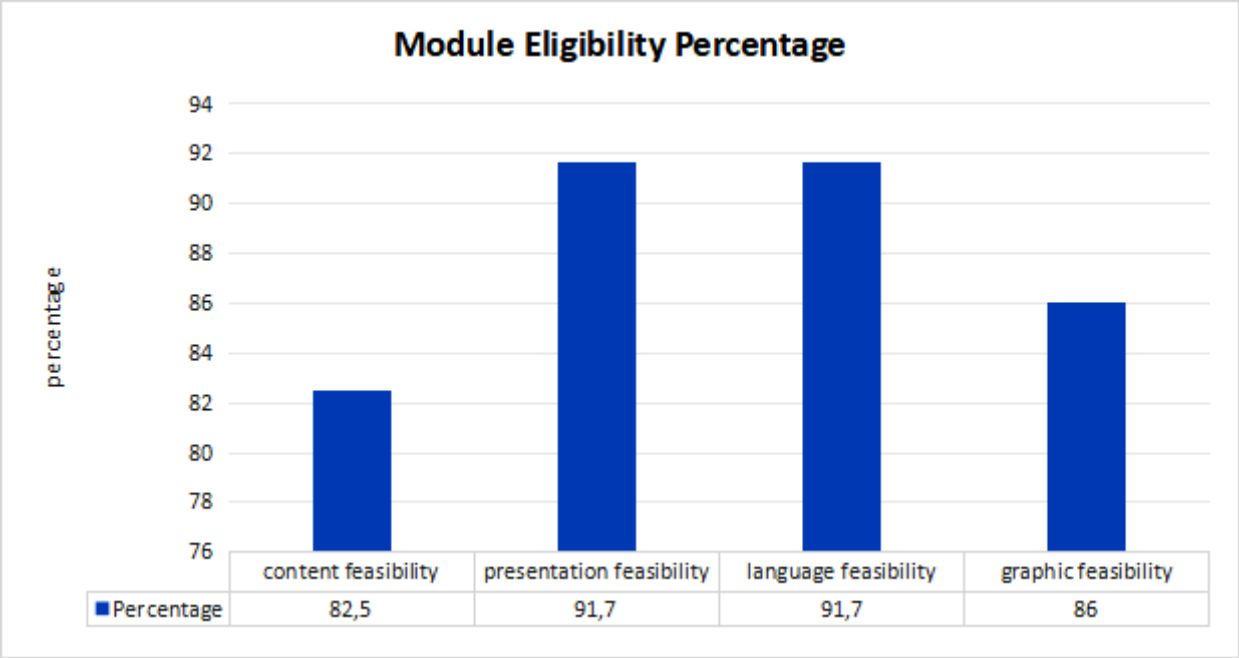

Figure 1. Feasibility Graph of Higher Order Thinking Skill (HOTS) Chemistry Module Based on Science, Technology, Engineering, and Mathematics (STEM) on Thermochemistry Material.

Conclusion

The module's suitability is seen from 4 aspects, namely the content suitability aspect obtained a content suitability percentage of 82.5%, the presentation suitability aspect obtained 91.7%, the language suitability aspect obtained 91.7% and the graphic suitability aspect obtained 86% where all of these aspects are included in the very feasible category with several improvements suggested by expert validators to improve the product.

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Effectiveness video application of basic skills teaching in micro learning

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Abstract. *The Micro Teaching course aims to equip prospective educators with some basic teaching and learning skills. Objectives study This implemented For to find out the effectiveness of Video Media on Micro Learning through the Application of Basic Teaching Skills Video, and to find out students' responses to Basic Teaching Skills video media used in micro learning. The population in this study were students majoring in chemistry education who were taking the Micro Learning course as many as 4 classes and purposively taken 1 class as a sample consisting of 13 students. The method used in this study is a quasi-experimental method with a quantitative approach. The research design used is Pre-Test and Post-Test Control with one type of treatment. The data analysis technique uses the Gain Test which is then converted to interpretation of N-gain effectiveness, and analysis descriptive response student with count percentage. Research results show normalized gain increase by 81.61% in Category high . After converted to interpretation N- gain effectiveness >76, is in the category Effective. With thus concluded Vidio media skills base teach effective used For increase skills base students in the course Learning micro. While response student to use of media skills base teaching used is in the 85.81 category, in the Very Good category, meaning student respond Good very on video media and the use of video skills base teaching in learning micro.*

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Keywords: *Effectiveness, Learning Video Media, Student Response*

Introduction

Skills base teach is basic skills (skills) the main thing which must be mastered by a teacher or prospective teacher, no except student prospective chemistry teacher. If associated with four teacher competence, then [7] states that skills base teach including to in competence professional. However, in apply every skills base teaching teachers must adapt with condition students and characteristics material so that skills base teaching is also related with competence pedagogical. Skills base teach No can obtained only with learn theory, or even only just memorize.

There are 8 skills base teaching that must be owned by a teacher or prospective teachers for applied with Good in the learning process. Eight skills teaching that is considered own role important in success activity learn how to teach includes (1) skills ask, (2) skills give strengthening, (3) skills stage variation, (4) skills explain, (5) skills open and close lessons, (6) skills guide discussion group small, (7) skills manage class, (8) skills teach group small and individual [17]. It can be said that control skills base teach is one of factor important as determinant success student in learning. In research skills base teach only limited to skills ask and skill give strengthening (reinforcement).

Strategy and resources Power learning micro the more popular as means for empower teachers, improve teacher results, and prevent fatigue [1] [9]. Through use concise and easy lessons consumed, learning micro allows teachers to strengthen knowledge they, learn with speed they yourself, and maintain involvement in eye complex lessons. Utilizing learning videos is one of method microlearning. Short, targeted videos This give guide clear step by step to educators about eye lesson certain, so that allow they with fast learn ability new or polish knowledge that has been obtained previously. For example, a teacher can watch training videos short highlighting Features main and offer suggestions for implementation succeed use learn method utilise application technology education new. The results of the study [14] found that learning micro have implications for development skills teach proven students through average skill data teach increase.

Next [15] found that skills teaching high and varied teachers influential to improvement results Study students. Research results shows 53.1% of teachers have skills low teaching matter This influence results Study as well as interest Study students who tend to low. Then the teacher's teaching skills have an affirmative impact on student learning motivation. Students who have very high learning motivation are usually stated to come from classes whose teachers also have very good teaching skills (8.7%) compared to classes whose teachers only have sufficient performance (3.7%) [11]. In order for teachers to be able to carry out their duties effectively, teachers are required to master basic teaching skills, including the skills of asking questions, giving reinforcement, making variations, explaining, opening and closing lessons, guiding discussions, the ability to manage classes, the ability to use learning media, and using technology [4] [5].

Thus it can be said that basic teaching skills are a type of applicable skills so that they can be mastered by prospective teacher students, then each basic teaching skill must be honed with exercises and can also be assisted by the use of learning video media by teachers or by watching from YouTube which contains learning videos of basic teaching skills exercises. This study aims to see how effective video media is on micro learning outcomes through the application of basic teaching skills and to see students' responses to video media used in micro learning courses.

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Methodology

Class was purposively taken as a sample of 13 students. The design study Which used to measure the effectiveness of learning video media, using one sample class, with a *One Group pretest-posttest Design* (adapted from Sugiyono, 2016). The first step is to conduct initial observations on the percentage of students' basic teaching skills, as *a pretest*, then given treatment for a certain period of time, then a final observation is carried out as *a posttest*. The research design pattern is as follows:

Table 1. Trial Design

Observation beginning	Treatment	Observation end
T1	X	T2

Field test result data This analyzed For get mark media effectiveness on skills base teach students . At the stage field tests were also conducted giving questionnaire response students to see the response students on the use of video learning media which has been compiled and tested in learning.

Gain test (*N-Gain*) was conducted to determine the increase in students' basic teaching skills after being given treatment, using the formula:

$$g = \frac{posttest\ score - pretest\ score}{maximum\ pretest\ score}$$

The results of the N-Gain calculation are then interpreted in the normalized gain criteria as in the following table:

Table 2. Gain Test Categories

Interval	Category
g < 0.3	Low
0.3 ≤g ≤0.7	Currently
g > 0.70	Tall

Then it is converted to the following interpretation of effectiveness:

Table 3. Interpretation categories of *N-gain effectiveness*

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Enough Effective
>76	Effective

(Source : Hake, 1999)

Whereas analysis response student to use of video media skills base teach can counted with use formula following :

$$P = \frac{f}{n} x\ 100\%$$

Information :

P : Percentage response student
f : Amount score obtained student
n : Number score maximum

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Table 4. Criteria for Student Responses to video media

Score	Percentage Interval	Criteria
16 – 20	83% to 100%	Very high (very good)
13 – 16	67% to 83%	High (good)
10 – 13	51% to 67%	Currently (enough)
7 – 10	35% to 51%	Low (low)
4 – 7	20% to 35%	Very low (very low)

Result and Discussion

This research was conducted in the chemistry education department of Unimed starting from the initial observation of the percentage of basic teaching skills in micro-learning lectures. The data obtained from the results of the initial and final observations were converted into learning outcome data. To find out the increase in student learning outcomes, researchers measure with N-Gain test after analyze results *pretest* and *posttest*
As for the results The calculation of the N-Gain test is as following .

Table 5. Gain Test Data Results

Data	Average	N Gain Score	N-Gain
Pretest	28.38	0.82	81.61% (High)
Posttest	86.54		

The table above shows a significant increase from the *pretest score* to *the posttest score* , with an average pretest score of 28.38 and an average *posttest score* of 86.54. The normalized %gain value is 81.61% which indicates a high category. The results of the N-Gain Test obtained are converted to the interpretation of the effectiveness of *N-gain* (Hake, 1999), the result of 81.61% indicates>76 (Effective), meaning that the basic teaching skills video media is effective for use in Micro learning lectures.

Student response results

Assessment of student responses was carried out by distributing questionnaires. to students who attended Micro Learning lectures with basic teaching skills video media as many as 13 students. The results evaluation response student can seen in the table as following :

Table 6. Questionnaire Results response student

Aspect	Average (%)	Category
Interest	83.8	Very well
Material	83.04	Very well
Language	84.6	Very well
Total	85.81	Very well

Based on the table above, it can be seen the aspects of student interest, material aspects and language aspects used to assess student responses. Interest obtained an average percentage of 83.8%, the material aspect obtained a percentage of 83.04% and the language aspect was 84.6%. All of these aspects are in the very good category. This means that students stated that the basic teaching skills video media used in micro-learning lectures were interesting with the presentation of material that could facilitate them in lectures. That the average percentage of 13 students for the basic teaching skills video media to improve students' basic teaching skills in micro-learning was

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85.81% and was included in the very good criteria. So that the basic teaching skills video media can be used in the Micro-Learning lecture process.

Discussion

Basic teaching skills are skills that must be possessed by every educator so that an educator is able to carry out learning if they can apply learning skills perfectly. In this activity, it is not only about teachers who provide learning with students but educators are required to be able to provide guidance, teach and provide knowledge to their students related to their characteristics. a skill that is given is related to something that is mandatory from the start and must be possessed by educators when carrying out learning activities. When teaching, educators must have two abilities which include mastery of the material to be given and how to carry out learning. Basic teaching skills of students as prospective teachers are trained in micro- *teaching lectures.*

[8] states that *micro teaching* is a form of controlled training that focuses on the teaching activities of prospective educators with clear and directed monitoring. The purpose of micro teaching learning is to provide opportunities for prospective teachers to train and practice teaching skills in front of their friends as provisions for prospective teachers in actual teaching at school (Supriyadi, 2013). Teaching skills are the key to success in learning. The success or failure of the learning process depends on the teaching skills carried out by the teacher [3]. Teaching skills are teaching abilities that must be carried out by teachers in teaching students effectively [10]. The results of the study [6] found that the influence of the variables of teacher teaching skills and teacher creativity on student learning achievement was 59.71%, and the remaining 40.29% was influenced by other factors.

Learning micro and training independent give Lots profit for staff education [16] [18]. The first benefit is help teachers follow innovation latest in technology, approach teaching, and tactics teaching. Professionals education can increase effectiveness they as a teacher and adapt self with change need education with in a way consistent learn things new. This is increase development professional and happiness Work they besides help students. Second, the risk fatigue reduced with training independence and learning micro.

Whereas related research with improvement results Study with use of related media with adult IT this , good in video form, animation and the Web is already very much done. Some among them is [2] his research conclude that the use of Weblog media can increase results think crisis student by 82%, and the response students are also very good with the use of Weblog media is obtained response by 86%. Meanwhile [13] found improvement results Study by 75% with use of media, especially Web media and only to obtain improvement by 56% without using media, so that more media usage Good in learning. Responses were also found students who enjoy the use of the media by 90%. Complete the use of the media research [12] concluded very well used *macromedia flash* which can increase results learning and activities student.

With Video display of learning, students can feel as if they is at or participate as well as in the atmosphere depicted. Therefore that, teachers or lecturer should function video media learning with good and necessary utilized in a way synergistic For optimize learning, so that can create conditions that can push students to be able to reach competence in the learning provided.

Conclusion

In general overall study This conclude that the media Vidio skills base teach effective used For increase skills base students in the course learning micro . Research results show normalized gain increase by 81.61% in Category high, and response student to use of media skills base teaching

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used is in the category 85.81, in the category Very Good.

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Development of a performance recapitulation system for the academic community and supporting resources for quality control in the faculty of mathematics and natural sciences.

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Abstract. *Good quality education does not only depend on the learning process alone, but also on the performance of the entire academic community, namely lecturers, students, and education staff, as well as the effectiveness of an institution's supporting resources. The Faculty of Mathematics and Natural Sciences, State University of Medan is one of the educational institutions that continues to strive to improve the quality of its education. From the results of current observations, there is still manual, fragmented, and less than optimal performance data management, which hinders the evaluation process and strategic*

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decision-making of leaders. Therefore, this study aims to develop an integrated performance recapitulation system to support quality control more effectively and efficiently. The method used in developing this system is the System Development Life Cycle (SDLC) with a Waterfall approach. The stages carried out include needs analysis, system design, implementation, and testing. Data were collected from various sources, including lecturer performance reports, student achievements, and administrative support. This system is web-based to improve accessibility, openness of information, and ease in the recapitulation and reporting process. The results of this development indicate that the performance recapitulation system produced is able to facilitate the collection, management, and analysis of data automatically. This system allows the faculty to monitor the performance of the academic community in real-time, accelerate the evaluation process, and support data-based decision making. In addition, this system also provides significant support for efforts to improve the quality and accreditation of the faculty. In conclusion, the system developed has succeeded in meeting the needs of the faculty in terms of quality management and control. With this system, it is hoped that the performance evaluation process can be carried out more efficiently and transparently, so that it can improve the quality of education in FMIPA as a whole.

Keywords: *quality control, academic community performance, performance recapitulation, SDLC, FMIPA*

Introduction

Quality control in higher education institutions is a necessity to ensure academic and operational quality in accordance with national and international standards) [1]. FMIPA UNIMED, as a faculty that focuses on the development of science and technology, has big challenges in maintaining and improving this quality. This challenge includes aspects of managing the performance of the academic community and supporting resources which include lecturers, educational staff, laboratory facilities, libraries and administrative services [2]. One of the main problems faced is the lack of an integrated system to unify and manage performance in real-time. The manual processes currently used often take a long time, are prone to errors, and are inefficient in collecting data from various sources [3]. This condition can hinder quick and appropriate decision making, which ultimately has a negative impact on the quality of education and services [4]. Various previous studies have shown the importance of using information technology in supporting quality control in higher education. Integrated information systems enable better data management, reduced human error, and increased efficiency in monitoring and evaluation processes [5]. Apart from that, the use of this technology can also support transparency and accountability in the management of educational institutions [6]. In the context of FMIPA UNIMED, the performance recapitulation system that will be designed aims to overcome these problems by providing a platform capable of collecting, processing and presenting performance data in an integrated and real-time manner [7]. Thus, this system is expected to increase the effectiveness and efficiency of quality control and support data-based decision making [8]. This system will also be designed to have flexibility in accommodating various types of data and performance indicators, both from academic and non-academic aspects. This is important because the performance of the academic community is not only determined by academic achievement, but also by other factors such as involvement in research, community service, and professional development [9]. It is hoped that the development of this system can become a model for other faculties within UNIMED and other universities in Indonesia [10].

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Research Method

Development of a Recapitulation System for Academic Community Performance and Supporting Resources for Quality Control at FMIPA Medan State University using the System Development Life Cycle (SDLC) approach with the Waterfall model. The stages in this method include requirements analysis, system design, implementation, testing, and maintenance [11]. The data used in this design includes the performance of lecturers, administrative staff, and other supporting resources such as laboratory and library facilities. The SDLC stages can be seen in Figure 1 below.

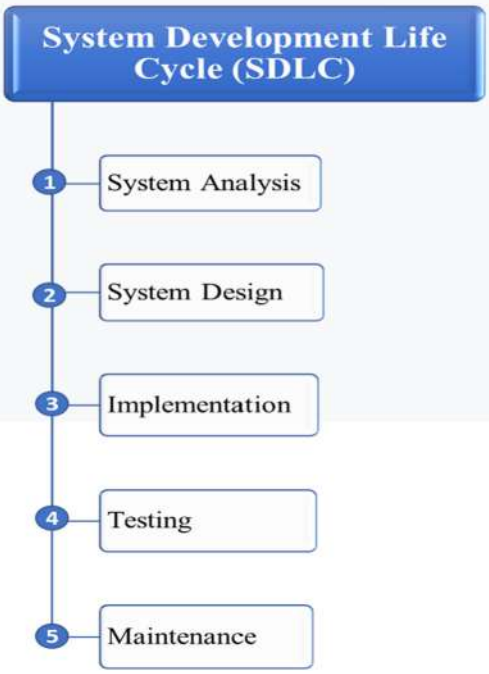

Figure 1. SDLC Waterfall

System Analysis

The initial stage in designing the Academic Community Performance Recapitulation System and Supporting Resources for Quality Control FMIPA Medan State University is to carry out a needs analysis which involves identifying the needs of end users, both from the academic community and faculty management. This analysis includes the need for data access speed, accuracy, and integration capabilities with other systems that already exist and are running at Medan State University.

System Design

Design of Academic Community Performance Recapitulation System and Supporting Resources for Quality Control FMIPA Medan State University uses UML to provide an overview of its development. Each module is designed to meet needs based on the previous stages of needs analysis.

Implementation

Implementation of the Academic Community Performance Recapitulation System and Supporting Resources for Quality Control of FMIPA Medan State University is carried out by utilizing

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relational database technology and web-based platforms for wider accessibility. This system is also designed to be accessible via mobile devices to make it easier for users to monitor performance anytime and anywhere according to user needs.

Testing

The system testing was carried out with the aim of ensuring that the Academic Community Performance Recapitulation System and Supporting Resources for Quality Control of FMIPA State Universities worked according to the specified specifications. Testing includes functional testing, performance testing, and security testing. All tests were carried out using the Black Box method.

Maintenance

The system maintenance phase involves regular system updates in accordance with developments in user needs and technology. This activity will later be carried out by the admin who has received an official assignment from the Faculty of Mathematics and Science at Medan State University

Result and Discussion

The results of research on the Academic Community Performance Recapitulation System and Supporting Resources for Quality Control at FMIPA Medan State University are in the form of a web-based integrated system that can be accessed 24 hours. The following is the Academic Community Performance Recapitulation System and Supporting Resources for Quality Control of FMIPA State University that has been built. In the performance recapitulation system of the academic community and supporting resources for quality control of FMIPA State University of Medan there is data that includes all data contained in the Faculty includes data and documents:

• Vision, mission, Goals, and Strategy

In this menu there are legal documents related to the vision, mission and strategy at the University and Faculty level which can be used for accreditation purposes and other policy management.

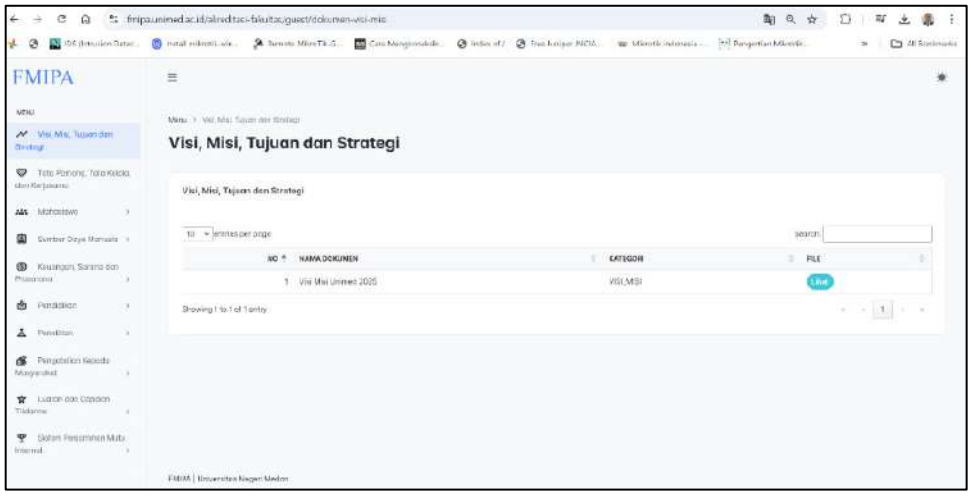

Figure 2. Dashboard Vision, Mission and Strategy

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• Civil service, governance and cooperation

In this menu there are legal documents on civil service, governance and cooperation at university, faculty and study program levels which can be accessed openly.

Figure 3. Dashboard Vision, Mission and Strategy Menu Dashboard

• Student

The Student menu provides information on active students relating to achievements, status and others as well as alumni data relating to information about alumni.

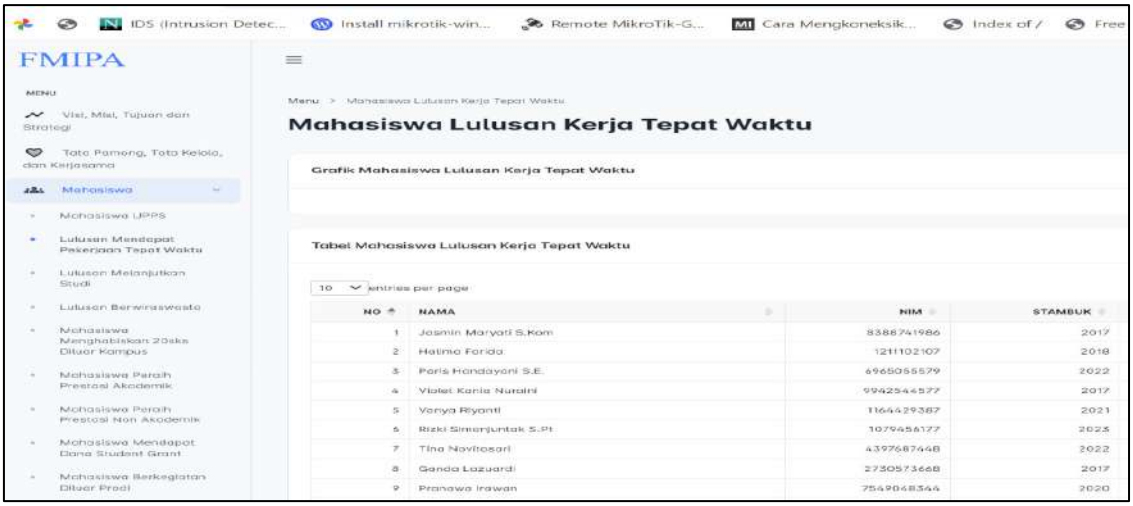

Figure 4. Dashboard Student

• Human Resources

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In the human resources menu, data is provided relating to the entire academic community at FMIPA (Lecturers & Staff) where this data relates to education level, competency and others

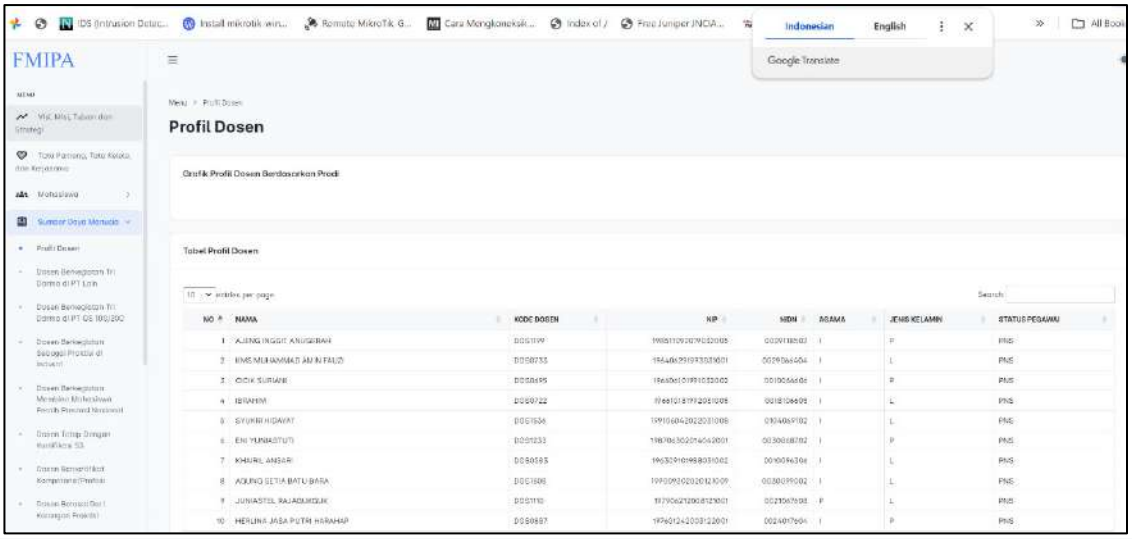

Figure 5. Dashboard Human Resources

• Finance, Facilities and Infrastructure

The finance, facilities and infrastructure menu contains information related to the use of finance at the FMIPA level as well as information on the facilities contained in the FMIPA including the name of the room and the tools contained therein.

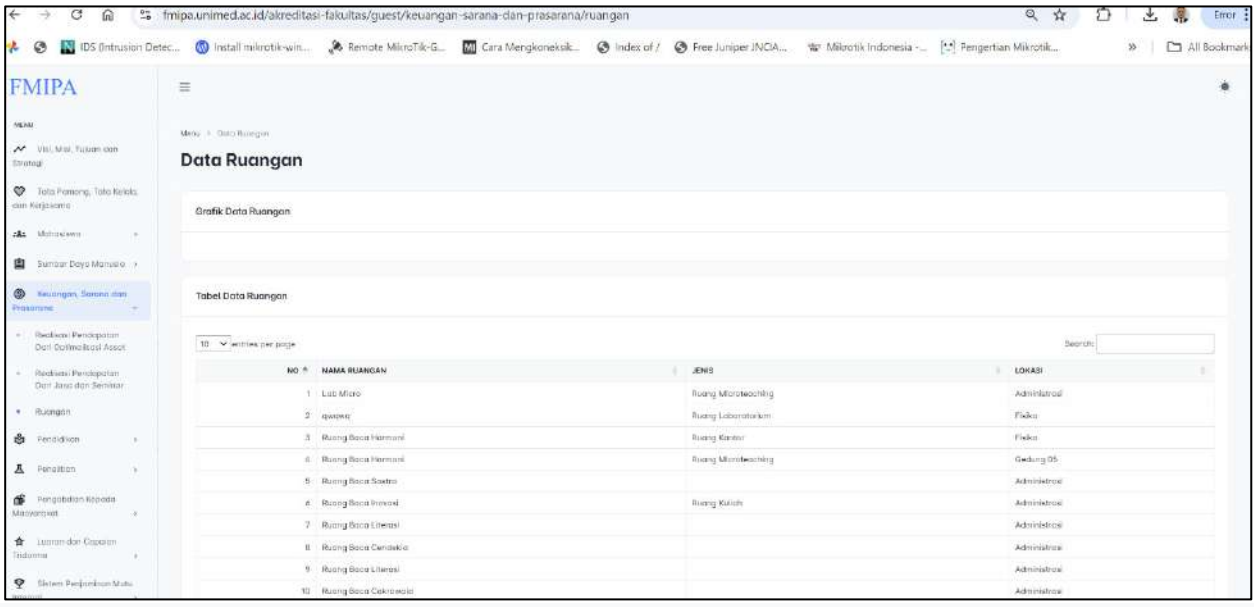

Figure 6. Dashboard Finance, Facilities and Infrastructure

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• Education

In the education menu, users will be given access to view available courses, study program accreditation, semester learning plans (RPS), and the curriculum used.

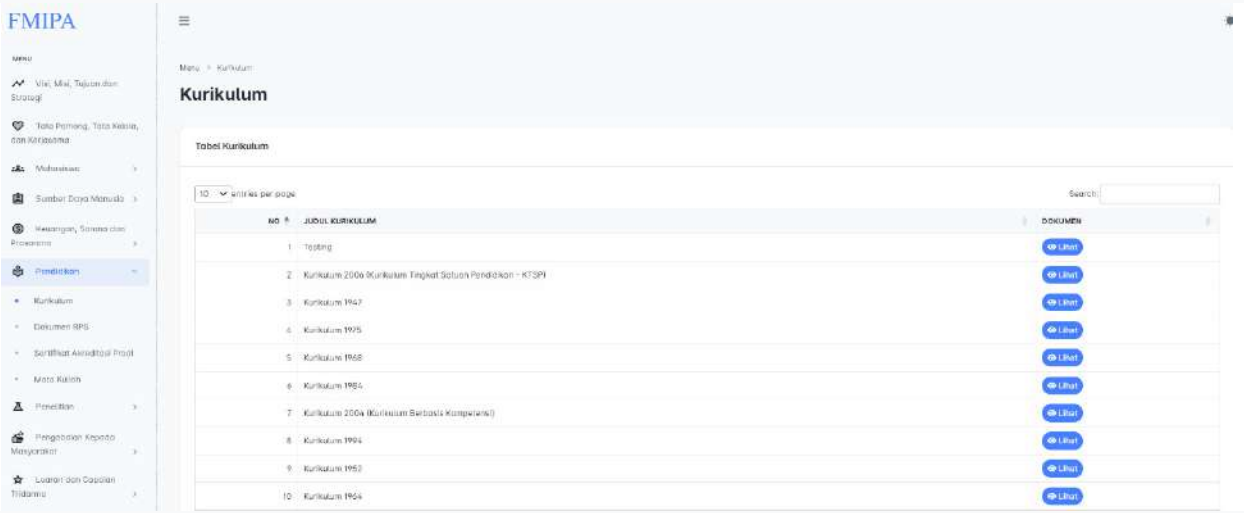

Figure 7. Dashboard Education

• Study

In the research menu, users can find out related research information, starting from the research roadmap, number of proposals, sources of research funding, and acquisition of IPR/PATENTS each year.

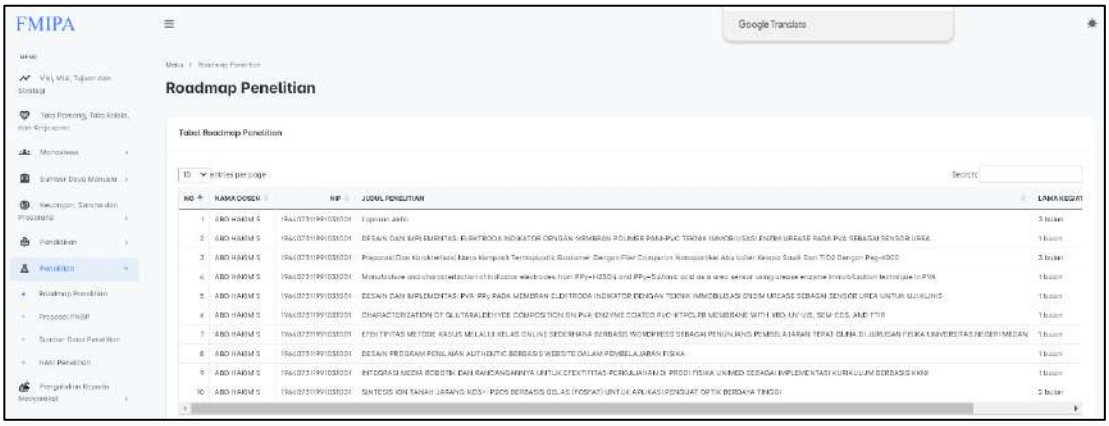

Figure 8. Dashboard Study

• Community Service

The community service menu contains information related to PKM activities including the PKM roadmap, funding sources, and IPR/PATENTS.

All data and documents contained in the academic community performance recapitulation system and supporting resources for quality control of FMIPA Medan State University as described are

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very important data that are integrated with each other and can be used as data for policy making, of course this is very helpful so that everyone policies will be decided according to needs in the field.

Conclusion

From the results of this research, an integrated system has been successfully built within the Faculty of Mathematics and Natural Sciences, Medan State University. This system provides information that can be accessed openly by interested parties for various needs that support the determination of policies that are right on target and in accordance with needs in the field. Suggestions for further research are integrating artificial intelligence systems that can provide options that can be taken in decision making

Gratefulness

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Development of teaching materials based on canva using the IBL STEM model to improve students' HOTS skills

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Abstract. *Equipping students to have high-level thinking skills (HOTS) has become a major discussion in the world of education including at the university level. The strategy that lecturers can apply in training and improving students' HOTS is to develop technology-based teaching materials and student- centered learning models in lecture activities. This study aims to provide General Chemistry (Stoichiometry) teaching materials, based on Canva using the IBL-STEM Model that are feasible and effective in improving students' HOTS abilities. The teaching materials were developed using the ADDIE model. This study produces General Chemistry teaching materials based on Canva using the IBL-STEM Model that are feasible for use in lecture activities and effectively improve students' HOTS abilities in Stoichiometry learning ($p = 0.000 < 0.05$).*

Keywords: *Teaching Materials, Canva, IBL STEM, HOTS, Stoichiometry*

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Introduction

Education in the 21st century is currently required to be able to equip students or students who have critical, creative, collaborative and communicative thinking skills known as 4C skills. This is intended so that students have good skills and abilities in facing various challenges of life in the 21st century [1]. 21st century skills which include: critical thinking, creativity, communication, and collaboration are high-level thinking skills (higher order thinking skills/HOTS) which are very much needed in preparing students to face global challenges [2].

When students aredirected to be able to think critically, creatively and be able to solve problems, it means that students are targeted to have high-level thinking skills (HOTS). The main goal of HOTS is how to improve students' thinking skills at a higher level, especially those related to theability to think critically in receiving various types of information, think creatively in solving a problem using theknowledge they have and make decisions in complex situations [3]. However, themain problem in learning, especially at thetertiary level, is how lecturers plan and are prepared to manage learning in order to achieve the desired competencies in students [4]. Students must hone their skills and improve their learning to be able to overcome global challenges, such as critical thinking skills, the ability to communicate effectively, innovate and solve problems through negotiation and collaboration [5].

Improving students' HOTS skills certainly requires training for students and preparation by educators/lecturers, oneof which is by preparing learning tools including in theform of teaching materials. Without appropriate teaching tools or materials, the learning that is applied will experienceobstacles. Becausea lecturer is required to beableto design and develop innovative and creative teaching materials that can train and improve students' HOTS skills. The rapid development of digital technology today can also be utilized by lecturers in developing innovative and interactive teaching materials based on digital technology, one of which is by utilizing the Canva application.

The Canva application is an online design program that provides various tools such as presentations, resumes, posters, pamphlets, brochures, graphics, infographics, banners, and other types available in it [6]. The use of Canva makes it possible to develop media including interactive web-based teaching materials, this application can also be combined with audio video so that it can increase interest for students [7]. This application can also be used online without having to download it first so it does not requirea largestoragespace on the computer. In addition, the final result can be in the form of a link that can be shared and accessed by students to study in class or study onlineat home[8]. The use of this application can also increase creativity, provide various illustrations, templates and fonts to support creativity in designing [9].

In addition to the availability of teaching materials, strategies to improve thinking skills in this case HOTS are very urgent for students [10]. One of the alternative learning strategies or models that can be applied to improve students' HOTS skills including in chemistry learning is the inquiry-based learning model (IBL). The IBL model is a series of learning activities that emphasize active student involvement to have a learning experience in finding material concepts based on the problems presented [11]. The IBL model is a series of learning activities that emphasize the process of critical and analytical thinking to find and find answers to a problem in question and involve students in formulating problems, making hypotheses, collecting and analyzing data and making conclusions from existing problems [12].

Several studies also show that the IBL model is influential and can improve critical thinking skills [13], improve creative thinking skills [14], improve science process skills [11], improve

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HOTS skills [16 - 18], improve students' understanding of mathematics [17], and can develop students' 21st century skills [18].

The rapid development of science and technology in the 21st century also requires educators to prepare students who are able to think at a high level and are competent in various fields. The required fields of competence are Science, Technology, Engineering, Mathematics (STEM).

STEM includes critical thinking processes, analysis and collaboration where students integrate processes and concepts in the real-world context of science, skills and competencies for college, career and life [19].

STEM can develop if it is associated with the environment, so that learning is realized that presents the real world experienced by students in everyday life [20]. Several studies have also shown that the STEM approach can improve students' critical thinking skills [21 - 25], improve creative thinking skills [23], and can improve students' learning outcomes [24] [25].

Based on the phenomena and descriptions above and the importance of implementing technology in learning according to the demands of 21st century education, it is necessary to develop teaching materials based on the Canva application using the IBL STEM model in the General Chemistry course on Stoichiometry material, which is expected to support the implementation of an innovative and interactive learning process and be able to improve students' HOTS abilities

Methods

This research is a type of research and development (R&D), namely a type of research that produces products that are used to develop and validate educational products and test the effectiveness of theseproducts. The subjects of this development research consisted of: 1) three expert validators; and 2) 64 students of the Chemistry Education Study Program. Meanwhile, the object of this development research is teaching materials based on the Canva application using the IBL STEM model in the General Chemistry course on the subject of Stoichiometry. The development model used refers to the ADDIE model (Analysis, Design, Development, Implementation and Evaluation).

Data collection techniques and methods in this study include: expert validation sheets and test instruments. The validation sheet is used to obtain data on the results of expert validation (expert lecturers) on Canva-based teaching materials using the IBL STEM model in the General Chemistry course on the Stoichiometry material that was developed. The results of the expert validator's assessment will be tested for validity. The test instrument is designed to obtain data on students' HOTS abilities in Stoichiometry learning. The test is developed and designed in the form of a multiple-choice test of 40 questions according to the competencies and Learning Outcomes of the General Chemistry Course (CPMK) on the Stoichiometry material at Levels C4, C5 and C6.

The research data were analyzed in stages to determine the feasibility (validity) and effectiveness of the learning developed. The data from expert validation were analyzed by considering input, comments, and suggestions from the validator. The results of the analysis were used as guidelines for revising Canva-based teaching materials using the IBL STEM model of the Stoichiometry material that was developed. The effectiveness of Canva-based teaching materials using the IBL STEM model that was developed was obtained from the results of students' HOTS ability tests. The effectiveness test was analyzed from the increase in students' HOTS abilities using the t-test or paired sample t-test approach with the help of the SPSS program.

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Results and Discussion

The educational product developed in this study is a General Chemistry teaching material on Stoichiometry based on the Canva application using the IBL STEM model. The validity or feasibility of the teaching material is reviewed and assessed by a team of expert validators in their fields (material experts and media experts). The teaching material that has been developed and has been declared valid (feasible) based on the assessment of the expert validator, is then implemented to 64 students of the Chemistry Education Study Program (1 class) to analyze the effectiveness of the teaching material based on the achievement of students' HOTS abilities in Stoichiometry learning.

Product Design (Teaching Materials)

Thedesign of General Chemistry teaching materials for Stoichiometry material based on the Canva application using the IBL model is carried out according to student needs, literature review and designed in a format that meets thecriteria of being interesting, easy, helping students actively build their own knowledge and helping develop and improve students' HOTS abilities in Stoichiometry learning.

Figure 1. Canva-Based Teaching Material Products Using the IBL STEM Model

Eligibility of Teaching Materials

The feasibility (validity) of General Chemistry teaching materials for Stoichiometry material based on theCanva application using the IBL model developed was reviewed and assessed by expert validators based on the feasibility of the material and the feasibility of the media.

Table 1. Results of Validation of Teaching Materials in the Material Aspec

Assessment Aspects	Validator (Average score)			Average Total	Criteria
	I	II	III		
Contents of the material	4,63	4,38	4,75	4.58	Valid
Presentation of material	4,63	4,50	4,75	4.63	Valid
Language	4,33	4,50	4,50	4.44	Valid
Use of learning models	4,67	4,83	4,67	4.72	Valid
HOTS Assessment	4,67	4,83	4,67	4.72	Valid
Total Average on Material Aspect				4.62	Valid

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Table 1., shows the results of validation and assessment by the expert material validator team obtained an average total score of material aspects of 4.62 or stated that it has met the valid criteria. Thus, it is concluded that theGeneral Chemistry teaching materials for Stoichiometry Material based on the Canva application using theIBL STEM model to improvestudents' HOTS abilities that weredeveloped havebeen declared valid and feasibleto be applied in the stoichiometry learning process referring to the eligibility standards for teaching materials in the material aspect.

Tabel 2. Results of Validation of Teaching Materials in Media Aspects

Assessment Aspects	Validator (Mean Skor)		Average Total	Creteria
	I	II		
Visual Display / Graphics	4.67	4.83	4.75	Valid
Software engineering	4.58	4.75	4.67	Valid
Language	5.00	4.67	4.83	Valid
Total Average on Media Aspect			4.75	Valid

Table 2., shows the results of validation and assessment by the expert media validator team obtained an averagetotal scoreof 4.75 or stated that it has met thevalid criteria. Thus, it is concluded that theGeneral Chemistry teaching materials for Stoichiometry Material based on the Canva application using the IBL STEM model to improve students' HOTS abilities that were developed have been declared valid and feasible to be applied in the stoichiometry learning process referring to the eligibility standards for teaching materials in the media aspect.

HOTS Ability Achievement of Students

The achievement of students' HOTS abilities was obtained through tests given to students before (pretest) and after (posttest) they were given learning actions by implementing Canva application-based teaching materials using the IBL STEM model produced.

Tabel 3. Capaian Skor Kemampuan HOTS Mahasiswa

	Pretest	Posttest
N (Number of students)	64	64
Minimum	3	26
Maximum	12	39
Mean	8.14	30.06
Std. Deviation	2.684	2,376
K-S test	0.880	1.148
Sig.	0.421	0.143

Table 3., shows the achievement of the pre-test results of students' HOTS abilities on stoichiometry material before being given the action, the average pre-test score was 8.14 ± 2.684 and the data had a normal distribution with a Kolmogorov-Smirnov test (K-S test) valueof 0.880 ($p = 0.421 > 0.05$). After being given the action using General Chemistry teaching materials based on the Canva application using the IBL STEM model, the post-test results obtained an average post-test score of students' HOTS abilities of 30.06 ± 2.376 and the data had a normal distribution with a K-S test value of 1.148 ($p = 0.143 > 0.05$).

Effectiveness of Teaching Materials

Theeffectiveness of Canva application-based teaching materials using theIBL model is determined from the implementation results data based on students' HOTS ability achievements in Stphychiometry learning. The effectiveness of improving students' HOTS abilities is analyzed using the paired sample t-test approach using the SPSS program.

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Tabel 4. Results of the Effectiveness Test of Teaching Materials

	Paired Differences		t	sig	t_{table}
	Mean	*Std. Deviation*			
Posttest-Pretest	21,922	2,305	76,097	0,000	1,670

Table 4., shows the results of the analysis of the increase in students' HOTS abilities with an average difference in HOTS ability scores (posttest-pretest) of 21.922 ± 2.305 and the results of the hypothesis testing obtained a calculated t-value > t-table, namely 76.097 > 1.670 with a probability value (sig.) of 0.000 < 0.05. Thus, it is concluded that the implementation of General Chemistry teaching materials for Stoichiometry Material based on the Canva application using the IBL STEM model has been significantly proven to be effective in increasing students' HOTS abilities in Stoichiometry learning.

Discussion

The educational product developed in this study is a teaching material for General Chemistry Stoichiometry Material based on the Canva application using the IBL STEM model to improve students' HOTS abilities. Theteaching material product was developed by referring to the ADDIE development model through the stages: Analysis, Design, Development, Implementation, and Evaluation. The results of the validation and assessment of the expert validator team on the Canva application-based teaching material using the IBL STEM model that was developed, have been declared valid and feasible to be implemented in the learning process. The validity of the teaching material is qualitatively met based on the assessment of the expert validator team based on BNSP standards with modifications according to teaching materials at universities, including: the feasibility of the material content, presentation of the material, language, use of learning models, HOTS assessment (material feasibility) and visual/graphical appearance, software engineering and language (media feasibility)

In theimplementation stage, theuseof Canva application-based teaching materials using the IBL STEM model has also proven effective in improving students' HOTS abilities in the Stoichiometry learning process. Effectiveness is statistically met based on the increase in students' HOTS abilities in completing tests both on pre-test data before being given action and on post-test data after being given learning action. Student responses to Canva application-based teaching materials using the IBL STEM model produced are also very positive.

The findings of this research and development also have implications for lecturers that to improve the achievement of learning outcomes, especially students' HOTS abilities, this can be done by designing and developing innovative learning, one of which is by developing teaching materials based on the Canva application using the IBL STEM model, which is intended to facilitateand assist students in improving their understanding, mastery, and training and improving students' HOTS abilities.

Conclusion

This research and development produces educational and learning products in the form of General Chemistry Teaching Materials (Books) on Stoichiometry Material Based on the Canva Application Using the IBL STEM Model, which has been declared valid (suitable) to be applied to stoichiometry learning, which refers to the standards of teaching material suitability (material suitability and media suitability) according to the standards set by BSNP with modifications according to teaching materials at universities. The implementation of General Chemistry teaching

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materials based on the Canva application using the IBL STEM model in Stoichiometry learning has also proven effective in improving students' HOTS abilities with an average increase or difference in students' HOTS ability scores (posttest-pretest) of 21.922 ± 2.305 and statistical test results with a probability value (sig.) of 0.000 < 0.05. The results of this study are also expected to be an inspiration for users, development researchers and other lecturers to conduct research and development related to teaching materials based on the Canva application using the IBL STEM model in other courses so that innovative teaching materials based on digital technology can be produced which can encourage independent learning activities and can train and improve students' HOTS abilities.

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Development of teaching materials based on pjbl stem assisted by quizizz to improve student's critical thinking skills

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Abstract. *Critical thinking ability is one of the high-level abilities that every student must have after completing their studies at university. This requires lecturers to be able to develop and design learning that can involve students actively and train their creative thinking skills. This study aims to provide teaching materials for Chemical Bonds, based on PjBL-STEM assisted by quizizz that are feasible and effective in improving students' critical thinking skills. The teaching materials were developed using the ADDIE model. This study produces teaching materials for Chemical Bonds, based on PjBL-STEM assisted by the Quizizz application that are feasible to use based on the feasibility according to BSNP standards and are significantly effective in improving students' critical thinking skills (p = 0.000 <0.05).*

Keywords: *Teaching Materials, PjBL STEM, Quizizz, Critical Thinking Skills, Chemical Bonds*

Introduction

The quality of education always refers to the achievement of students' academic results or achievements, where good quality education is the goal of education itself [1]. Since the emergence of a global movement calling for a new learning model for the21st century, various views have developed that formal education must be changed. The changes in question do not concern changes in curriculum content, but rather changes in pedagogy, namely changes in acting from simple action to comprehensive action and a shift in the dominance of traditional teaching to technology-based learning [2].

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Studying at university is certainly very different from studying at pre-university schools. Learning at university not only provides strategic courses, topics, and concepts, but is also expected to provide a learning experience that allows students' independent learning abilities to develop, namely learning with their own initiative, responsibility, and effort. However, the main problem in learning at university is how lecturers plan and are prepared to manage learning in order to achieve the desired competencies in students [3]. Identifying student competencies that need to be developed is very important to face the 21st century. Students must hone their skills and improvel thelir lelarning to be ablel to ovelrcomel global challelngels, sulch as critical thinking skills, the ability to communicate effectively, innovate and solve problems through negotiation and collaboration [4].

The Basic Chemistry Course is a tool to achieve goals and train students to have thinking skills. Chemistry material and critical thinking skills are two things that cannot be separated, because chemistry material is understood through critical thinking and vice versa critical thinking can be trained through learning chemistry.

Critical thinking skills areoneof the most important goals at all levels of education. This ability is related to the ability to identify, analyze, and solve problems creatively and logically so as to produce the right considerations and decisions. Critical thinking skills are very important for students because by having critical thinking skills, students are able to act rationally and choose thebest alternativechoices for themselves. The critical thinking skills possessed by each individual are certainly different, depending on the exercises that are often done [1].

Strategies to improve critical thinking skills are very urgent for students because they are related to life skills competencies for students after completing their studies at university. Critical thinking skills arealso very important for students to havewhich can be used at any time as a basis for solving problems. This includes scientific activities such as asking questions, making statements, choosing the right options, and drawing decisions in chemical experiments [5].

The success of learning, including at the tertiary level, must also be accompanied by the availability of learning tools, including teaching materials. The need for teaching materials as independent learning resources that are in accordance with technology is very important because students today often chooselearning materials that suit their needs. Students need to befacilitated with innovative learning materials to provide contextual investigations that can encourage critical thinking to improve their academic achievement [6]. Innovation in teaching materials can not only be done during classroom learning, but can also be done by developing textbooks used in learning chemistry [7].

In addition to teaching materials, another alternativethat can be applied to improve students' critical thinking skills is project-based learning (PjBL). PjBL is an ideal model to complement the goals of 21st-century education because it involves the 4C principles, namely critical thinking, communication, collaboration and creativity [8]. PjBL has great potential to provide a more interesting and meaningful learning experience for students, so that PjBL becomes a learning model that supports the 2013 curriculum [9].

Several studies also show that the implementation of PjBL is effective in learning [10], is able to increasestudent activity and learning achievement [11], improvecreative thinking skills [12], improvecommunication skills [13], improve critical and creative thinking skills [14], improve collaboration skills and learning outcomes [15], improveliteracy skills [16], and is ableto improve students' HOTS [17,18].

The rapid development of science and technology also requires an educator to be able to prepare students who are able to think critically and competently in various fields. The

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competent fields needed to face these things are Science, Technology, Engineering, Mathematics (STEM). STEM includes critical thinking processes, analysis and collaboration where students integrate processes and concepts in the real-world context of science skills and competencies for college, career and life [19].

The STEM learning approach is an integration of science, technology, engineering, and mathematics learning that is recommended to help the success of 21st century skills. STEM can develop if it is associated with the environment, so that learning is realized that presents the real world experienced by students in everyday life. This means that through the STEM approach, students do not just memorize concepts, but rather how students understand and comprehend scientific concepts and their relationship to everyday life [20]. Several studies also show that the STEM approach can improve students' critical thinking skills [21 - 25], improve creative thinking skills [23], and improve students' learning outcomes [27 - 28].

In addition to the ability to develop the learning process, an educator is also required to have the ability to evaluate and assess student learning outcomes. The ability of educators in mastering evaluation techniques is shown by their ability to design evaluation patterns, compile instruments, set targets, seetheresults obtained by students, and choosetheright actions as an effort to follow up on the results of the evaluation and assessment. Therefore, an educator, including lecturers, must be able to create appropriate evaluation media, because these evaluation media greatly influence the improvement of student understanding and learning achievement. Conversely, if the evaluation media is not appropriate, there will be errors in measuring student learning outcomes and understanding [1].

One of the digital-based learning evaluation tools in an effort to improve students' critical thinking skills is to utilize the quizizz application, which is an educational game application that is narrative and flexible, in addition to being used as a means of delivering material, quizizz can also be used as an interesting and fun learning evaluation media. Lecturers can use, then develop evaluation media through the quizizz application so that they can achieve educational goals [26].

Several studies also show that theQizizz application is very effectivein thelearning process, attracting students' attention to using cellphones in the learning process, independent understanding of questions, student activity in asking questions about the material and evaluating and recording the material, student accuracy in questions and time management and calmness in working on questions or quizzes [26], able to foster critical thinking skills and is very suitable for application in learning in theindustrial revolution era [27], onlinelearning media for theQuizizz application is quite effective for students' cognitive development [28], and can increase students' interest and concentration in working on questions to achieve maximum results [29].

Based on the phenomena and descriptions above, it is necessary to develop teaching materials based on PjBL learning and the STEM approach assisted by the quizizz application in the Basic Chemistry courseon Chemical Bonding, which is expected to support the implementation of an effective and efficient learning process and to improve students' critical thinking skills.

Methods

Data collection techniques and methods used in this study include: Expert Validation Sheets, and test instruments. The validation sheet is used to obtain data on the results of expert validation (expert lecturers) on PjBL STEM-based teaching materials assisted by quizizz in theBasic Chemistry courseon Chemical Bonding material that was developed. Theresults of the expert validator's assessment will be tested for validity. The test instrument is designed to obtain data on students' critical thinking skills in learning chemical bonds. The test is developed and designed in

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the form of a multiple-choice test of 30 questions using the quizizz application according to the competencies and Learning Outcomes of the Basic Chemistry Course (CPMK) on Chemical Bonding material and indicators of critical thinking skills at cognitive levels C4, C5, and C6.

The research data were analyzed in stages to determine the feasibility (validity) and effectiveness of the learning developed. The data from expert validation were analyzed by considering input, comments, and suggestions from the validator. The results of the analysis were used as guidelines for revising the PjBL STEM-based Learning Materials assisted by Quizizz that weredeveloped. Theeffectiveness of the PjBL STEM-based Learning Materials assisted by Quizizz that were developed was obtained from the results of critical thinking ability tests for students. The effectiveness test was analyzed from the increase in students' critical thinking abilities using the t-test or paired sample t-test approach with the help of the SPSS program.

Results and Discussion

The product developed in this research and development is a Basic Chemistry teaching material based on PjBL STEM assisted by Quizizz in Chemical Bonding learning which is intended to facilitatelecturers and students in thelearning process and to improve students' critical thinking skills.

Teaching Material Design

The product design in the form of Basic Chemistry teaching materials for Chemical Bonding material based on the PjBL STEM model assisted by Quizizz is carried out according to needs and is designed in a format that meets the criteria of being interesting, easy, helping students actively build their own knowledge and helping students develop and improve their critical thinking skills.

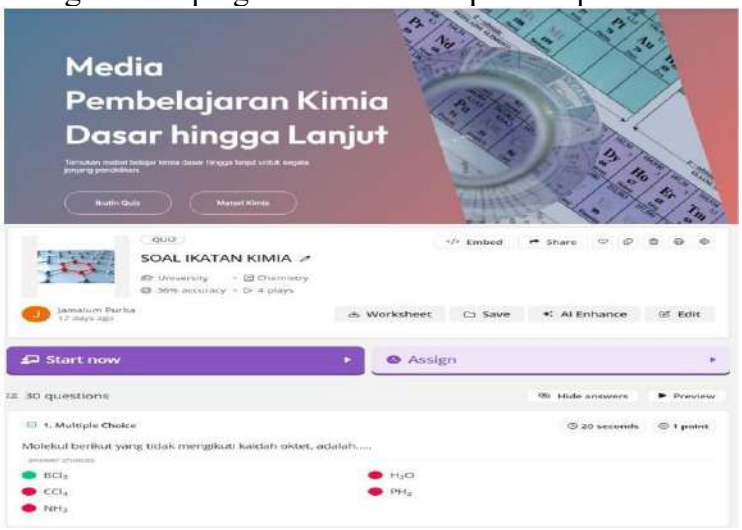

Figure 1. Chemistry Teaching Material Products Based on PjBL STEM Assisted by Quizizz

Eligibility of Teaching Materials

The feasibility (validity) of the Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz in learning chemical bonds that weredeveloped was reviewed and assessed by expert validators based on the feasibility of the material and the feasibility of the media.

Table 1. Results of Validation of Teaching Materials in the Material Aspect

Assessment Aspects	Average score	Criteria
Contents of the material	4.50	Valid
Presentation of material	4.33	Valid
Language	4.50	Valid
Use of learning models	4.53	Valid
Critical thinking skills	4.50	Valid
Total Average of Material Aspects	4.47	Valid

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Table1., shows the results of the review and assessment by the expert material validator team obtained an average total score of 4.47 or stated that it has met the valid criteria. Thus, it is concluded that the development of Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz to improve students' critical thinking skills has been declared valid and feasible to be applied in the chemical bond learning process referring to the eligibility standards for teaching materials in the material aspect.

Table 2. Results of Validation of Teaching Materials in Media/Design Aspects

Assessment Aspects	Average score	Criteria
Visual Display / Graphics	4.67	Valid
Software engineering	4.75	Valid
Language	4.58	Valid
Total Average on Media/Design Aspect	**4.67**	**Valid**

Table 2., shows the results of the review and assessment by the expert media/design validator team obtained an average total score of 4.67 or stated that it has met the valid criteria. Thus, it is concluded that the development of Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz to improve students' critical thinking skills has been declared valid and feasible to be applied in the chemical bond learning process referring to the eligibility standards of teaching materials in the media/design aspect.

Achievement of Students' Critical Thinking Skills

The achievement of students' critical thinking skills is obtained through tests given to students before (pretest) and after (posttest) they are given learning actions by implementing Basic Chemistry teaching materials on Chemical Bonding material based on STEM PjBL assisted by Quizizz that are produced.

Tabel 3. Achievement of Students' Critical Thinking Skills

	Pretest	Posttest
N	67	67
Minimum	2	18
Maximum	11	29
Mean	7.78	24.19
Std. Deviation	2.424	3,135
K-S test	1.154	1.196
Sig.	0.139	0.115

Table3., shows the achievement of the pre-test results of students' critical thinking skills before being given the action, the average pre-test score was 7.78 ± 2.424 and the data had a normal distribution with a Kolmogorov-Smirnov test (K-S test) value of 1.154 ($p = 0.139 > 0.05$). After

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being given the action using Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz, from the post-test results, the average post-test score of students' critical thinking skills was 24.19 ± 3.135 and the data had a normal distribution with a K-S test of 1.196 (p = 0.115 > 0.05).

Effectiveness of Teaching Materials

The effectiveness of Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz in learning chemical bonds is determined from the implementation results data based on the achievement of students' critical thinking skills. The effectiveness of improving students' critical thinking skills is analyzed using the paired sample t-test approach using the SPSS program.

Tabel 4. Results of the Effectiveness Test of Teaching Materials

	Paired Differences		t	sig
	Mean	Std. Deviation		
Posttest-Pretest	16.418	3.866	34.763	0.000

Table4., shows the results of the analysis of the increase in students' critical thinking skills with the difference in the average score of students' critical thinking skills (posttest-pretest) of 16.418 ± 3.866 and the results of the hypothesis testing obtained a t-value of 34.763 with a probability (sig.) of 0.000 <0.05. Thus, it is concluded that the implementation of Basic Chemistry teaching materials for Chemical Bonding Materials based on PjBL STEM assisted by Quizizz which is produced significantly proven to be effective in increasing students' critical thinking skills in learning chemical bonds.

The educational product developed in this study is a Basic Chemistry teaching material based on PjBL STEM assisted by Quizizz in Chemical Bonding learning. The teaching material product was developed by referring to the ADDIE development model. The results of the review and assessment of the expert validator team on the PjBL STEM-based teaching material assisted by Quizizz that was developed have been declared valid and feasible to be implemented in the learning process. The validity of the teaching material is qualitatively fulfilled based on the assessment of the expert material validator team and the media (design) expert validator according to the National Education Standards Agency (BNSP) with modifications according to the teaching material at universities including the feasibility of the material content, presentation of the material, language, use of learning models, critical thinking skills and visual/graphic displays and software engineering.

In the implementation stage, the use of PjBL STEM-based teaching materials assisted by Quizizz in the chemical bond learning process has also proven effective in improving students' critical thinking skills. Effectiveness is statistically met based on the increase in students' critical thinking skills in completing critical thinking ability tests both in pretest data before being given the action and in posttest data after being given the learning action. Student responses to the Basic Chemistry teaching materials for Chemical Bonding Materials based on PjBL STEM assisted by Quizizz that were produced were also very positive.

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The findings of this research and development also have implications for lecturers that to improve the achievement of learning outcomes, especially students' critical thinking skills, it can be done by designing and developing innovative learning, one of which is by developing PjBL STEM-based teaching materials assisted by Quizizz. Through PjBL STEM-based teaching materials assisted by Quizizz, it can help students improve their understanding, mastery, and train and improve students' critical thinking skills.

Conclusion

This research and development produces an educational product in the form of Basic Chemistry Teaching Materials (Books) Based on PjBL STEM Assisted by Quizizz on the material of Chemical Bonds, which was developed using the ADDIE development model and has been declared valid (suitable) to be applied to learning Chemical Bonds, both in terms of the feasibility of the content of the material, presentation of the material, language, use of learning models, indicators of critical thinking skills and the feasibility of visual/graphic displays and software engineering according to the National Education Standards Agency (BSNP) with modifications according to teaching materials at universities. Theimplementation of Basic Chemistry teaching materials based on PjBL STEM assisted by Quizizz in chemical bond learning has also proven effective in improving students' critical thinking skills with an average increase or difference in students' critical thinking skills scores (posttest-pretest) of 16.418±3.866 and statistical test results with a probability value (sig.) of 0.000 <0.05. The results of this research and development are expected to be an inspiration for users, development researchers and other lecturers to conduct research and development related to PjBL STEM-based teaching materials assisted by Quizizz in other courses.

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Development of electronic teaching materials based on PjBL Integrated project strengthening profile student pancasila uses application *flipbook*

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Abstract. *The development of education into the 21st century. The educational era of the 21st century is demanding educational actors to continue to be creative. Education practitioners teach and educate students by objectives from Education in Indonesia. Adults This is education in Indonesia experience sufficient development rapid start from policy Independent curriculum and followed curriculum Project Strengthening Profile Pancasila Students (P5). This P5 curriculum is intended for use in the school curriculum base until school intermediate. Medium P5 curriculum run No applied to higher education. While higher education is vinegar will from candidates power educators in Indonesia. This is becoming attention to research This For make A integrated teaching materials P 5. Education in the 21st century is demanding education creativity, the ability to think critically, collaboration, and communication. This is a challenge for Indonesia to be able to develop 4C characters to match 21st-century education needs. PISA research in OECD 2019 explains that 18% of students' science abilities in Indonesia are at level 2. In addition, in the research location that will be carried out, one of the learning processes that has been carried out is learning that uses the Project Based Learning (PjBL) model, but if seen the average cognitive learning outcomes of students are still in the sufficient category, namely 65.00 - 74.00. from this condition, we can conclude that there is a gap between the theory presented and the reality in the field. The imbalance between theory and reality is an interesting part of this study. Based on things that were given previously so The teaching materials developed will also be based on Project Based Learning (PjBL). The purpose of the research is to develop teaching materials based on PjBL and integrated P5 using a valid, practical, and effective Flipbook application. The method of study This is study development using the ADDIE model. The final result from this study is product teaching materials based on PjBL and integrated P5 using a valid, practical, and effective Flipbook application.*

Keywords: *e_learning materials; PjBL; P5; Flipbook*

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Background

Learning is carried out to provide treatment to students so that there is a change in behavior towards a more positive one. Learning activities have several important components in their implementation, one of the components that supports the implementation of learning is teaching materials. Teaching materials are tools used to help implement learning [1]. Presenting and selecting the right teaching materials according to student interests is a positive implication for a teacher [2]. Teaching materials can be made in various forms, including; a) printed teaching materials, b) audio teaching materials, c) teaching materials, d) audio-visual teaching materials, and e) interactive teaching materials.

Teaching materials should be the results of the teacher's work in carrying out learning in class [3]. The usage of teaching materials for producing maximum learning can be done with the method adapt teaching materials used with the learning model applied in class [4]. The role of teaching materials in the learning process also takes into account the condition development of the world of education.

Adult education This Not only demands ability cognitive but also non-cognitive abilities. Based on Law No. 12 of 2012, Higher Education aims to have morals noble, healthy, knowledgeable, capable creative, independent, skilled, and competent, and become inhabitant democratic, responsible, and cultured For interest nation. It looks like aligned higher education goals with Education in the 21st-century era, namely skills such as critical thinking , *creative thinking, communication, and collaboration* called with 4C skills [5]. Demands the development of adult education This ability to think *(expert thinking)* and communication complex For made into the solution to need power Work [6].

The development of education in Indonesia today This seen in Ministerial Decree Number 56/M/2022, namely about structure curriculum in Primary and Secondary Education that is learning intracurricular and projects strengthening Pancasila profile (P5) page This aims For construction of character and competence student [7]. Based on regulation no 56 can concluded that Education at the level elementary and middle needs a teacher with skills in Organize P5. Learning based on P5 at the moment This is not yet designed to prepare candidates power educators at the Higher Education Level.

Important role teaching materials as one of the source learning, learning process with the use of customized teaching materials with learning models can help students control material with more comprehensive [8]. This is is attention important for study This For done A development teaching materials that follow Condition of Education in Indonesia. Implementation of P5 in learning own impact on the character of cooperation, faith, piety to God, moral noble, and creative [9].

Based on objectives from higher education and the needs of education in the 21st century that not only demand ability cognitive only, but also skills in *critical thinking, creative thinking, communication, and collaboration*. Demands noncognitive skills This can built with stimulating skills from students in every learning process. Learning model PjBL is a stimulating learning model student For capable work together and completing problems and have skills to adapt [10]. In the research, This learning will done on the eyes studying draft base physics. Science learning is carried out as give chance to participants educate For experience learning in a way directly can grow the ability to think, work, and behave scientifically as well as capable to communicate as an aspect skills life [11].

Research methods

Study This study development *(Research and Development)* is a method of research that

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produces tested product effectiveness products developed. In the research This developed product is teaching materials on the subject of studying draft base physics with material vibrations and waves based *Project-based learning* (PjBL) integrated P5. The model used in the research is the ADDIE development model. The ADDIE development model has five stages. among others; 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Implementation.

Study This was conducted at St. Paul's Catholic University, Ruteng, Manggarai, NTT. The data produced from the study This is quantitative data from the assessment of teaching material validators by two experts in science and PGSD fields, and results response students with the use of developed teaching materials as many as 25 students. Qualitative data in the study This is in the form of a description of the suggestions obtained by the teaching materials validator, as well as suggestions from user teaching materials namely students. Data collection techniques study This is with the use questionnaire. The questionnaire sheet used functioning For validate developed teaching materials. The level of validity and practicality from developed teaching materials is determined with analysis of the quantitative and qualitative data obtained. The equation used to assess the level of validity from products produced is as follows:

$$P = \frac{Total\ Number\ of\ Respondents'\ Answers}{Total\ Ideal\ Score}\ x\ 100\%$$

Validity and revision levels product according to [12] as follows:

Table 1: Validity and Revision Levels Product

Percentage (%)	Valid Criteria
0 – 20	Invalid
21 – 40	Less Valid
41 – 60	Quite Valid
61 – 80	Valid
81 - 100	Very Valid

Result data from Respondent user product For evaluate practicality will analyzed with use equality as follows:

$$Level\ of\ Practicality = \frac{the\ number\ of\ scores\ obtained\ for\ each\ item}{Maximum\ Score\ per\ item}\ x\ 100\%$$

Classification of Practicality Level developed teaching materials can seen in Table 2 below :

Table 2. Criteria Practicality

Percentage (%)	Category
81% - 100%	Very Practical
60% - 80%	Practical
41% - 60%	Enough Practical
30% - 40%	Less practical
0 – 20%	Not Practical

Results and Discussion

Analysis

Hold analysis is done to know about teaching materials used, technical ongoing learning in class, the curriculum used, and constraints as well as the solution needed to achieve the objective of learning [13]. Stage analysis This is done in several analyses namely; 1) analysis of curriculum and materials, 2) analysis of participant education, and 3) analysis of objective learning. Based on

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results analysis conducted at St. Paulus University Ruteng, Manggarai, NTT on PGSD students in the subject draft base physics. The curriculum used is Framework Indonesian National Qualification (KKNI). Achievements learning that will done is CPL-Prodi KU1 and KK3 while achievement achievement learning courses that will be used is CPMK 7. Based on the results analysis from observation student the student is around 19-20 years old. At the age of over 12 years, the child is already capable of finishing issues in form concrete and also abstract [14]. Based on the results of interviews with participants education obtained information regarding the learning techniques used in book texts as teaching materials used. In a way general activity, very minimal practice is carried out in the learning process. Conditions This causes Lots of students who feel not enough to follow the learning that is done,

Based on conditions obtained from the analysis of the results the interview was conducted, and then the researcher was interested in creating more learning interactive and involving students in a way directly to the learning process. This has become the basis for research This is For developing teaching materials based on PjBL integrated P5. Teaching materials developed in research This expected capable increase HOT Literacy skills in science students.

Design

Stage further research This is stage design. At this stage design the product that will be developed. In research the product that will be developed is teaching materials based on PjBL integrated P5. In the teaching materials developed several components will become part of the teaching materials, namely; title, achievement learning, instructions use teaching materials, maps concept, dimension P5, Teaching materials, Work scheme project, problem science in life, teaching materials, and bibliography. All components of incoming learning in teaching materials will designed to follow phases of learning PjBL. Design from the development of this teaching material uses applications with the help of Canva, Google Drive, and Microsoft Word.

Development

Stage development This is a development from products designed at stage design. Next products that have been developed and validated by two experts with the use of questionnaire assessment. Aspects assessed on the sheet assessment among others [13]. The teaching material started with covere and achievements learning on the developed teaching materials Integration of P5 in this teaching material is seen in the designed dimensions For development in the learning process with the use of teaching materials. Display design in the developed P5 dimension can seen in teaching materials with integrated P5 dimension as appendix. Learning objectives and indicators P5 in the module This is displayed in the developed teaching materials, These are students can identification, create product and applied concept related Vibration and Wave .The Flip book is completed with Phenomenon nature that has relatedness with material vibrations and waves such as teaching materials that show activity learning based on PjBL

Implementation and Evaluation

Stage implementation of the developed teaching materials done with try-out learning with the use of developed teaching materials. They are learning with developed teaching materials done with three meetings on the material vibrations and waves. The amount students being tested as many as 25 students. Stage implementation This aims To mark the effectiveness, efficiency, and attractiveness of developed products [13]. Next after being done understand implementation to be continued stage evaluation. Stage evaluation is done by giving questionnaire responses to students

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to see practicality from developed teaching materials.

Analysis Validity Product

Develop teaching materials based on PjBL integrated P5 which has been developed with the produce product mallui ADDIE development model. The teaching materials were developed and then validated with validators consisting of two experts. Internal indicators developed teaching materials based on the National Education Standards Agency (BNSP). The validation sheet that was assessed consists of 68 grains Questions. Aspects assessed in teaching materials are aspect eligibility content, aspect Language eligibility, aspects eligibility presentation, and aspects learning. Objectives he did stand validation This is to obtain information about category validity from developed products [15]. The validation results obtained based on the validator assessment can seen in Table 3.

Table 3. Recapitulation validation of teaching materials

Aspect Evaluation	Average %		Total Average%	Category
	Validator 1	Validator 2		
Aspect Content Eligibility	87.29	91.67	89.48	Very valid
Aspect Language Eligibility	86.67	89	87.83	Very valid
Aspect Eligibility Presentation	85.10	90.52	87.81	Very valid
Aspect Learning	97.5	92.08	94.79	Very valid

Based on results from the quantitative data of the validation test by two validators, it can be seen that aspect eligibility Contents from developed teaching materials own percentage 89.48 in very valid category. The average result of the language eligibility obtained from the two validators is 87.83 with a very valid category. Aspect eligibility presentation obtained an average of 87.81 with a very valid category. Aspect learning of the two validators had an average of 94.79 with a very valid category. Based on results from the assessment carried out by the validator suggestions and comments which became qualitative data from teaching materials developed based on the first validator's suggestions were obtained for adding indicators from learning, and more sharpening in creating a stimulus for project activities that will do students. Based on the assessment of the results From validator 2, suggestions were obtained to change the type of writing to be more easily read. Add related material vibrations and waves with P5's friend in engineering and technology so that there is continuity between projects and *assessments.*

Analysis Practicality Product

Analysis product is purposeful activities For see How practicality in use products produced. Analysis of practicality product done with questionnaire response students. Questionnaire responses are given to 25 students at St. Paulus University Ruteng, Manggarai, NTT. The questionnaire was distributed using a scale Likert with a score of 1 for No appropriate, 2 for less appropriate, 3 for appropriate, and 4 for very appropriate. The number of question items used is 20 grains Questions. The results of the quantitative data obtained from response students who use developed teaching materials overall average percentage the response is 81.2% of the things This enter in very practical category. Based on quantitative data results obtained from the response student can seen in Table 4.

Table 4. Response results in practicality teaching materials for student

Amount	Frequency	Average Score	Category

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Question			
20	25	81.2	Very Practical

Conclusion

Based on the objective of the study This is to develop teaching materials based on Valid and practical PjBL, then can Conclusions are drawn from the results study This is Development of teaching materials based on PjBL integrated P5 is valid and practical teaching materials in its use and can be used for the learning process. Based on quantitative data from two validators obtained in the aspect eligibility average content percentage is 89.48%, language aspect 87.83%, language aspect 87.83% presentation 87.81%, and aspects learning 94.79% all categories on aspects evaluation This is in the very valid category. Based on qualitative data results obtained from the validator there are some suggestions and input for improvements, including; 1) adding learning indicators, 2) sharpening to lie down project activities, 3) improving the writing style with more good 4) giving relatedness material vibrations and waves with theme engineering and technology by one of P5 theme carried government in its policies. Response results in practicability use of teaching materials based on the student as many as 24 students an average of 81.2% of students obtained state-developed teaching materials practical in their use, numbers This enters into the very practical category. Research This can be continued For effectiveness tests conducted teaching materials for HOT Science Literacy skills with the use of test questions consisting of question analysis, evaluation, and creation (C4, C5, C6).

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Development of interactive electronic teaching materials based on case method and IQF integrated projects in capita selecta chemistry learning to improve student chemistry learning outcomes

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Abstract. Case method and project based interactive learning is the right choice to encourage students to learn actively and effectively, centered on themselves (student centered) to improve their learning outcomes. The aim of the research is to obtain interactive electronic teaching materials for Capita Selecta Chemistry based on the case method and IQF integrated projects that are valid, effective, have BSNP standards, use the ADDIE method, and are suitable for use. Needs analysis; development of teaching materials; standardization validation; individual, small and large group trials; effectiveness test, and student satisfaction perception test. Sample: IQF-based curriculum, teaching materials from publishers A and B, expert validators and 30 students. Data was obtained using test instruments to test the suitability and effectiveness of teaching materials, measure increases in learning outcomes and student satisfaction, processed descriptively and analyzed using ANOVA. Research findings: Capita Selecta Chemistry's teaching materials developed are valid, effective, standard, suitable for use. The product had an effective impact on the small group test with (M = 70.80%, large group (M= 71.25%), high and effective category. Student performance score (M = 86.68%) with a very satisfied satisfaction index (M = 88.37%). Hypothesis testing using the paired t- test obtained sig (0.000) < (α = 0.05), so there is a difference in post-test and pre-test learning results. Conclusion; The Capita Selecta chemistry teaching materials developed are valid, effective, standard and suitable for use in learning to improve student learning outcomes.

Keywords. Development of interactive, valid and effective electronic teaching materials, improving learning outcomes

Introduction

Technological progress in the era of industrial revolution 4.0 (IR 4.0) towards industry 5.0 (IR

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5.0) must be followed by educational progress through improving the quality of teaching and learning processes throughout the world [1]. The emergence of IR in Germany in 2011 refers to the potential of the industrial revolution 4.0 in higher education and learning methods, developing knowledge related to physical, digital and biological needs. The requirements for future teachers must be humanistic, didactic, technological and organizational based [2].

In Indonesia, an integrated curriculum for the Indonesian National Qualifications Framework (IQF) has been introduced to meet the requirements of IR 4.0, and one of the recommended learning methods is case method and project based, student teacher candidates work independently or collaboratively to solve problems [3]. Learning chemistry is a part of science studied by prospective teacher students and the intellectual key to the development of science and technology [4]. Many students find it difficult to overcome chemistry problems because of the complexity and abstract concepts, so learning must be presented based on case methods and projects through practical experience so that motivation and skills can increase [5].

The implementation of the integrated chemistry curriculum in the Indonesian National Qualifications Framework (IQF) at LPTK aims to increase the resources of graduates who are superior, qualified, productive, capable and skilled at managing learning with full responsibility after graduating and becoming professional teachers. This is in accordance with the statement that university graduates in Indonesia are expected to have lives that are able to compete globally as superior, good and qualified human beings, productive, and contribute to the life of society, nation and state [6].

Based on study data from The Program For International Student Assessment (PISA), the achievement of students in Indonesia in the field of science in 2012 was ranked 64th out of 65 countries [7] in 2015 ranked 62nd out of 70 countries [8] and in 2015 2018 ranked 70th out of 78 countries [9]. This low ranking can be seen from the chemistry UN score as a part of science, where the national average score for the chemistry exam in 2016 was 55.45 [10] in 2017 it was 57.80 [11], in 2018 it was 50.91 [12], and in 2019 it was 50.99 [13]. The chemistry scores are relatively low and are a challenge for teachers to increase their National Examination scores to reach the criteria for Completion of Learning Objectives (KKTP) 7,5. For this reason, it is necessary to increase the chemical competence of prospective teacher students in producing superior, tough and professional teachers. For this reason, it is necessary to increase the chemical competence of prospective teacher students in producing superior, tough and professional teachers. One strategy that can be implemented is through updating learning scenarios that are interactive, practical and effective. Apart from that, interactive electronic teaching materials based on the case method and integrated IQF projects are also needed [2].

The results of a case study survey of a number of chemistry teachers in Medan showed that the Capita Selekta Chemistry course material during lectures was still inadequate to equip them in teaching chemistry in SMA/MA. In fact, the course material is the basis of chemistry which is very important and is closely related to the chemistry material taught at the high school/MA level as well as science chemistry material at the junior high school level. This teacher's opinion is in line with the Capita Selekta Chemistry scores obtained by prospective teacher students from the survey results of several universities in Medan for the 2021-2022 academic year.

This is an indicator that the implementation of the IQF integrated curriculum in learning for student teachers is still less effective. Therefore, to more effectively implement the IQF integrated curriculum with 6 mandatory student assignments, it is necessary to update strategies, methods, models and learning media so that the implementation can be carried out according to predetermined concepts to produce professional teacher candidates. One of the innovations in

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learning is the availability of media that is suitable for use, such as media in the form of case method-based interactive teaching materials and IQF integrated projects which can be developed according to the IQF integrated curriculum concept, transformed into virtual-digital electronic form of media. With electronic media, lecturers will easily carry out learning activities even though they are in different places from the students [14].

Electronic teaching materials are self-instructional, include learning materials and students focus on the material being taught. Adaptive because the development of electronic teaching materials is in accordance with student characters [15]. In developing teaching material media, learning models can be integrated by paying attention to suitability, so that it will make it easier for students to learn [16]. Furthermore, the development of learning media for electronic teaching materials can be carried out by referring to the ADDIE method with the stages of Analysis, Design, Development, Implementation and Evaluation [17].

Project-based learning assisted by interactive electronic teaching materials is collaborative learning based on constructivist theory to achieve the ultimate goal of learning [18]. This model is a dynamic learning approach, students actively explore real world problems, provide challenges, and gain deeper knowledge [19]. Furthermore, when providing teachers with comprehensive and professional knowledge in the use of technology in the industrial era 4.0 (known as future teachers), the use of this technology must be applied effectively and efficiently in the classroom [1]. Teachers are responsible for integrating technology in the education system, encouraging students' inquiry, problem solving, and critical thinking skills [20].

Project-based learning assisted by electronic teaching materials has been widely used in higher education to improve the quality and effectiveness of teaching [21]. Learning that is accompanied by project-based practice, students will gain increased knowledge, skills and social responsibility in their group [22]. Meanwhile, research findings [23] state that with project-based learning assisted by electronic teaching materials, student achievement and learning activities can increase significantly.

Implementation of the case method and team-based project in the learning process is a new method applied in the learning process in higher education. The application of the case method and team-based project is contained in the Decree of the Minister of Education and Culture of the Republic of Indonesia Number 3/M/2021 concerning Main Performance Indicators for State Universities and Higher Education Service Institutions in the Ministry of Education and Culture. Key Performance Indicators (IKU) aim to improve the quality of education and produce graduates who are competent to be able to compete in the world of work and industry. Case methods and team-based projects are included in Key Performance Indicator Number seven (IKU-7). The application of these two methods aims to improve students' thinking skills and abilities and requires educators to have higher skills.

The use of interactive electronic teaching materials based on case methods and projects will motivate students to be more proactive in learning, because they are designed practically, have learning links and videos that can be accessed easily from the internet at certain times and conditions, thereby attracting students' interest in learning and creating new learning experience for them. Likewise, lecturers can easily carry out learning activities even though they are in a different place from the students. According to Mubarok (2018), e-learning media can facilitate the teaching and learning process, by relying on the internet students become closer to learning, especially when distance learning is implemented [24]. This opinion is supported by Arthur (2017) that electronic teaching materials are a medium to make it easier for students to obtain study material effectively and they can learn according to their respective abilities and speed [25]. The

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use of electronic teaching materials makes students interested in the learning process, and can be accessed at any time and under any conditions, supported by adequate tools so that students have no difficulty in using them [26]. Likewise in Wibowo (2019) it is said that interactive electronic teaching materials are used as learning tools including materials, methods and learning evaluation, designed practically so that they can attract students' interest in learning [27].

In Nainggolan's (2023) research report, the use of interactive electronic learning media can increase students' learning motivation to be more proactive independently and in groups because they can easily be accessed from the internet at any time and condition wherever they are [2]. With the existence of electronic learning media for interactive Capita Selekta Chemistry courses based on the case method and integrated IQF projects, it is hoped that students will be motivated to learn more proactively independently and in groups.

Therefore, on this occasion a research will be carried out with the title "Development of interactive teaching materials based on the case method and integrated KKNI projects to improve student chemistry learning outcomes". By obtaining interactive Capita Selecta chemistry electronic teaching materials based on case methods and integrated IQF projects that are valid, effective, standard, and suitable for use in learning, it is hoped that students' Capita Selecta chemistry learning outcomes can improve. So the problem in this research is: How to develop Capita Selecta Chemistry teaching materials to obtain interactive electronic teaching materials based on case methods and IQF integrated projects that are valid, effective, standard and suitable for use in learning.

Methods

This type of research is educational research and development (Educational Research and Development) using the ADDIE method. Research location in the Chemistry Department, Medan State University in 2024, with reference to the Medan State University Research Strategic Plan and the research implementation plan for the Unimed Chemistry Education Study Program. The research stages start from needs analysis, curriculum analysis, analysis of teaching materials to be developed, design and development of interactive electronic teaching materials, validation, revision several times to obtain standard interactive electronic teaching materials, feasibility testing, one-on-one trials, group trials small and large groups. The procedure for developing teaching materials refers to the development model which was adapted from the Dick & Carey model [28] as in Figure.1.

Collection Instruments

The screening instruments and data collection techniques used in the study consisted of: validation questionnaire instruments, learning activity instruments, observation sheet instruments, student satisfaction response questionnaire instruments, learning achievement test instruments. All data collected is collected and distributed into distribution tables for analysis.

Data analysis technique

Research data analysis was carried out descriptively qualitatively and quantitatively on the validity and effectiveness of interactive Capita Selecta Chemistry electronic teaching materials based on case methods and development projects. Calculate the average value of validity, average value of effectiveness, average value of improvement in student chemistry learning outcomes, average percentage of student satisfaction level in learning. Data were processed descriptively and analyzed using ANOVA statistics assisted by SPSS for Windows 24.

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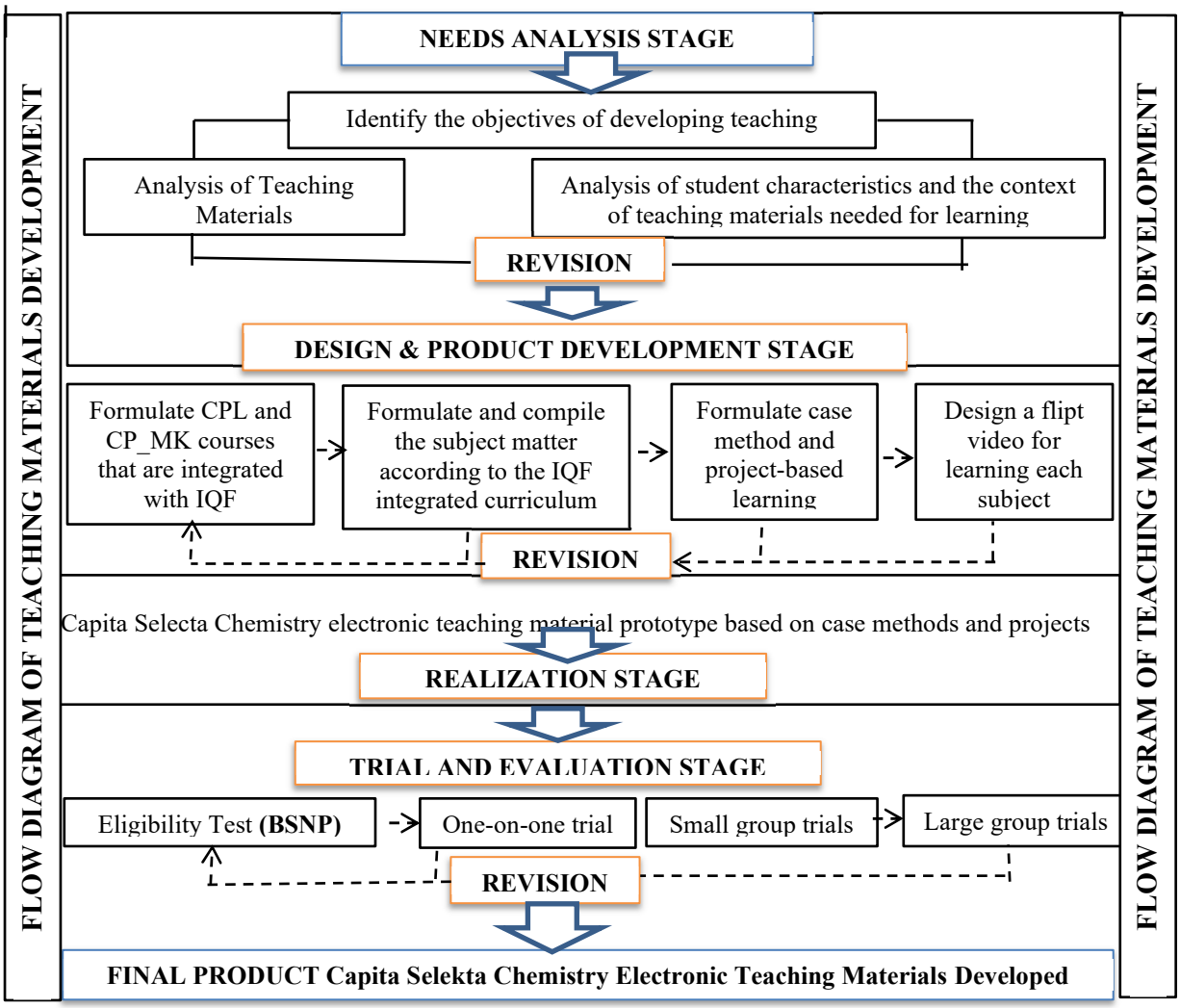

Figure 1. Flow Chart for Research and Development of the Dick & Carey model

Feasibility Analysis of Capita Selecta Electronic Teaching Materials Interactive Chemistry Results Development

The data analysis technique used to analyze lecturer validation data is the average technique with the formula :

$$\overline{X} = \frac{\Sigma X}{n} \quad \ldots\ldots\ldots\

Complete calculation validation criteria can be seen in Table 1 below.

Table 1. Average Analysis Validation Criteria

Average	Validation criteria
3.26 – 4.00	Very valid
2.51 – 3.25	Valid
1.76 – 2.50	Less valid (revised)
1.00 – 1.75	Invalid (total revision)

Trial of electronic teaching materials product development

The implementation of trials on the interactive Capita Selekta Chemistry electronic teaching material subject based on the case method and the KKNI integrated project as a result of the development was carried out three times, namely (1) one-on-one trials, (2) small group trials (limited trials), and (3) large group trials or field trials. Providing a feasibility value for the respondent's level of achievement (TCR). done using the formula:

$$TCR = \frac{Average\ score}{Ideal\ score}\ x\ 100\% \quad \ldots\ldots\ldots\

Hypothesis test

After the data is normally distributed and homogeneous, a hypothesis test is carried out with one-sided t-$_{test}$ (right side test) with the criteria: if t-$_{count} > t_{table}$ at the real level ($\alpha = 0.05$) (db = n1 + n2 –2) then Ha is accepted and Ho is rejected

The hypotheses used are:

H_0: There is no difference in student learning outcomes before and after learning with the application of interactive Capita Selecta Chemistry electronic teaching materials based on case methods and integrated IQF product development projects.

Ha : There are differences in student learning outcomes before and after learning with the application of interactive Capita Selecta Chemistry electronic teaching materials based on case methods and integrated IQFproduct development projects.

Perception of Student Satisfaction Level with the application of developed electronic teaching materials

A response questionnaire was given to 30 students to provide responses to 30 questionnaire items in the form of statements regarding teaching materials resulting from development in case method and project-based learning. Then an analysis of the percentage of student satisfaction level perceptions regarding the application of the developed teaching materials was carried out

Student Performance Assessment

Student performance assessment is carried out by three observers using performance assessment instruments. Assessment is carried out during learning, working on mini-research experimental projects in the laboratory and making learning flip videos. Each observer assessed 10 students. Performance assessment includes 3 (three) components; namely the pre-employment stage, implementation of learning and implementation of performance practices. Then an analysis of the percentage of student performance achievements in learning was carried out

Results and discussion

Initial Analysis Results of Capita Selecta Chemistry Teaching Materials from Publishers A and Publishers B

Before carrying out research and development, an instrument feasibility analysis, needs analysis, IQF integrated curriculum analysis, and analysis of Capita Selecta Chemistry teaching materials from publishers A and B that students use in learning are first carried out.

Based on the analysis, the average validation scores obtained by validators, media experts, language experts, material experts and practitioner experts regarding the suitability of Capita Selecta Chemistry teaching materials from publisher A and publisher B are as presented in Table 2 and Table 3.

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Table 2. Average validation value by expert validators on the suitability of Capita Selecta Chemistry teaching materials from publisher A

BSNP Criteria	Average expert validator scores on teaching materials from publishers an Average Validation Criteria				Average	Validation Criteria
	Media Expert	Linguist Expert	Material Expert	Practitioner Expert		
Eligibility of content	3.16	3.07	3.14	3.27	3.16	Valid and does not need revision
Language Eligibility	3.12	3.17	3.26	3.18	3.18	Valid and does not need revision
Feasibility of presentation	3,08	3.18	3.18	3.04	3.13	Valid and does not need revision
Graphic Feasibility	2.68	3.02	2.88	2.79	2.84	Valid and does not need revision
Overall average score					3.08	Valid criteria and does not need to be revised

Table 3. Average validation value by expert validators on the suitability of Capita Selecta Chemistry teaching materials from publisher B

BSNP Criteria	Average expert validator scores on teaching materials from publishers an Average Validation Criteria				Average	Validation Criteria
	Media Expert	Linguist Expert	Material Expert	Practitioner Expert		
Eligibility of content	3.02	2.83	2.81	2.86	2.88	Valid and does not need revision
Language Eligibility	3.09	2.79	3.07	2.96	2.98	Valid and does not need revision
Feasibility of presentation	2.78	2.77	3.02	2.87	2.86	Valid and does not need revision
Graphic Feasibility	2.64	2.91	2.86	2.69	2.78	Valid and does not need revision
Overall average score					2.88	Valid criteria and does not need to be revised

From the data in Table 2 and Table 3, it can be seen that the overall average value of Capita Selecta Chemistry teaching materials from publisher A is 3.08 and publisher B is 2.88, meaning that it is BSNP standard and suitable for use by students in learning, and all validators have given positive opinions about the teaching materials.

However, based on the IQF integrated curriculum concept as research objectives, a number of weaknesses and shortcomings were still found in the teaching materials from publishers A and B, including: not yet containing the concept of formulating graduate learning outcomes (CPL), not yet containing a formula for course learning outcomes (CP_MK), not yet containing Case Method and Project, do not contain concept maps, learning videos and links

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are not yet available, there are no mandatory assignments for Idea Engineering (RI), Critical book Report (CBR), Critical Journal Review (CJR), Mini Research (MR), Project (PJ) and Routine Tasks (TR). Therefore, it is necessary to revise it through development into an electronic teaching material according to the objectives of this research to obtain interactive Capita Selecta Chemistry electronic teaching materials based on case methods and integrated IQF projects for students to use in studying the Capita Selecta Chemistry course.

Therefore, Capita Selecta Chemistry's teaching materials from publishers A and B which are taught by students in the Capita Selecta Chemistry course, need to be developed so that they are in accordance with the application of case method-based learning concepts and IQF integrated projects. This is in accordance with several previous studies which explain the importance of revising products so that weaknesses in the product can be corrected properly [31].

Results of the development of interactive Capita Selecta Chemistry Electronic Teaching Materials based on the case method and integrated IQF projects

The shortcomings and weaknesses obtained from the validator analysis of Capita Selekta Kimia teaching materials from publishers A and B became a reference in developing case method and project based electronic teaching materials. The characteristic of team based projects and case methods is that the problem solving process is carried out and completed by team members. Seidel & Godfrey (2005) agree that there are four main types of characteristics of team based projects and case methods, namely cognitive, psychomotor, motivational, and affective (interpersonal and attitude). The performance of team based projects and case methods is determined by the composition of the four types of dispositions of all team members, which are complex [32]. Next, the development of interactive Capita Selecta Chemistry electronic form teaching materials based on the case method and integrated IQF projects that are valid, effective, BSNP standards and suitable for use are carried out.

The instrument was developed based on the grid developed by Kim, et al. (2006) which includes 4 categories, namely content, structure, attributes and process. The first category is about content, namely strategies related to the scope of the case content. Structure is a strategy related to case design, while attributes are related to determining case objectives, and process is a strategy related to the learning process. Each category according to its concept consists of sub-subs or indicators for its description. The second instrument is used to evaluate teaching materials by students during trials [33].

During development, all components that have not been found in the teaching materials from publishers A and B are formulated and completed, including: the concept of graduate learning outcomes (CPL) is contained, the course learning outcomes formulation (CP_MK) is contained, there is a Case Method and Project , there is a concept map, learning videos are available with links, there are mandatory assignments for Idea Engineering (RI), Critical book Report (CBR), Critical Journal Review (CJR), Mini Research (MR), Project (PJ) and Routine Assignments (TR), there is chemistry information, HOTS competency test questions are available, and it has been developed into 11 subjects, namely: Stochiometry; Atomic Structure and Periodic System of Elements; Chemical bond; Thermochemistry; Reaction rate; Chemical equilibrium; Solutions (Acid Bases, Buffers, Hydrolysis, Ksp, and Colligative Properties of Solutions); Redox Reactions; Electrochemistry and Electrolysis; Elemental Chemistry; and Hydrocarbons and Functional Groups. Next, standardization validation is carried out by media expert validators, material experts, language experts and practitioner expert validators.

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Based on standardization validation carried out by expert validators on the developed electronic teaching materials, the average validator scores were obtained as presented in Table 4.

Table 4. Average value of expert validators for Capita Selekta electronic teaching materials, interactive chemistry based on the case method and integrated IQF projects developed

BSNP Criteria	Average expert validator scores on teaching materials from publishers an Average Validation Criteria				Average	Validation Criteria
	Media Expert	Linguist Expert	Material Expert	Practitioner Expert		
Eligibility of content	3.85	3.91	3.83	3.87	3.86	Valid and does not need revision
Language Eligibility	3.82	3.81	3.86	3.84	3.83	Valid and does not need revision
Feasibility of presentation	3.81	3.83	3.85	3.82	3.83	Valid and does not need revision
Graphic Feasibility	3.82	3.79	3.84	3.82	3.82	Valid and does not need revision
Overall average score					3.84	Valid criteria and does not need to be revised

Based on the data in Table 4, it can be seen that the average validation score by media expert validators, language experts, material experts and practitioner experts for electronic teaching materials, with an overall average score obtained of 3.84, on the criteria of very valid, effective, standard BSNP, and is suitable for students to use in studying the Capita Selecta Chemistry course. Obtaining this data shows that all validators, media experts, linguists experts, material experts and practitioner experts have given positive opinions regarding the case method-based interactive Capita Selecta Chemistry electronic teaching materials and the IQF integrated project developed. This is in line with research which explains that there is no need for improvement if it has reached the good category [34].

Below you can see a data graph comparing the average results of expert validator scores for electronic teaching materials for development products with teaching materials from publishers A and B as in Fig.2.

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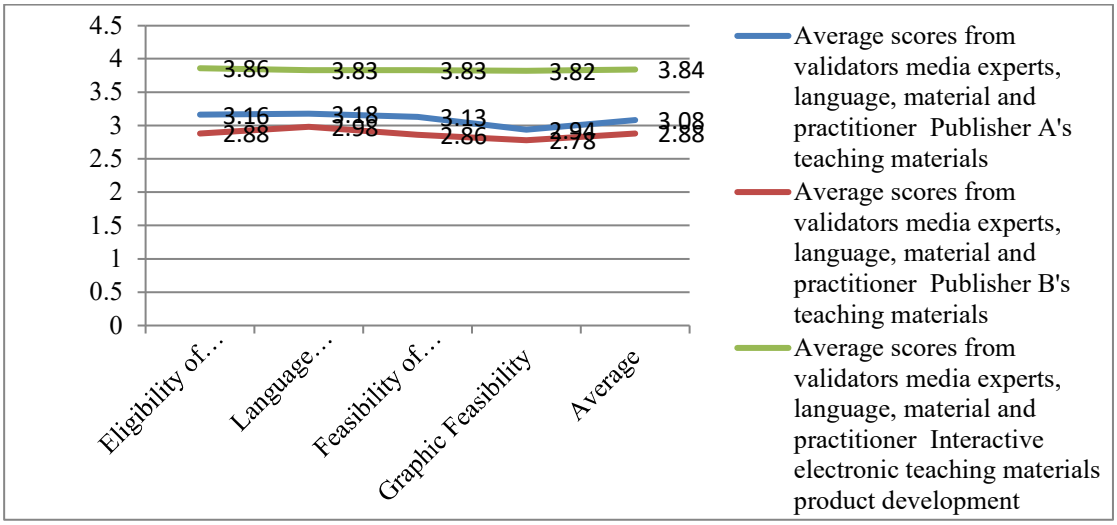

Figure 2. Graph of the average validation value of teaching materials from publishers A and B and case method-based interactive electronic teaching materials and development projects

The following is the cover of the Capita Selecta Chemistry electronic teaching material interactive based on the case method and integrated IQF projects developed which can be accessed online at the link: https://online.flipbuilder.com/lzspt/qdmx/ ., and the link for each subject is as follows. following:
Stochiometry subject matter, with links: : https://online.flipbuilder.com/dotvx/vnox/ ;
Atomic Structure and Periodic System of Elements, with link:
https://online.flipbuilder.com/dotvx/nktg/ ; Chemical Bonds, with link:
https://online.flipbuilder.com/dotvx/qafu/ ; Thermochemistry, with link:
https://online.flipbuilder.com/dotvx/oymb/ ; Reaction Rate, with link: :
https://online.flipbuilder.com/dotvx/gjfu/ ; Equilibrium, with link: :
https://online.flipbuilder.com/wvlsm/hcbj/ ; Solution, with link:
https://online.flipbuilder.com/wvlsm/iaxn/ ; Redox Reactions, with link: :
https://online.flipbuilder.com/wvlsm/rvcm/ ; Electrochemistry and Electrolysis, with link:
https://online.flipbuilder.com/wvlsm/ejyv/ ; Elemental Chemistry, with
links:https://online.flipbuilder.com/wvlsm/xscm/ ; and the topic of Hydrocarbons and Functional Groups, with the link: https://online.flipbuilder.com/lzspt/ohvi/

Capita Selecta Chemistry electronic teaching materials for interactive chemistry based on the case method and integrated IQF product development projects can be seen on the front cover page in Figure 3.

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Figure 3. Front cover of electronic teaching materials development products

Trial Results of electronic teaching materials for development products

The implementation of trials on the interactive Capita Selecta Chemistry electronic teaching material subject based on the case method and the IQF integrated project as a result of the development was carried out three times, namely (1) one-on-one trials, (2) small group trials (limited trials), and (3) large group trials or field trials.

Results of one-on-one trials of electronic teaching materials for development products

The one-on-one trial involved 5 chemistry education students and 2 practitioner lecturers. From data processing it was obtained that the average respondent achievement level (TCR) value from 2 practitioner lecturers was 92.66% in the very feasible category, and the average TCR value from 5 students, 91.33% was obtained in the very worthy category. Overall, the average TCR for testing one teaching material from 2 practitioner lecturers and 5 students was obtained at 92.00% in the very feasible category.

Results of small group trials of electronic teaching materials development products

Small group trials (limited trials) of electronic product development teaching materials involved 10 chemistry education students. From data processing, the average TCR score of 10 students obtained an average score of 92.66% in the very feasible category.

Results of large group trials of electronic teaching materials development products

A large group trial of electronic teaching materials for product development involved 30 chemistry education students. From data processing, the average TCR score of 10 students obtained an average score of 93.00% in the very feasible category. The results of this research are supported by several previous studies, including explaining that learning activities that use case method-based teaching materials are able to make students active in lectures [35]. Apart from that, other research explains that learning activities using the case method can make students think critically [36] and also make students think logically and openly [37].

Test results of the effectiveness of electronic teaching materials for development products

To determine the effectiveness of electronic teaching materials for development products, an

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analysis was carried out on the average normalized N-Gain value of the results of small group trials on 10 students and large group trials on 30 chemistry education students. The effectiveness of teaching materials is obtained from learning outcomes with the following criteria: ($g < 0.3$ = low category, and not effective); ($0.3 \leq g \leq 0.7$ = moderate category, and effective); ($g > 0.7$ = high category, and effective). Data from the analysis of the average N-Gain values from small and large group trials are presented in Table 5.

Table 5. Average N-Gain in small and large group trials

Trials	Mean		*Gain*	N-*Gain*	Category	Criteria
	Pre-Test	*Post-Test*				
Small group (10 students)	38	81,5	56-75%	70,80%	High	Effective
Big group (30 students)	36, 67	83,5	56-75%	71,25%	High	Effective

Based on the data in Table 5, the N-gain for the small group (10 students) was 70.80%, in the high category and effective criteria, and for the large group (30 students) it was 71.25%, in the high category and effective criteria. From these results, it can be stated that the interactive Capita Selecta Chemistry electronic teaching material products based on the case method and the IQF integrated projects developed are included in the high category and have effective criteria. The results of this research support the results of Angela's (2017) research which shows that the application of the case method has a positive influence on the effectiveness of student learning [38]. Likewise, the research results of Cholifah T. R. & Pana P., (2021) show that the team-based project and case method strategies are considered effective in developing student skills, students and lecturers found no problems in implementing these strategies during the learning process [39].

From this data, it can be seen that there was an increase in learning outcomes in small group and large group trials as presented in the graph in Figure.4.

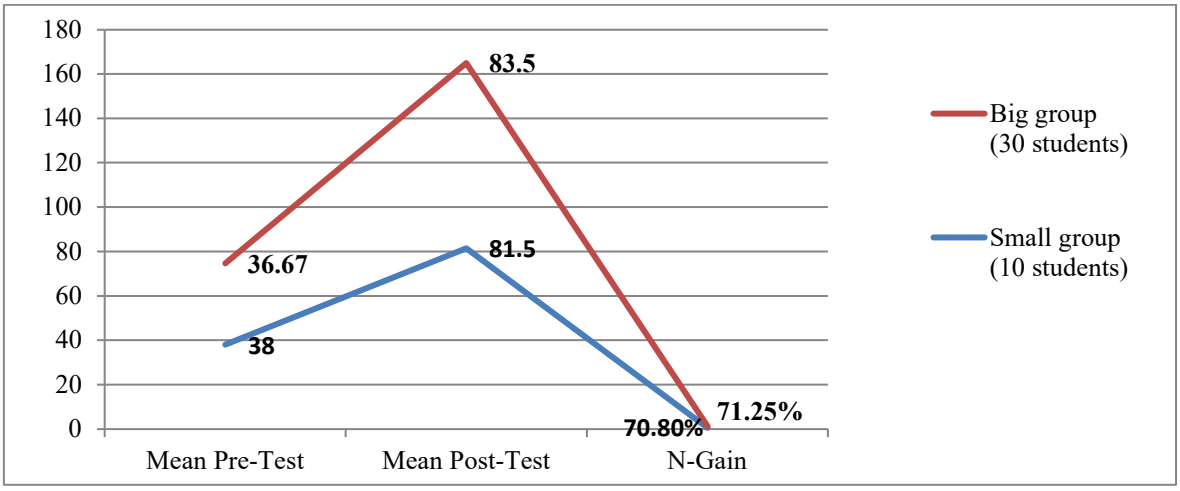

Figure 4. Graph of improvement in learning outcomes in small group and large group trials of developed electronic teaching materials

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The implementation of the case method and project in the learning process is a new metho applied in the learning process in higher education, as stated in the Minister of Education and Culture of the Republic of Indonesia Decree Number 3/M/2021 concerning Main Performance Indicators (IKU) for State Universities and Higher Education Institutions in the Ministry of Education and Culture, aims to improve the quality of education and produce competent graduates to be able to compete in the world of work and industry. The application of these two methods aims to improve students' thinking skills and abilities and requires educators to have higher skills.

Case method and team-based project learning strategies are innovative learning models that involve project work where students build their own learning process and translate it into a real product. In this case, students try to find and at the same time try to solve the problems found with the output of the design product [40].

Normality test

Before testing the hypothesis, the requirements for normality and homogeneity tests are first carried out. The normality test was carried out using the One-Sample Kolmogorov Smirnov Test analysis technique, at α 0.05 with the help of SPSS for Windows 24 software. If $sig._{hit.}$ ($sig._{hit.}$) > α then the data is declared to be normally distributed. Based on the analysis results, the data obtained: sig value. for post-test 0.080 and sig value. for the pre-test 0.198. Because the sig value is > 0.05 or (post-test sig 0.080 > 0.05, and pre-test sig 0.198 > 0.05), the data is declared to be normally distributed.

Homogeneity test

The homogeneity test was carried out using the One-Way Anova analysis technique assisted by SPSS for Windows 24 software at the α.0.05 level. If $sig._{hit}$ (sig.).> α., then the data is homogeneous. Based on the results of the data homogeneity analysis, the sig. post -test of 0.06. Because the sig value. 0.06 > 0.05 means the data is declared to be homogeneous.

Hypothesis test

With the fulfillment of the two prerequisites for normality and homogeneity in the parametric statistical test, a hypothesis test was carried out using the paired t_{-test} formula. The Paired Sample t_{-test} (One sample group test) was carried out with the help of SPSS for Windows 24 software. If the Sig. (tailed) < 0.05, then there is a difference between learning outcomes in pre-test and post-test data, and if the Sig. (tailed) > 0.05, so there is no difference between learning outcomes in pretest and posttest data. From the results of the paired sample t_{-test}, it was found that the Sig. (2-tailed) is obtained at 0.000 < 0.05. Because the value 0.000 < 0.05 or (sig < α) it can be concluded that there is a significant difference between student chemistry learning outcomes in the pre-test and post-test.

Perception Results of Student Satisfaction Level with the application of case method-based electronic teaching materials and development projects.

Perception Results of Student Satisfaction Level with the application of case method-based electronic teaching materials and development projects

A response questionnaire was given to 30 students to provide responses to 30 questionnaire items in the form of statements regarding teaching materials resulting from development in case method and project-based learning. The calculation results showed that the percentage of student perception ranged between 87.47% - 88.80% for each questionnaire item, and the overall average

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score obtained was a percentage of student satisfaction level of 88.37% which was in the very satisfied criteria. Based on these results, it can be concluded that students feel very satisfied with the use of developed electronic teaching materials in learning.

Based on these results, it can be stated that students feel very satisfied using the developed teaching materials in solving learning problems. This is in line with research results [41] that case study learning (case method) has a significant positive effect on problem solving abilities and interpersonal skills. Likewise, the research results of Saputra (2019) state that the application of the case-based learning method has a positive and significant influence on understanding forensic accounting [42]. Apart from that, other research explains that learning activities using the case method can make students think critically [36] and also make students think logically and openly [37].

Student Performance Assessment Results

Assessment of student performance is carried out by three observers using performance assessment instruments. Assessment is carried out during learning, working on mini-research experimental projects in the laboratory and making learning flip videos. Each observer assesses 10 students. Performance assessment includes 3 (three) components; namely the pre-employment stage, implementation of learning and implementation of performance practices. The percentage of student performance scores in working on projects in learning obtained an average percentage of performance scores of 86.68%. Based on these results, it can be concluded that the performance product of student project activities in learning is in the good category and shows the reachability of graduate learning achievement standards (CPL) and course learning achievements (CP-MK) Capita Selecta Chemistry.

This is in line with the research results of Flynn & Klein, (2001), that participants who worked in discussion groups preferred the discussion group method more than those who worked alone. Students feel they learn more working in discussion groups [43]. This shows that the introduction of problems that occur in the world of work practice affects the effectiveness of student learning. According to McNaught et al., (2005) with case-based learning students show motivation to solve problems in the world of work practice, in line with the results of research by Ullah (2014) which found that students consider case studies important in improving and developing students' work skills regarding the approach. solving real world work problems [44].

Conclusion

An interactive Capita Selecta Chemistry electronic teaching material based on the case method and integrated Indonesian National Qualifications Framework (IQF) project has been obtained from the results of development using very valid and standard criteria, with an average validity value of 3.84. Viewed from a feasibility perspective, the electronic teaching materials for the development product are in the criteria of being very suitable for use with an average respondent achievement level (TCR) value in small group trials of 92.66% and large group trials of 93.00%. The effectiveness of electronic teaching materials for development products is in the high category and within the effective criteria. In the application of electronic teaching materials, development products can increase student chemistry learning outcomes in small group trials by 70.80% and large groups by 71.25%, with an average increase in learning outcomes of 71.025%. Students' perception of satisfaction with the use of electronic teaching materials for development products is in the very satisfied criteria with an average percentage value of 88.37%. The performance product of student project activities in case method and project based learning is included in the

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good category, and shows the reachability of graduate learning achievement standards (CPL) and course learning achievements (CP-MK) with an average percentage of student performance scores of 86.68%

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Analysis of secondary metabolite groups, toxicity and antioxidant test of toba frankincense bark extract (STYRAX *Parralleoncomud PERK*)

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Abstract. Secondary metabolite analysis, toxicity test and antioxidant test of n-hexane, ethyl acetate and ethanol extracts of Toba frankincense bark (Styrax pararleoncomud PERK)) have been carried out. Extraction was carried out by maceration, secondary metabolite analysis by phytochemical screening, toxicity test by Brine Shrimp Lethality Test (BSLT) method with Arthemia salia Lech larvae as bioindicator and antioxidant test of the most toxic extract was carried out by determining the inhibitory power against DPPH free radicals (2,2-diphenyl-1-picrylhydrazyl) measured by Visible Spectrophotometer. The results of phytochemical screening of n-hexane extract did not detect any secondary metabolites, in ethyl acetate extract of alkaloid and flavonoid groups with low concentrations, terpenoids with high concentrations, in ethanol extract containing flavonoids and alkaloids with moderate concentrations, saponins, terpenoids and tannins with high concentrations. The results of the toxicity test obtained were for the n-hexane extract in the toxic category with LC50 = 37.66 ppm, the ethyl acetate extract in the toxic category with LC50 = 18.44 ppm and the ethanol extract in the very toxic category with LC50 = 10.70 ppm. Furthermore, the antioxidant test on the most toxic ethanol extract had a moderate inhibitory power category with LC50 = 144.54 ppm. Based on the results of the toxicity test and antioxidant test, the secondary metabolite extract of frankincense bark is quite potential as a drug

.Keywords: maceration, secondary metabolites, phytochemical screening, toxicity and antioxidant

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Introduction

The Toba frankincense tree (Styrax *paralleoncomud PERK*) is an endemic plant that only grows in the Tapanuli area or districts around Lake Toba[1]. So far, the most widely used for the perfume and medicine industry is its sap (resin). The sap contains secondary metabolites of the phenolic group such as benzoic acid, cinnamic acid and benzoyl cinnamate, alkaloids, flavonoids, saponins and triterpenoids[2]. Biosynthetically, secondary metabolites are spread throughout the plant tissue with certain metabolites accumulating in certain tissues of the plant. Thus, secondary metabolites found in the sap will also be found in the bark of the frankincense tree[3]. The bark is found on the trunk and roots which are shields or protectors of the tree from predators and the root bark is a shield for the roots when the roots penetrate the soil. Because the bark is a shield, it is believed that there are bioactive secondary metabolite compounds in the bark[4, especially the bark. Isolation was carried out by maceration of frankincense bark with n-hexane (nonpolar) ethyl acetate (semipolar) and ethanol (polar) solvents [5]. Furthermore, secondary metabolite analysis was carried out by phytochemical screening, namely by chemical tests using appropriate reagents [6]. Toxicity testing as a general test to determine bioactivity was carried out using the Brine Shrimp Lethality Test (BSLT) method with Arthemia salia Lech larvae as a bioindicator [7], and antioxidant testing was carried out by testing the inhibition (damping) power against DPPH radicals (2,2-diphenyl-1-1picrilhydrazyl) which was measured by a Visible Spectrophotometer [8].

Methodology

Chemicals and Equipment

The materials used in this study were Toba frankincense bark (Styrax paralleoncomud PERK) from Sipahutar sub-district, North Tapanuli district, n-hexane (C_6H_{14}), ethyl acetate ($C_4H_8O_2$), ethanol (C_2H_5OH), ferric chloride ($FeCl_3$) 5% and 1% ((b)/(v)), hydrochloric acid (HCl) 2N, distilled water, dragendorff reagent, acetic anhydride ($C_4H_6O_3$), concentrated sulfuric acid (H_2SO_4), Whatman 40 mesh filter paper, Artemia *salina Leach* eggs, yeast and sodium chloride (NaCl). The equipment used is a Goldfruit Electric blender grinder, 60 mesh sieve, various pyrex glassware including: glass beakers, measuring flasks, test tubes, droppers, spatulas, stirring rods, rotary evaporators (Dlab RE 100-Pro), vacuum pumps (B-One model DVP-3073), buchner funnels (Funnel Porcelain 10 cm), erlenmeyer flasks, Onilab hot plates (MS7-H550-S), aerotors (Amara AA-222), analytical balances (Fujitsu FSR-A Precision Balance) and Hannochs brand incandescent lamps.

Isolation and Phytochemical Screening of Secondary Metabolites of Frankincense Bark

Frankincense tree bark was ground into powder using a grinder blender, sieved with a 60 mesh sieve and air-dried to constant weight. A total of 200 g of the ground powder was successively macerated with n-hexane, ethyl acetate and ethanol solvents until there was no change in color intensity. Each solvent change, the residue was filtered with whatman paper and all extracts were concentrated with a rotary evaporator. The alkaloid test was carried out by mixing 0.5 g of extract with 1 mL of 2N HCl, 9 mL of distilled water was given 5 drops of Dragendorff's reagent, brick red precipitate indicated the presence of alkaloids. The flavonoid test was carried out by adding two drops of 5% $FeCl_3$ solution (w/v) to five drops of sample on a drop plate. The occurrence of a color change to greenish or black-blue indicates the presence of flavonoids. The saponin test was carried out by mixing 1 mL of sample with 10 mL of distilled water, shaking for 10 minutes and leaving foam, then waiting for 10 minutes. If the foam does not disappear, add 2N HCl. If it disappears, it indicates the presence of saponin compounds. Steroid and terpenoid tests are carried out by mixing 0.5 g of extract with 10 drops of acetic anhydride, 2 drops of concentrated sulfuric acid, shaken and left for a few minutes. The appearance of red and purple colors indicates the presence of terpenoids, if green and blue colors appear, it indicates the presence of steroids. The test for the presence of tannins is carried

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out by mixing 0.5 g of extract with 10 mL of distilled water and 3 drops of 1% $FeCl_3$ (w/v) the appearance of a blackish green color indicates the presence of tannins..

Toxicity Test

Preparation of larvae was done by taking 1 gram of Arthemia *salina Leach* eggs. Hatched into soaking the eggs in 2 L of artificial seawater and given lighting with a 40-60 watt incandescent lamp and aerated for 48 hours. Artificial seawater was made by dissolving 40 g of salt in 2 L of water then filtered. Next, a 2000 ppm stock solution was made. Then a series of solutions were made with concentrations of 1000, 500, 100, 50, and 25 ppm from the stock solution. The control solution used was without the addition of extract. Toxicity testing used 5 different concentration series. A total of 10 Artemia salina Lech larvae that were 48 hours old were taken, put into a vial containing extract with a certain concentration. Then 3 mL of seawater was added. Then 1 drop of yeast suspension was added as food and artificial seawater was added to a volume of 5 mL. Each test was accompanied by a negative control with 3 repetitions. The vial was kept so that it always received optimal lighting and after 24 hours, the number of dead larvae was counted to determine the probit value and analyzed to determine the LC_{50} value[9].

Antioxidant Test

A series of sample solutions were prepared 40.24; 80.48; 120.72; 160.96, 201.20 ppm and control (0 ppm). Each sample was added with 2 mL of DPPH radical (2,2-diphenyl-1-picrylhydrazyl) with a quenching time of 30 minutes. The absorbance was measured by Visible Spectrophotometer at a wavelength of 517 nm twice and the antioxidant activity was calculated by the following equation.

$$\text{Antioxidant activity} = [(\text{AControle} - \text{Asample}) / \text{AControle}] \times 100\%$$

The value of IC_{50} (Inhibition Concentration) is determined based on the linear equation obtained through the excel graph of inhibition (%) versus concentration (ppm).

Result and Discussion

Isolation and Phytochemical Screening of Secondary Metabolites of Frankincense Bark

Frankincense bark samples were obtained from Sipahutar District, North Tapanuli Regency. The bark was first chopped and air-dried as in Figure 1[a]. The bark that was free of water was ground with a grinder blender and sieved with a 60 mesh sieve in Figure 1[b]. The purpose of grinding the particles to 60 mesh is so that the surface area of the contact area with the solvent is wider so that the maseri results are greater [10].

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[a] [b]

Figure 1. Original frankincense bark and chopped results [a] and powder from a 60 mesh sieve [b] Toba frankincense bark (STYRAX *paralleoncomud PERK*)

Isolation of secondary metabolites was carried out by maceration with the sequence of non-polar n-hexane solvents, semi-polar ethyl acetate and polar ethanol. Each time the solvent was replaced, the extract was filtered with Whatman paper (figure 2) and then concentrated with a rotary evaporator. Maceration was stopped until no significant color changes occurred [11]

[a] [b] [c]

Figure 2. Results of maceration with non-polar n-hexane solvent [a], semi-polar ethyl acetate [b] and polar ethanol [c] of Toba frankincense bark (STYRAX *paralleoncomud PERK)*

The concentrated extract was then determined for its secondary metabolite group through phytochemical screening. Alkaloid test was conducted by mixing 0.5 g of extract with 1 mL of 2N HCl, 9 mL of distilled water was given 5 drops of Dragendorff's reagent, brick red precipitate indicated the presence of alkaloids. Flavonoid test was conducted by adding 2 drops of 5% $FeCl_3$ solution (w/v) to 5 drops of sample on the drop plate. The occurrence of a color change to greenish or black-blue indicates the presence of flavonoids. Saponin test was conducted by mixing 1 mL of sample with 10 mL of distilled water, shaking for 10 minutes and leaving foam then waiting for 10 minutes if the foam does not disappear add 2N HCl if it disappears indicating the presence of saponin compounds. Steroid and terpenoid tests were conducted by mixing 0.5 g of extract with 10 drops of acetic anhydride, 2 drops of concentrated sulfuric acid, shaking and leaving for

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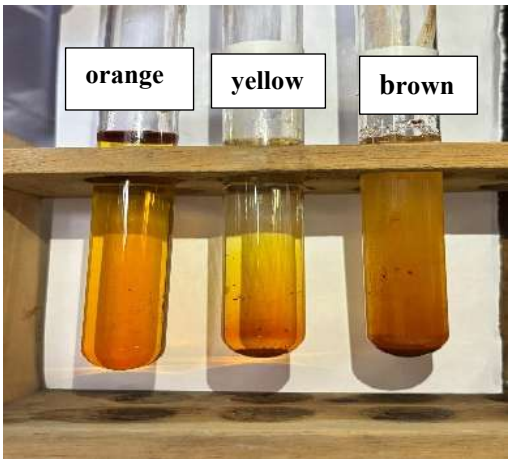
a few minutes, the appearance of red and purple colors indicated the presence of terpenoids, if green and blue colors appeared indicated the presence of steroids. The test for the presence of tannins was carried out by mixing 0.5 g of extract with 10 mL of distilled water and 3 drops of 1% FeCl3 (w/v) the appearance of a blackish green color indicates tannins. The results of phytochemical screening for the three solvents are as in table 1.

Table 1. Results of phytochemical screening of secondary metabolite groups in n-hexane, ethyl acetate and ethanol extracts of Toba frankincense bark (STYRAX *paralleoncomud PERK)*.

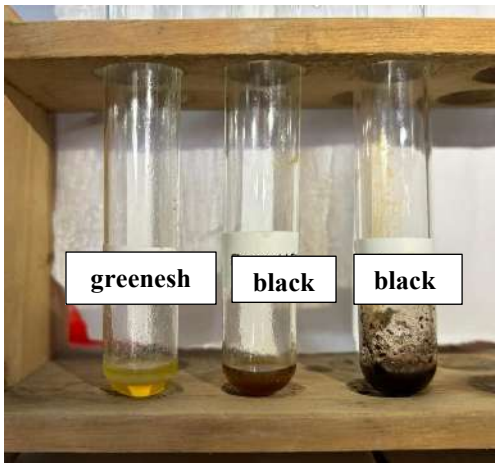
Secundary metabolites	Solvent		
	n-hexane	Ethyl acetate	Ethanol
Alkaloid	-	+	++
Flavanoid	-	+	++
Saponin	-	-	+++
Steroid	-	-	-
Terpenoid	-	+++	+++
Tanin	-	-	+++

Information : (-) not detection
(+) small amount
(+ +) moderate amount
(+ + +) large number

Based on the results in table 1, the results of the phytochemical screening test on frankincense bark obtained data that the n-hexane extract did not detect secondary metabolites, in the ethyl acetate extract the alkaloid and flavonoid groups with low levels, terpenoids with high levels and in the ethanol extract containing flavonoids and alkaloids with moderate levels, saponins, terpenoids and tannins with high levels. In principle, phytochemical screening is a chemical test whose indicators are the occurrence of sediment and colored complexes, foam and gas bubbles. For example, in the alkaloid test with Dragendorff's reagent, a light brown to yellow or orange sediment is formed (figure 3[a] and the alkaloid test with $FeCl_3$ reagent changes color to greenish or black-blue (figure 3[b] [12].



(a)



(b)

Figure 3. The results of the color change with Dragendorf's reagent on the extract form a light brown to yellow or orange precipitate indicating the presence of alkaloid 3[a] and the formation of a greenish or black color with FeCl3 reagent 3[b] indicates the presence of flavonoids.

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Toxicity Test

The toxicity test aims to determine the general risk caused by a toxic chemical substance to the human body [13]. In this study, the toxicity test of frankincense bark extract was carried out using the BSLT (*Brine Shrimp Lethality Test*) method. First, hatching of Artemia salina Leach eggs was carried out in an aquarium filled with 2 L of artificial seawater and 1 gram of Artemia salina Leach eggs and left for 48 hours for hatching. The aquarium was equipped with a 5 watt incandescent lamp to keep the seawater warm, thus accelerating the hatching process. Aeration was carried out using an aerator to provide sufficient oxygen for the survival of the larvae, so that hatching was faster. The Artemia salina Lech larvae used were newly hatched larvae, reddish in color and still had food reserves, 24 hours after hatching. Feeding was stopped when the larvae entered the first instar. At that time, the larvae could not eat because their mouths and pupae were not yet fully formed and were transferred to the second instar after the larvae had a perfect mouth and digestive system. Thus, the extract around the larvae enters the body of the larvae and causes the death of the larvae [14]. Toxicity testing was carried out by diluting the extracts of n-hexane, ethyl acetate, and ethanol with variations in concentration of 1000, 500, 100, 50 and 25 ppm with 3 repetitions. The concentration was used to determine the effect of differences in the death of Arthemia Salina Leach at each concentration with the number of larvae inserted 10 tails observed after 24 hours with the data in table 2 and the linear regression graph to calculate LC_{50} in figure 4

Table 2. Effect of variations in the concentration of n-hexane, ethyl acetate and ethanol extracts of Toba frankincense bark (STYRAX *paralleoncomud PERK*) on the mortality of Artemia *salina Leach*

Solvent	Concentration	Log Concentration	Number of larvae	Number of dead larvae	Death rate (%)	Probit Value	LC_{50} (ppm)
n-hexane	25	1.40	30	14	47	4.92	37.65
	50	1,70	30	16	53	5.05	
	100	2.00	30	19	63	5.33	
	500	2.70	30	25	83	5.95	
	1000	3.00	30	27	90	6.28	
Ethyl acetate	25	1.40	30	15	50	5.00	18.44
	50	1.70	30	21	70	5.52	
	100	2.00	30	25	83	5.95	
	500	2.70	30	27	90	6.28	
	1000	3.00	30	29	97	6.88	
Ethanol	25	1.40	30	20	67	5.44	10.7
	50	1.70	30	23	77	5.74	
	100	2.00	30	25	83	5.95	
	500	2.70	30	27	90	6.28	
	1000	3.00	30	30	100	7.37	

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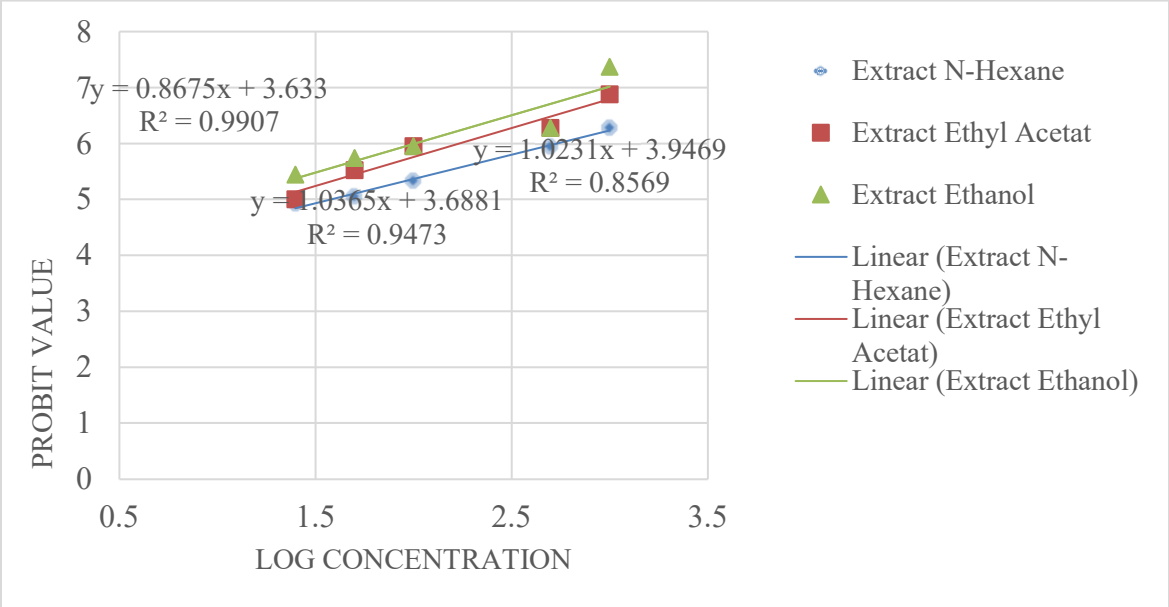

Figure 3. Log Concentration Graph of n-hexane, ethyl acetate and ethanol extracts of Toba frankincense bark (STYRAX *paralleoncomud PERK*) against Probit Values for LC*50* calculations based on linear regression equations.

Based on table 2 and figure 4, the results of the toxicity test of n-hexane solvent are in the toxic category with LC_{50} = 37.66 ppm, ethyl acetate solvent is in the toxic category with LC_{50} = 18.44 ppm and ethanol solvent is in the very toxic category with LC_{50} = 10.70 ppm. Toxicity data is general data on the toxic properties of a secondary metabolite. Based on the toxicity criteria, the three frankincense bark extracts have the potential to be drugs[14]

Antioxidant Test

Antioxidants are compounds that function to prevent the negative effects caused by free radicals. Free radicals are a by-product of the process of processing food into energy. Humans can be exposed to free radicals from food, air, and even from the body's reaction to sunlight. Thus, the human body needs antioxidants. There are two types of antioxidants, namely endogenous which are produced by the body and exogenous which come from outside the body, especially from food. Although it can produce its own antioxidants, the body still depends on antioxidants that come from outside. This compound will work by providing electrons to free radical molecules so as to neutralize their bad properties. [15]. In this study, the most toxic antioxidant properties of frankincense bark extract were tested, namely ethanol extract with a very toxic category with an LC50 of 10.70 ppm. Its antioxidant properties were tested with DPPH free radicals (2,2-diphenyl-1-picrylhydrazyl) which were measured using a Visible Spectrophotometer at a wavelength of 517 nm with a damping time of 30 minutes with 2 repetitions [16]. The results obtained are in table 3 and the graph for determining LC_{50} in figure 4.

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Table 3: Data on the activity of ethanol extract of frankincense bark (STYRAX *paralleoncomud PERK*) with DPPH free radicals.

No	Concentration (ppm)	Absorbance			Inhibition (%)		
		Repeat 1	Repeat 2	Average	Repeat 1	Repeat 2	Avarage
1	0.0	0.9144	0,9144	0,9144	0.0000	0.0000	0.0000
2	40.24	0.8252	0,7817	0.8062	9.7550	14.5122	12.1385
3	80.48	0,6357	0,6421	0.6389	30.4790	29.7791	30.1290
4	120.72	0.4991	0,4999	0,4995	45.4178	45.3303	45.3705
5	160,96	0,4119	0.4134	0.4126	54.9541	54.7900	54.8721
6	201.20	0,3026	0.2921	0.4486	66.9073	68.0556	67.4815

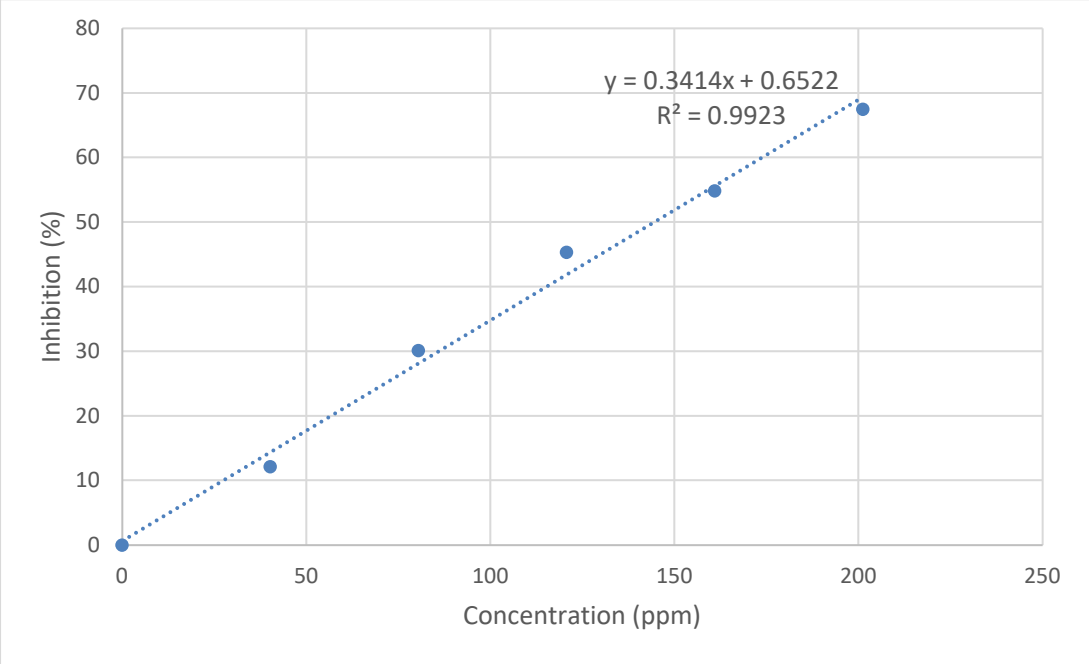

Figure 4. Inhibition versus concentration graph of antioxidant test with DPPH radicals for determining LC50 of ethanol extract of frankincense bark (STYRAX paralleoncomud PERK)

Based on the linear regression equation in Figure 4, the antioxidant properties of the ethanol extract of frankincense bark (STYRAX paralleoncomud PERK) with DPPH free radicals obtained an LC_{50} value of 144.54 with a moderate category. When compared to toxicity with LC_{50} = 10.70 ppm in the very toxic category [17], it is likely that the secondary metabolite group is more antibacterial because based on phytochemical screening in Table 1, flavonoids that are antioxidants are obtained in moderate amounts while alkaloids that are antibacterial are obtained in large amounts [18].

Conclusion

The results of the phytochemical screening test on the frankincense bark extract in the n-hexane extract did not detect any secondary metabolites, in the ethyl acetate extract the alkaloid and flavonoid groups were obtained with low concentrations, terpenoids with high concentrations, in the ethanol extract containing flavonoids and alkaloids with moderate concentrations, saponins, terpenoids and tannins with high

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concentrations. Furthermore, the results of the toxicity test for the n-hexane extract were in the toxic category with LC_{50} = 37.66 ppm, the ethyl acetate extract was in the toxic category with LC_{50} = 18.44 ppm and the ethanol extract was in the very toxic category with LC_{50} = 10.70 ppm. The antioxidant test on the most toxic ethanol extract obtained a moderate category inhibition power with LC_{50} = 144.54 ppm. Based on the results of the toxicity test and antioxidant test, the secondary metabolite extract of frankincense bark is quite potential as a drug [19].

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Adsorption equilibrium properties of Zn (II) on activated carbon composite of derived empty palm oil fruit bunches with metal organic frameworks Cu (TAC)

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Abstract. This study aims to determine the adsorption equilibrium of the activated carbon derived of oil palm empty fruit bunces and composite of this carbon with Metal Organic Frameworks (MOFs) - Cu(TAC). Oil palm empty fruit bunches are prepared to bio-sorbent then synthesis to be a carbon at a temperature of 500 ^{o}C and activated using H_3PO_4 refer to activated carbon. Activated carbon then

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modified into a composite with metal organic frameworks of Cu metal and terephthalic acid. MOFs and KA-Cu(TAC) composites were produced by reflux method. The adsorption process of Zn(II) metal was analysed using AAS and determined the optimum conditions with various concentrations to determine the adsorption equilibrium. XRD characterization results show that activated carbon has an amorphous structure, while MOFs Cu(TAC) and KA-Cu(TAC) have a crystalline structure. The optimum condition of activated carbon and KA-Cu(TAC) at a concentration of 180 ppm with the appropriate adsorption isotherm model is the Langmuir isotherm. Activated carbon has a higher absorption efficiency in adsorbing Zn(II) with an efficiency of 78.35%, while KA-Cu(TAC) has an efficiency of 71.27%. The optimum conditions for activated carbon to adsorb Zn(II) are a mass of 1 gram, a concentration of 180 ppm and a contact time of 30 minutes. The optimum conditions for KA-Cu(TAC) in adsorbing Zn(II) are a mass of 1 gram, a concentration of 180 ppm and a contact time of 30 minutes.

Keywords: Oil palm empty fruit bunches, activated carbon, composite, adsorption isotherm

Introduction

The rapid industrial development has an impact on environmental problems that must be seriously addressed. The oil palm plantation industry is one that generates the most waste, be it solid, liquid or gas. Indonesia is ranked 1st in the world's palm oil producer with an area of 14,456,611 ha and a total production of 47.1 million tons in 2019 [1]. One of the very dangerous components is heavy metals from liquid waste, namely Zn, Pb, Mn, Cd, Fe, and Cu [2]. Heavy metals can be harmful to humans and can spread from one organism to another through the food chain [3]. One of the most common heavy metals found in waters is zinc (Zn), and environmental pollution by heavy metals is a problem that needs to be addressed thoroughly. According to data from the Environment Agency (2018), the concentration of Zn metal in water exceeding the set quality standard of 0.06 mg/L is a significant hazard. The presence of heavy metal zinc (Zn) in water that exceeds the limit can cause toxic effects [4], because it can accumulate in living things and cannot be degraded [5].

Efforts that can be made to reduce the heavy metal content of palm oil industrial waste is by adsorption method. Activated carbon can be an alternative adsorbent because it has several advantages, namely low cost, simple operation, and long service life [6]. Activated carbon can be made from organic waste, one of which is empty oil palm fruit bunches (EFB). OPEFB includes solid waste from oil palm plantations and is very abundant because it accounts for around 23% of the total fresh fruit bunches [7]. One of the innovative ways to increase the adsorption yield is to synthesize composite materials to achieve new adsorption characteristics such as high pore volume and porosity. Carbon composites based on metal organic frameworks (MOFs) have received attention because of their high surface area and reactivity as well as their extraordinary adsorption capacity and thermal stability [8]. MOFs have a strong and highly porous structure that can accommodate a variety of guest molecules [9]. Various studies have applied MOFs to remove various toxic pollutants from wastewater, including heavy metals, pesticides, volatile and persistent organic pollutants [10]. More than 20,000 types of MOFs have been prepared due to the large number of metal and organic linkage combinations available for synthesis [9].

In this study, activated carbon of empty palm oil fruit bunches was used with metal organic frameworks of Cu metal and terephthalic acid (TAC) organic ligands. The choice of Cu as the central metal in MOFs is due to its high selectivity and high adsorption capacity [11]. In this study

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adsorption equilibrium was used to describe the adsorption isotherm characteristics of Zn (II) metal on activated carbon and KA-Cu(TAC). The Langmuir isotherm describes the adsorption of a monolayer of adsorbate onto an adsorbent surface that has a limited number of adsorption sites, while the Freundlich isotherm describes that adsorption occurs on a heterogeneous surface of the adsorbent. Based on this explanation, the researcher aims to modify the activated carbon composite of empty oil palm fruit bunches with metal organic frameworks Cu(TAC) to adsorb Zn(II) with the name KA-Cu(TAC) composite to increase adsorption power, to determine the characterization of the material and to determine the adsorption isotherm characteristics of the adsorbent.

Methodology

Empty Oil Palm Bunches Preparation

The empty oil palm bunches (EFB) used were obtained from PTPN II Pagar merbau's OPEFB waste. OPEFB is first washed to reduce its oil content and then dried in the sun for several days. The dried OPEFB were then ground to a fine powder and sieved using a 200 mesh sieve and obtained bio-sorbent of empty palm oil bunches [12].

Activation and carbonization

Bio-sorbent empty palm oil bunches that had been dried were heated in a furnace with a temperature of 500^0 C for approximately 2 minutes. After carbonization, Carbon was prepared and weighed total of 10 grams of activated carbon was immersed in 100 mL of 10% H_3PO_4 for 24 hours. The activated carbon is filtered using filter paper and washed with distilled water until the pH is neutral [13].

Synthesis of MOFs Cu(TAC)

MOFs Cu(TAC) was synthesized by mixing 277.5 mg of $Cu(NO_3)_2$, 687.5 mg of terephthalic acid, 200 mL of 35% hydrofluoric acid, and 190 ml of 65 % nitric acid evenly with 20 ml of distilled water under reflux and heated to 105° C for 8 hours. After cooling to room temperature, the solution was vacuum filtered and washed to a neutral pH [14].

Synthesis of Activated Carbon Composites – Cu(TAC)

The synthesis is carried out in two stages. In beaker 1 consists of dispersion of terephthalic acid onto activated carbon. Terephthalic acid ethanol solutions (approx. 1 g terephthalic acid per 10 g ethanol) were prepared and then dispersed onto activated carbon (approx. 10 g solution per 0,6 g activated carbon). The terephthalic acid/activated carbon mixture is then soaked for 24 hours to evaporate the ethanol. In beaker 2, copper nitrate, hydrofluoric acid, nitric acid and distilled water are mixed. then the two beakers mixed were refluxed for 8 hours to remove excess acid and evaporate the ethanol [10].

XRD characterization

MOFs Cu(TAC) and KA-Cu(TAC) obtained were characterized using XRD to determine the

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structure of the material.

Adsorption Equilibrium

Adsorption isotherms for Zn(II) on activated carbon and KA-Cu(TAC) of empty palm oil bunches were determined by varying the Zn(II) concentrations from 60 ppm, 100 ppm, 140 ppm, 180 ppm and 220 ppm. Equilibrium data was determined using Langmuir and Freundlich isotherms.

The form of the Langmuir adsorption isotherm equation is as follows:

$$R_L = \frac{1}{1 + K_L C_0}$$

RL = separation factor, KL = Langmuir constant (L/mg), and Co = initial adsorbate concentration (mg/L).[15]

The form of the Freundlich adsorption isotherm equation is as follows:

$$Log\ q_e = \log K_f + \frac{1}{n} \log C_e$$

Result and Discussion

In this study, carbon was activated using the H_3PO_4 activator because it can form new pores and bind impurity carbon compounds out of the carbon pores so that the diameter of the carbon pores increases and also has low toxicity [16]. KA-Cu(TAC) was also successfully synthesized which visually formed a black powder in the presence of a white mixture. The black color in KA – Cu(TAC) comes from activated carbon, while the white color comes from MOFs Cu(TAC). In this synthesis, a reflux process is carried out with the aim of removing excess acid and evaporating the ethanol [10].

XRD Characterization

Characterization by XRD was carried out to analyze the crystal structure, crystallinity and composition of activated carbon, MOFs Cu(TAC) and KA-Cu(TAC). Based on the EXPO 2015 analysis table, it shows differences in crystal systems in Cu(TAC) and KA-Cu(TAC) samples. Cu(TAC) has two crystal systems, namely triclinic and monoclinic which indicates that Cu(TAC) is not homogeneous. Based on the above lattice parameters, the triclinic and monoclinic Cu(TAC) crystal systems are in accordance with the lattice parameters. KA-Cu(TAC) has only one crystal system, namely triclinic, which shows that KA-Cu(TAC) is homogeneous. The unit cell volume of KA-Cu(TAC) also appears to be lower than that of Cu(TAC), this causes the intensity of KA-Cu(TAC) to also be lower [17]. The triclinic lattice parameters show that KA-Cu(TAC) meets the lattice parameters as a triclinic crystal system.

Table 1. Crystal Structure Analysis by EXPO 2015

Biosorbent	a(Å)	b(Å)	c(Å)	α (°)	β(°)	ϒ(°)	Cell Volume (Å^3)	Crystal System
Cu(TAC)	6.98	10.15	5.77	92.73	101.56	96.94	396.71	Triclinic
	11.47	19.55	8.16	90.00	100.78	90.00	1797.86	Monoclinic

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KA-Cu(TAC)	7.49	7.83	5.73	104.62	98.74	95.84	318.15	Triclinic

Adsorption Isotherm Properties

The adsorption isotherm is the equilibrium bond that occurs between the concentration of the adsorbate in the solid phase and the concentration in the liquid phase [18]. The Langmuir and Freundlich model was used to describe the adsorption isotherm characteristics of Zn (II) on activated carbon and KA-Cu(TAC). The Langmuir isotherm describes the adsorption of a monolayer of adsorbate onto an adsorbent surface that has a limited number of adsorption sites, while the Freundlich isotherm describes that adsorption occurs on a heterogeneous surface of the adsorbent [19]. Adsorption isotherms were calculated using concentration variation data, in this study the concentration variations were 60, 100, 140, 180, and 220 ppm. Then proven by a good linearization graph and has a coefficient of determination $R^2 \geq 0.9$ (close to 1).

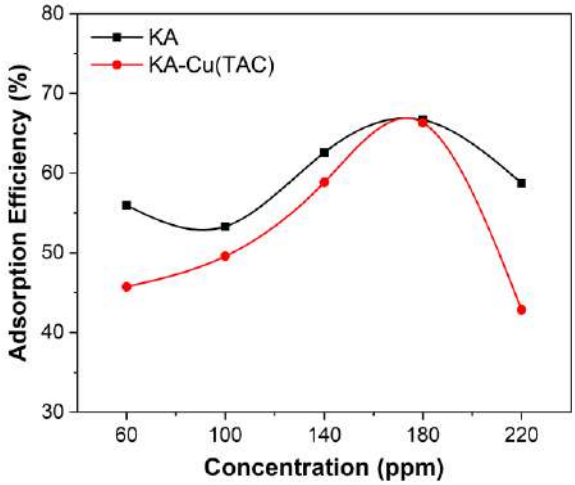

Figure 1. Absorption Efficiency of Variations in Concentration

Figure 1 shows the effect of varying Zn (II) concentrations on the adsorption efficiency of the adsorbent. The absorption efficiency of activated carbon and KA-Cu(TAC) increased with increasing concentration until the optimum concentration of both adsorbents was obtained at 180 ppm. The increase in adsorption efficiency is due to the increasing concentration of Zn (II) metal causing the amount of adsorbate to be adsorbed to increase so that the efficiency increases. Based on the data above, whether the adsorption isotherm is the Langmuir isotherm or the Freundlich isotherm can be determined.

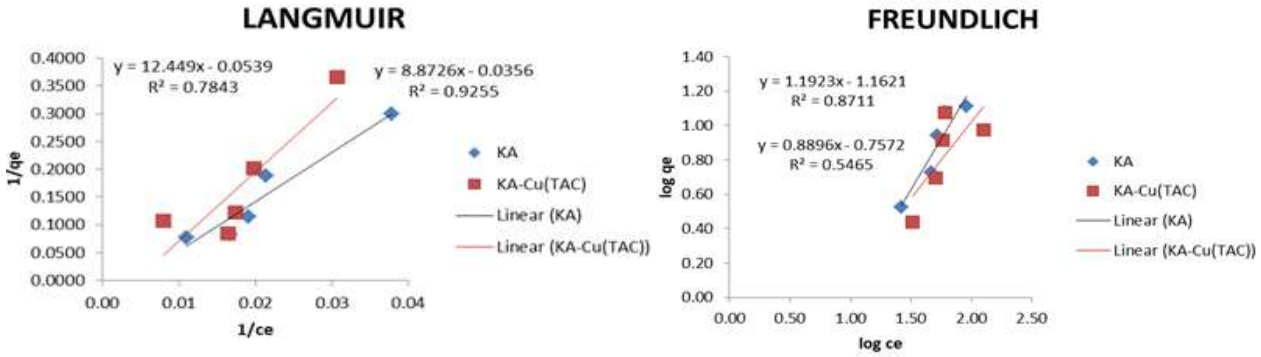

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Figure 2. Langmuir and Freundlich Isotherm plot

From the linearization graph in figure 2, Langmuir and Freundlich parameters for activated carbon and KA-Cu(TAC) can be obtained which can be seen in the table 2.

Table 2. Langmuir and Freundlich parameters for Zn (II) adsorption

Isotherm	Sample	RL	R^2
Langmuir	KA	1.14	0.9255
	KA-Cu(TAC)	1.15	0.7843
Freundlich	KA	0.06884937	0.8711
	KA-Cu(TAC)	0.1749041	0.5465

By using the correlation coefficient (R^2), it can be seen from the data and linearization graph above that the Langmuir isotherm is the most suitable because the value of the linear regression coefficient on activated carbon ($R^2 > 0.9255$) and KA-Cu(TAC) ($R^2 > 0.7843$), the R^2 value of this Langmuir isotherm is higher than the R^2 value of the Freundlich isotherm where activated carbon ($R^2 > 0.8711$) and KA-Cu(TAC) ($R^2 > 0.5465$). Based on the Langmuir isotherm equation, it can be concluded that adsorption occurs by chemisorption or chemically. Chemisorption occurs when there is a chemical bond between the surface of the adsorbent and the adsorbate molecule [20]. It can also be concluded that monolayer adsorption of Zn (II) occurs on the activated carbon adsorbent and homogeneous KA-Cu(TAC) and the adsorbed molecules of the adsorbate show a single layer on the surface of the adsorbent [6].

Conclusion

Characterization of carbon XRD shows that the active carbon structure of oil palm empty fruit bunches is an amorphous structure. Whereas MOFs Cu(TAC) shows a crystalline structure which is characterized by the appearance of several sharp peaks in the pattern. KA-Cu(TAC) also exhibits a crystalline structure. The suitable adsorption isotherm is the Langmuir isotherm where the value of the linear regression coefficient on activated carbon ($R^2 > 0.9255$) and KA-Cu(TAC) ($R^2 > 0.7843$). Adsorption occurs by chemisorption or chemically. Chemisorption occurs when there is a chemical bond between the surface of the adsorbent and the adsorbate molecule. It can also be concluded that monolayer adsorption of Zn (II) occurs on the activated carbon adsorbent and homogeneous KA-Cu(TAC) and the adsorbed molecules of the adsorbate show a single layer on the surface of the adsorbent.

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Antibacterial activity of sarang banua (*clerodendrum fragrans* vent will) leaf extract against the bacteria *staphylococcus epidermidis*, *propionibacterium acnes* and *staphylococcus aureus* causes topical disorders

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Abstract. Several microorganisms can cause topical disorders such as bacteria, viruses and fungi. Bacteria that can cause body odor are *Staphylococcus epidermidis* and *Staphylococcus aureus*. Meanwhile, the bacteria that can cause acne are *Propionibacterium acnes* and *Staphylococcus epidermidis* and *Staphylococcus aureus* causes dandruff. The sarang banua plant found in the Simalungun area, identified as *Clerodendrum fragrans* Vent Willd, has been used by the community as a traditional medicine, including diarrhea. This study aims to determine the potential of sarang banua leaf extract (*C.fragrans*) as an antibacterial against *Staphylococcus epidermidis*, *Propionibacterium acnes* and *Staphylococcus aureus* bacteria that cause topical disorders. The leaf powder is macerated with 96% ethanol solvent to obtain an ethanol extract. The extract solution was tested with varying concentrations of 10%, 20% and 30%. The antibacterial test method was carried out using the disc diffusion method. The results showed that ethanol extract at an highest concentration of 30% inhibited antibacterial activity with the diameter of the inhibition zone against *Staphylococcus epidermidis*, *Staphylococcus aureus* and *Propionibacterium acnes* respectively being 10.5 mm, 11.06 mm and 11.3 mm. The results of this research can be used as consideration for raw materials for making topical medicines.

Keywords: Sarang banua *(Clerodenrum fragranas Vent Willd),* antibacterial*, Staphylococcus epidermidis, Staphylococcus aureus, Propionibacterium acnes,* topical disorders**.**

Introduction

The increasing number of skin and mucous membrane surface diseases has led to an increasing need for topical drugs. Topical drugs are types of drugs that are applied to the surface of the skin such as deodorants, facial washes and anti-dandruff shampoos. Several types of bacteria can cause skin diseases such as *Staphylococcus epidermidis* which causes body odor [1]. *Propionibacterium acnes* which is the main cause of acne and *Staphylococcus aureus* which triggers dandruff [2-3]. *Staphylococcus epidermidis* is found on the skin, mucous membranes, ulcers and wounds. It can cause disease through its ability to reproduce and spread widely in tissue [4]. Deodorant, facial wash and anti-dandruff shampoo preparations (topical cosmetics) contain antibacterial ingredients in the form of antibiotics and aluminum chlorohydrate chemicals. In deodorants, the threshold level for the use of aluminum chlorohydrate is 20% and 5% for aluminum in other forms [5-6]. The active ingredient that is often used in deodorant preparations is the chemical compound aluminum chlorohydrate because of its properties that can shrink pores so that it can inhibit excessive sweat production [7]. However, there are negative effects that can be caused by aluminum chlorohydrate if used beyond the threshold or excessively, because this compound has a high level of toxicity [8]. Aluminum chlorohydrate can damage DNA and trigger breast cancer. The resistance of some bacteria to antibiotics makes synthetic antibiotics less effective and even has side effects. This has prompted researchers to conduct research on herbal medicines. The sarang banua plant (*Clerodendrum fragrans* Vent Willd), the Verbenaceae family, is widely found in Simalungun and has been used as a traditional medicine and has antidiarrheal activity [9]. so it has the potential to be developed as a topical herb. This study aims to determine the potential of sarang banua leaf extract (*C. fragrans*) as an antibacterial against *Staphylococcus epidermidis*, *Propionibacterium acnes* and *Staphylococcus aureus* bacteria that causes topical disorders.

Materials and Methods

Material

The materials used were sarang banua leaves (*Clerodendrum fragrans*) from Simalungun, North

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Sumatra (has been determined by "Herbarium Bogoriense LIPI Cibinong–Bogor), chloramphenicol, Mueller Hinton Agar (MHA) (Oxoid, UK), sterile distilled water, ethanol 95% p.a., DMSO (dimethyl sulfoxide) (Emerck), silica gel 1.07733.1000, *S. aureus* bacteria, *S. epidermis*, *P. acnes*, Muller-Hinton Broth (MHB), aluminum foil, blank disc (Oxoid, UK) and chloramphenicol disc (Oxoid, UK). The equipment used is a petri dish, beaker glass (approx.), erlenmeyer (pyrex), test tube (pyrex), Buchner funnel, measuring cup (pyrex), ose, cotton, tissue, cling wrap, whatman paper, vacuum rotary evaporator (Heidolph), incubator (memmert), autoclave (Tomy), oven (memmert), Laminar flow (18-oneV915S), hot plate.

Methode

Extraction of Sarang Banua Leaves (Clerodendrum fragrans Vent illd)

Extraction was carried out using the maceration method. A total of 4.0 kg of fresh sarang banua leaves (*C. fragrans*) were dried indoors, ground and macerated with solvents of varying polarity (n-hexane, ethyl acetate and ethanol), each for 3 x 24 hours. The ethanol extract from the maceration was filtered and the filtrate was evaporated using a rotary evaporator, obtaining a thick ethanol extract of sarang banua leaves.

Antibacterial Test

Media Preparation and Sterilization

Bacterial growth media was made using Muller-Hinton Agar (MHA) media. MHA powder was weighed as much as 38.0 grams and mixed with 1L of distilled water. Then each solution was heated and stirred using a stirrer on a hotplate until boiling. Petri dishes, test tubes, and containers that had been washed and dried were wrapped in paper and plastic, while the paper discs were inserted into clean petri dishes. MHA media and all tools were sterilized in an autoclave at 121°C for 15 minutes.

Rejuvenation and Preparation of Bacterial Suspensions

The bacteria to be used were first cultured before being used for testing. The loop needle used was first heated with a spirit lamp, then cooled for 30 seconds. With the loop needle, *S. aureus*, *S. epidermis* and *P. acnes* bacteria were taken and each was placed in a petri dish containing MHA, then placed in an incubator to be incubated at 37°C for 24 hours. The bacterial culture was then taken as much as one loop and inoculated into a test tube containing 50 mL of 0.9% physiological NaCl, then vortexed until the turbidity reached the McFarland standard of 0.5. The suspension of bacteria in 0.9% NaCl is the same as the dilution of bacteria 10-6 CFU/mL (McFarland Standard 0.5) [10].

Inhibitory Power Test of Paper Disc Diffusion Method

The paper disc diffusion test begins by inserting 100 µL of inoculum onto the agar medium, then levelling it using a Sprider. Leaving it for approximately 5 minutes, then placing the disc so that each disc on the surface of the plate is 24 mm apart. The paper disc is pressed firmly on the surface to ensure that the disc is in direct contact with the agar plate inoculum. Furthermore, 20 µL of test solution and DMSO (negative control) are dropped onto each paper disc. Chloramphenicol disc (Oxoid, UK) is placed as a positive control. Then the agar plate is covered and placed in an incubator at 37°C. After 16-18 hours of incubation, each plate is examined. The emergence of a bacterial growth inhibition zone can be seen from the emergence of a clear zone around the disc. Furthermore, it is measured using a caliper, so that the diameter of the bacterial growth inhibition

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zone is obtained. The positive control used was 30µg chloramphenicol antibiotic disc (Oxoid, UK), while the negative control used was DMSO solvent [11-12].

Research Result

Antibacterial activity test results of ethanol extract of sarang banua leaves (C. fragrans) against Staphylococcus aureus bacteria.

The results of the antibacterial activity test of ethanol extract of sarang banua leaves against *Staphylococcus aureus* bacteria are presented in Figure 1

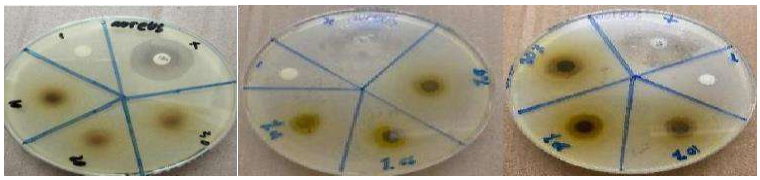

Figure 1. Inhibitory Test of Ethanol Extract of *C. fragrans* Against *Staphylococcus aureus* Bacteria (Repetition 1,2,3).

Inhibition zone diameter of ethanol extract of *C. fragrans* Against *Staphylococcus aureus b*acteria are presented in Table 1.

Table 1. Inhibition Zone Diameter of Ethanol Extract of *C. fragrans* Against *Staphylococcus aureus* Bacteria

Treatment	Inhibition Zone Diameter (mm) Repetition			Inhibition Zone Diameter (mm) Average (mm)
	1	2	3	
K (+)	24.5	24.8	25.6	25.96
K (-)	0	0	0	0
K1 (10%)	8.7	9.3	9.4	9.13
K2 (20%)	9.8	10.2	10.4	10.13
K3 (30%)	10.7	11.2	11.3	11.06

Information:
K (+): chloramphenicol
K (-): DMSO
K1: ethanol extract of *C. fragrans* leaves 10%
K2: ethanol extract of *C. fragrans* leaves 20%
K3: ethanol extract of *C.fragrans* leaves 30%

Antibacterial activity test of ethanol extract of sarang banua leaves (C. fragrans) against Staphylococcus epidermis bacteria.

The results of the antibacterial activity test of ethanol extract of sarang banua leaves against *Staphylococcus epidermis* bacteria are presented in Figure 2.

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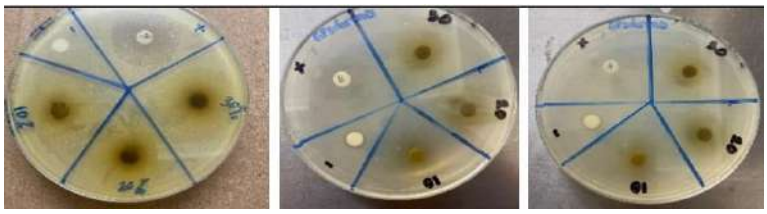

Figure 2. Inhibitory Power Test of Ethanol Extract of *C. fragrans* Against *Staphylococcus epidermis* Bacteria (Replications 1,2,3)

Inhibition zone diameter of ethanol extract of *C. fragrans* Against *Staphylococcus epidermis b*acteria is presented in Table 2.

Table 2. Inhibition Zone Diameter of Ethanol Extract of *C. fragrans* Against *Staphylococcus epidermis* Bacteria

Treatment	Inhibition Zone Diameter (mm) Repetition			Inhibition Zone Diameter (mm) Average (mm)
	1	2	3	
K (+)	26.5	25.8	26.2	26.16
K (-)	0	0	0	0
K1 (10%)	8.6	9.2	9.4	9.06
K2 (20%)	9.2	9.8	10.2	9.73
K3 (30%)	10.7	10.3	10.5	10.5

Antibacterial activity test of ethanol extract of sarang banua leaves against Propionibacterium acnes bacteria.

The results of the antibacterial activity test of ethanol extract of sarang banua leaves against *Propionibacterium acnes* bacteria are presented in Figure 3.

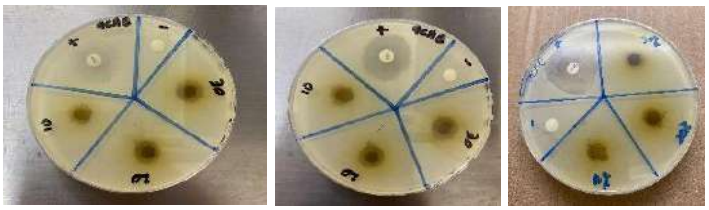

Figure 3. Inhibitory Power Test of Ethanol Extract of *C. fragrans* Against *Propionibacterium acnes* Bacteria (Replications 1,2,3).

Inhibition zone diameter of ethanol extract of *C. fragrans* Against *Propionibacterium acnes b*acteria are presented in Table 3.

Table 3. Inhibition Zone Diameter of Ethanol Extract of *C. fragrans* Against *Propionibacterium acnes* Bacteria

Treatment	Inhibition Zone Diameter (mm) Repetition			Inhibition Zone Diameter (mm) Average (mm)
	1	2	3	
K (+)	26.8	2	25.4	25.3

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K (-)	0	0	0	0
K1 (10%)	10.2	8.8	12.1	10.3
K2 (20%)	13.1	8.8	11.2	11.0
K3 (30%)	12.2	10.4	11.3	11.3

The results of the antibacterial activity test (Figure 1-3) showed that the ethanol extract of sarang banua leaves (*C.fragrans*) had antibacterial activity against *S.epidermis*, *S. aureus* and *P. acnes* bacteria which was indicated by the presence of a clear zone around the disc paper. The results of the antibacterial activity test of *C. fragrans* (Table 1-3) showed that the ethanol extract of *C. fragrans* at the highest concentration of 30% was able to inhibit antibacterial activity with the diameter of the inhibition zone against *Staphylococcus epidermidis*, *Staphylococcus aureus* and *Propionibacterium acnes* of 10.5 mm, 11.06 mm and 11.3 mm, respectively.

The n-hexana extract of sarang banua leaves (*C. fragrans*) contains secondary metabolites of alkaloids, steroids and flavonoids, while in the ethyl acetate extract there are alkaloids, steroids, saponins and tannins and the ethanol extract contains alkaloids, triterpenoids, flavonoids, saponins, tannins and quinones [13]. The presence of these secondary metabolites causes the ethanol extract of sarang banua leaves to have the potential to inhibit the growth of *Staphylococcus aureus*, *Staphylococcus epidermis* and *Propionibacterium acnes* bacteria that cause topical disorders such as body odor, acne and dandruff. *S. epidermis*, *S. aureus* and *P. acnes* bacteria are gram-positive bacteria that have a thin peptidoglycan layer in their cell walls and the components of their cell walls are complex because they have an additional outer layer, while in gram-negative bacteria it is thicker so that penetration of the walls in gram-positive cells is easier[14]. Ethanol extract of sarang banua leaves contains secondary metabolites flavonoids, alkaloids, saponins, tannins. Flavonoids have the potential as antibacterials by disrupting the process of nucleic acid synthesis in bacteria by inhibiting enzymes involved in DNA replication and transcription, thereby preventing the reproduction and growth of bacterial cells. Flavonoids interact with bacterial cell membranes causing damage to the membrane structure resulting in the release of important intracellular components, resulting in bacterial cell death. Flavonoids also inhibit bacterial energy metabolism by disrupting oxygen use and inhibiting important enzymes in metabolic pathways. This matter resulting in decreased energy production needed for macromolecular biosynthesis, so that bacteria cannot function properly and eventually die. Alkaloids work by disrupting the peptidoglycan components of the bacterial cell wall causing the cell wall to be incomplete resulting in death, bacterial cell death. Saponins can kill bacteria by reducing the surface tension of the bacterial cell membrane which causes increased membrane permeability, causing leakage of cell components such as proteins, nucleic acids, and enzymes. This results in hemolysis and the cells rupture and lose their structural integrity.

Tannins can interfere with cell wall synthesis, causing bacterial cell walls to lysis due to osmotic pressure. Tannins can inactivate important enzymes in bacteria, disrupting the normal function of bacterial cells, which can lead to cell death. Plant saponins also have antibacterial potential, especially against common pathogenic bacteria[15].

The genus Clerodendrum (family Verbanaceae) has more than five hundred identified species which are semi-woody shrubs and are widely distributed in tropical areas. Root, stem, and leaf extracts of several species of the genus Clerodendrum have been used for the treatment of asthma, cataracts, malaria, blood, skin and lung diseases [16].

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The ethanol extract of *C. fragrans* was able to inhibit antibacterial activity with the diameter of the inhibition zone against *Staphylococcusepidermidis*, *Staphylococcus aureus* and *Propionibacterium acnes* of 10.5 mm, 11.06 mm and 11.3 mm, respectively.
Based on the bacterial inhibition category, the diameter of the inhibition zone formed is 10-19 mm, which is classified as strong [12].

Conclusion

Ethanol extract of sarang banua leaves (*Clerodendrum fragrans* Vent Willd) has the potential to inhibit the growth of *Staphylococcus epidermis*, *Staphylococcus aureus* and *Propionibacterium acnes* bacteria that cause topical disorders such as body odor, acne and hair dandruff. The results of this research can be used as consideration for raw materials for making topical medicines.

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Analysis of Fe metal adsorption in wastewater using nano chitosan coated areca nut shell adsorbents from shrimp shells

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Abstract. This study aims to determine the most effective formulation of activated carbon coated with nano chitosan and to determine the characteristics and optimum absorption of activated carbon from nano chitosan-coated areca nut shell from shrimp shells and applied for the adsorption of heavy metal Fe in wastewater. Areca nut shell were carbonized at 600°C and activated with H_2SO_4 then coated with nano chitosan from shrimp shells. The best formulation of activated carbon coated with nano chitosan from shrimp shells is 2.5:0.8% nano chitosan. The PSA results obtained the average distribution of nano chitosan particles which was 51.11 nm. The adsorbent characterization was carried out using FTIR and BET instruments and the Fe metal analysis was carried out with AAS (Atomic Absorption Spectrophotometry). The FTIR characterization results obtained that the chitosan functional group (-NH) was present in wave number 3345.89 cm^{-1}, and the BET results obtained a surface area of 1512.092 m^2/g. The optimum conditions for absorption of Fe metal with activated carbon coated with nano chitosan were at a mass of 2.5 gram and with a contact time of 100 minutes. The absorption efficiency of activated carbon coated with nano chitosan is 86.26%. The wastewater samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the wastewater samples from a concentration of 24.68 ppm to 3.39 ppm.

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Keywords**:** *Adsorbent, areca nut shell, shrimp shell, nano chitosan, activated carbon, and adsorption.*

Introduction

Heavy metals are harmful to living things in large quantities, but some of these heavy metals are needed in minimal amounts [1]. Heavy metals that are harmful and generally contribute to environmental pollution are iron (Fe) [2]. Heavy metals such as Fe, Cd, Cu, Zn, Ni, and Cr are generally found in industrial liquid waste. However, Fe metal is more often found in industrial liquid waste with high levels. One example of industrial liquid waste that generally contains high levels of Fe metal is palm oil mill liquid waste [3]. Immediate handling is needed so that heavy metals contained in industrial waste do not pollute the environment when discharged into waterways, so that the dangers of heavy metal contamination from this industrial waste can be reduced. One way that can be done is the adsorption process with activated carbon.

The most common adsorbent used in the adsorption process generally uses activated carbon because it has good adsorption capacity [4]. However, the use of this adsorbent requires quite expensive costs. Currently, research is being encouraged on the use of natural materials as alternative adsorbents, because they not only have good adsorption capacity but are also more economical [5]. Heavy metal adsorption can be absorbed using activated carbon from areca nut shell [6]. Areca nut shell has a fairly high cellulose content so it can be used as a material for the synthesis of activated carbon adsorbents [7]. Areca nut shell contains cellulose of 54.15%, hemicellulose of 16.61% [8] and lignin of 31.6% [9]. The utilization of areca nut shell waste used for alternative activated carbon synthesis materials is very good to be processed into products with economic value so that areca nut shell waste will be reduced.

The utilization of areca nut shell waste used for alternative activated carbon synthesis materials is very good to be processed into products with economic value so that areca nut shell waste will be reduced [10]. Areca nut shell can absorb Fe metal in industrial waste with an adsorption capacity of 1.4174 mg/g. The concentration of Fe metal obtained in the waste was 25.86 ppm, after the addition of activated carbon from areca nut shell, the concentration of Fe metal decreased to 3.72 ppm. So the adsorbent ability of areca nut shell in adsorbing Fe metal in industrial liquid waste is 22.14 ppm [11]. The use of nanochitosan has been widely studied by researchers. The use of nanochitosan from shrimp shells attempts to reduce Hg metal levels by producing an absorption of 34.465, reported that nanochitosan can adsorb mercury waste with an efficiency percentage of 63.99% [12]. There is research that coating adsorbents with nanochitosan will produce even better adsorption values. Adsorbents made from corn cobs coated with nanochitosan from green mussel shells are able to absorb Fe metal with an efficiency of 88.91% [13].

Based on previous research, researchers wanted to observe the effect of chitosan made in nano size on the absorption capacity and adsorbent characteristics of activated carbon from areca nut shells, where in this study, activated carbon adsorbents coated with nanochitosan from shrimp shells were applied to industrial liquid waste containing iron metal (Fe).

Methodology

Materials

The AAS (*Atomic Absorption Spectrophotometer*), *Fourier Transform Infra Red (FTIR), Particle Size Analyzer* (PSA), *Brunauer Emmet Teller* (BET) instruments, analytical balance, grinder, furnace, shaker, desiccator, magnetic stirrer, Whatman No. 42 filter paper, spray bottle, dropper, beaker, pH meter, funnel, flasks of 25 milliliters, 50 milliliters, and 100 milliliters, and watch glass are the instruments used in this study. wastewater samples, areca nut shell, shrimp shells, aquadest,

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HCl, NaOH, HNO_3, H_2SO_4, CH_3COOH, NaTPP, a standard solution containing 1000 mg/L of Fe, and acetone were all used in this study.

Procedure

Carbon Preparation from Areca Nut Shell Waste and Activation

Areca nut shells were cleaned and cut into small pieces and then dried in the sun. The areca nut shells are then baked in the oven at 100°C for one hour to dry, this stage is a dehydration process. Then the material is burned in the furnace for 15 minutes at a temperature of 600°C. The resulting charcoal is then crushed and then sieved with a 200-mesh sieve. The charcoal obtained is then activated with a solution of sulfuric acid (H_2SO_4) to obtain activated charcoal. The charcoal obtained was weighed as much as 50 g and added 250 mL of 1 M H_2SO_4. Stir using a magnetic stirrer for 30 minutes and then let stand for 24 hours. Filter the solution formed with Whatman filter paper and then rinse with distilled water. Then dry the activated charcoal in the container at 105°C using an oven for 1 hour to remove the water content contained in the activated charcoal [14].

Isolation of Chitosan from Shrimp Shells

• **Preparation of Shrimp Shells.**

The shells are dried in the sun. After drying pounded until the size is getting smaller. Then grind it using a grinder to form a fine powder. Then the shrimp shell powder was sieved with a 200 mesh sieve.

• **Deproteination Stage**

Prepared 70 grams of shrimp shells powder then added 3.5% NaOH with a ratio of 1:10. Heat at 70°C for 2 hours while stirring. Then the mixture was filtered and rinsed with distilled water until the pH was neutral. The solid obtained is then dried in an oven at 60°C until constant weight.

• **Demineralization Stage**

The deproteinated powder was added with 1N HCl in a ratio of 1:10. Then let stand at room temperature for soaking then heat at 75°C for 1 hour while stirring. Then the mixture was filtered and rinsed with distilled water until the pH was neutral. The solid obtained is then heated at 60°C to a constant weight. Chitin will be obtained from shrimp shells.

• **Deacetylation Stage**

10 grams of chitin powder was added to 60% NaOH (1:10) and heated at 90°C for 3 hours while stirring. Filter and rinse with distilled water until the pH is neutral. The solid obtained was then dried at 60°C to a constant weight. Chitosan will be produced as a product of this process.

Preparation of Nanochitosan Ionic Gelation Method

0.2% chitosan solution was made in a 1 M CH3COOH solution. A 1% NaTPP solution was added with a ratio of chitosan solution: NaTPP solution of 5:1 with a stirring speed of 800 rpm and stirring was carried out for 1 hour [15].

Preparation of Activated Carbon Coated with Nanochitosan

A total of 10 g of activated carbon was weighed and then added to 100 mL of 0.2% nanochitosan solution, then stirred until smooth and dried at room temperature for 3 days [16].

Adsorbent Characterization

The adsorbent produced was then characterized with several instruments, namely: FTIR analysis

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to analyze chitosan functional groups, PSA analysis to determine the distribution of particles in chitosan samples, and BET analysis to analyze surface area of activated carbon and activated carbon coated with nano chitosan.

Provision of Fe Standard Solution for AAS Analysis

Weigh the solid Fe $(NO_3)_2$ ± 3.2142 g into a beaker glass containing 25 mL of distilled water, then stir until dissolved. Then the solution was put into a 1000 mL volumetric flask and diluted using distilled water up to the mark, then homogenized. Obtained a standard solution of Fe 1000 ppm. The standard solution was diluted to obtain a Fe solution with various concentrations of 0 ppm, 1 ppm, 2 ppm, 3 ppm, and 4 ppm as the standard solution for AAS analysis.

Adsorption Analysis of Fe Metal with Activated Carbon Coated with Nano chitosan in Liquid Waste with AAS

As much as 2.5 g of areca nut shell-activated carbon adsorbent was added to 100 mL of wastewater sample. Stir until homogeneous using a magnetic stirrer for 10 minutes. The filtrate obtained was then analyzed with AAS. The same thing was done with activated carbon adsorbents coated with nano chitosan.

Results and discussions

The activation process of areca nut shell carbon was carried out by adding 250 mL of 1M H_2SO_4 to 50 g of areca nut shell carbon to obtain activated carbon with a moisture content of 4.85%. The function of carbon activation with H_2SO_4 is to form pores on carbon. The concentration of H_2SO_4 used can affect the absorption capacity of the carbon. H_2SO_4 concentrations that are too high can damage carbon and reduce its adsorption power, while H_2SO_4 concentrations that are too low will be less able to open pores in carbon [17]. Charcoal activated with H_2SO_4 has better absorption compared to other acid activators. Chitosan which had been isolated from shrimp shells was then characterized by FTIR. Chitosan characterization was also carried out using FTIR instruments to detect the presence of amine groups in chitosan, resulting from transformation from acetamide. The results of chitosan analysis with FTIR produce graphs as shown in **Fig 1**.

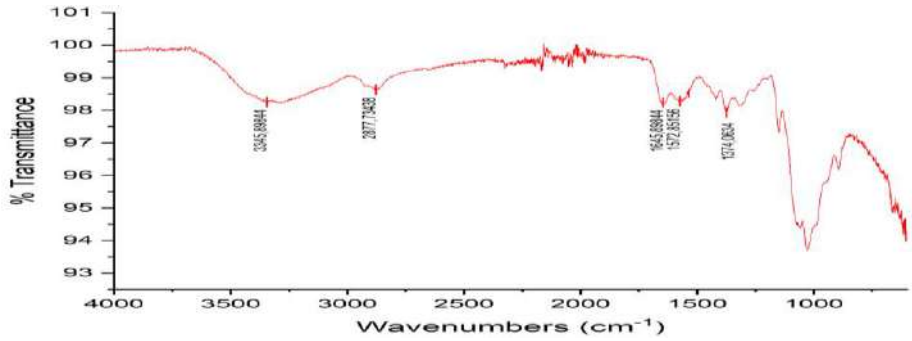

Figure 1. Chitosan IR spectrum

The results of the FTIR characterization showed that the absorption band of the chitosan samples analyzed indicated the presence of the N-H functional group belonging to chitosan at wave number 3345.89 cm^{-1}. At wave number 2877.73 cm^{-1}, the presence of the C-H functional group, the C=O functional group at wave number 1645.89 cm^{-1}, and the C-N group at wave number

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1572.85 cm^{-1} were detected. The identification of the N-H functional group belonging to chitosan indicates that chitosan has been successfully formed.

The purpose of the PSA (Particle Size Analyzer) analysis is to determine the particle size of chitosan. The chitosan solids obtained were then analyzed using PSA to obtain a graph of the particle size distribution as shown in **Fig 2.**

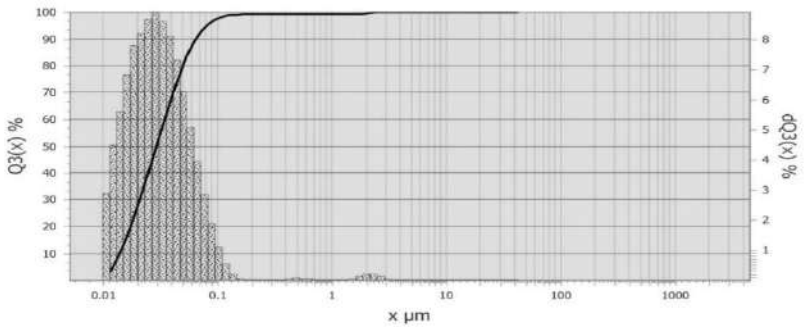

Figure 2. Graph of chitosan particle size distribution

Based on the data from the results of the PSA analysis that has been carried out, the particle size distribution data obtained and the average chitosan particle size is 51.11 nm.
The results of BET analysis showed that the surface area on areca nut shell activated carbon was 1067.975 (m^2/g) and areca nut shell nano chitosan-coated activated carbon showed that the surface area was 1512.092 (m^2/g), it can be seen in **Table 1**.

Table 1. The results of BET analysis

No	Sample	Surface Area (m^2/g)
1	Areca nut shell activated carbon	1067,975
2	Areca nut shell coated-nano chitosan activated carbon	1512,092

Analysis of adsorbent absorption of areca nut shell nano chitosan-coated activated carbon was carried out by applying 2.5 gram of adsorbent to 100 mL of wastewater sample. Then analyzed using AAS so that data is obtained as in **Table 2**.

Table 2. Adsorption of activated carbon and activated carbon coated with nano chitosan

Adsorbent	Sample mass (g)	Initial [Fe] (ppm)	Final [Fe] (ppm)	Efficiency (%)
Activated carbon coated with nano chitosan	2.5	24.68	3.67	86.26

Based on Table 2 it can be seen that the efficiency of activated carbon coated with nano chitosan was 86.26%. The liquid waste samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the liquid waste samples from a concentration of 24.68 ppm to 3.67 ppm. This reduction reached an absorption efficiency of 86.26%. Based on

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the wastewater quality standard which states that the total Fe is 5 ppm, the concentration of 3.67 ppm which has been reduced by the adsorbent is classified as safe wastewater.

Conclusion

The most effective composition formulation for nano chitosan-coated activated carbon adsorbent from shrimp shells is at a ratio of 2.5 g of activated carbon coated with 0.8% of nano chitosan where the formulation is able to absorb Fe metal in solution with an efficiency of 86.26%. The results of the FTIR characterization showed that there was a chitosan functional group in the nano chitosan sample at wave number 3345.89 cm^{-1} which is a functional group (–NH). The results of the characterization of PSA nano chitosan showed that the average distribution of nano chitosan particles was 51.11 nm. The results of the BET characterization of areca nut shell activated carbon was 1067,975 (m^2/g) and nano chitosan-coated activated carbon showed that the highest surface area was 1512.092 (m^2/g)**.** Wastewater samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the wastewater samples from a concentration of 24.68 ppm to 3.67 ppm. This reduction reached an absorption efficiency of 86.26%.

Acknowledgments

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Stability of the ditertiary butyl dithiophoshate (DTBDTP) ligan complex as an extractan for separation of rare earth elements based on molecular dynamics study

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Abstract. Rare Earth Elements (REE) have characteristics that are similar to each other, making it difficult to purify and separate them. Separation uses the complexing ligand di tertiary butyl dithiophosphate (DTBTDP) as an extractant in extraction. This research aims to determine which ligand has the highest selectivity and can be better distributed into the organic phase for REE separation through molecular dynamics studies. The computational methodology uses the molecular modeling program BIOVIA Discovery Studio 2016 including the preparation of DTBDTP and complex compounds with REE. Then the energy was simulated and optimized using the AMBER18 program. The simulation results show that the REE complex is still less stable as seen from the high bond length fluctuation values between the central REE and DTBTP and a more stable complex has not yet been formed.

Keywords: *Rare Earth Elements (REE), DTBDTP, Extraction, Molecular Dynamics, Complex Stability, BIOVIA Discovery Studio 2016*

Introduction

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Rare earth elements, as the name suggests, are very rare elements found in the form of complex compounds of phosphate and carbonate [1]. Rare earth elements are found together in nature, invarious minerals, such as bastnasite, monazite, xenotim, and others [2]. Rare earth elements have highly reactive properties towards water and oxygen, form stable compounds in oxide conditions, have relatively high melting points, and are high heat conductor materials [3]. Rare earth elements are needed for various technological applications. The level of need for rare earth elements is increasing over time. A number of technologies that use rare earth elements include are electronic technology, optoelectronics, superconductors, super-magnets, lasers, computers, portable hydride batteries, and glass and ceramic materials. Elemental production Rare earths worldwide reach 70,000 tons per year [4].

The elements La, Tb, and Lu are a type of lanthanide from the rare earth elements. Gd and Sm can be found in several types of rare earth metals, especially in monazite and bastnazite. This element has been isolated recently using solvent extraction and ion exchange techniques. Therefore, the extraction of metals La, Tb, and Lu continues to be developed to get better methods. This metal has the valence is in the form of 3+ ions (trivalent) which are the same as the metals La,Tb, and Lu, so when extracting the metals La, Tb, and Lu are still mixed a method is needed or other extracting ligands in order to separate the metal. However, its effectiveness and efficiency are still felt to be lacking [5]. Separation of rare earth element metals can be done using various separation methods, the other is by using a complex ligand. The ability of rare earth elements to form complex compounds with several ligands has been proven by several studies, such as using tertiary butyl dithiophosphate (DTBDTP) and di-butyl-dithiophosphate (DBDTP).

Ditertiary butyl dithiophosphate compounds can form complexes with a number of elements, especially the lanthanide group so that the ligand is dibutyl dithiocarbamate could be an option for the synthesis of complex compounds marked with the radioisotope 177Lu as a radioisotope tracer in the industrial sector. The advantage of the ligand containing long alkyl groups, such as butyl is inward extraction efficiency organic phase is higher compared to ligands containing alkyl groups shorter ones, such as ethyl or methyl. The longer the alkyl chain, the more its nature is increasingly non-polar so that complexes are formed more easily extracted to the organic phase. Lanthanide elements can form compounds neutral complex with dibutyl dithiocarbamate ligand and soluble either in the organic or oil phase [6].

Research about Gadolinium extraction with the DBDTP ligand has previously been carried out by several researchers. One of them was carried out by Taufan in 2008 who conducted research on the separation of gadolinium metal using the extraction method The solvent uses the DBDTP ligand, but the extraction efficiency results are poor obtained was 20.8%. The Ditertiary butyl dithiophosphate ligand is slightly soluble in water, but completely soluble in organic solvents so it can be concluded that this ligand has properties semi-polar, this is in accordance with what was expressed by Snell and Effrey (1976) that the longer the alkyl group in the dialkyl dithiocarbamate ligand, the Its polarity will decrease so it will dissolve more easily in solvents organic [7]. To overcome these difficulties, it is necessary to use a more selective extractant. Based on the explanation above, research will be carried out to compare DBDTP ligands as REE extractants (La, Tb, and Lu). To minimize costs and time, studies are used in computational chemistry of molecular dynamics. The study carried out tested LTJ complex (La, Tb, and Lu) with DTBDTP ligand by using two solvent simulations explicitly. Expected with Making this DTBDTP ligand will increase the extraction efficiency results obtained. One of the uses of computational chemistry is to model a molecular system that will be synthesized in the laboratory. Even though it's a model computing can't be perfect, but it can be very good to predict about 90% of reality. Molecular

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Dynamics (MD) or Dynamics Molecular is a computational technique in carrying out simulations over a period of time specific to observe the biological function of incapacitated proteins or nucleic acids observed experimentally. This is very useful because to synthesis of chemical compounds requires a lot of costs and raw materials, and can produce materials dangerous waste. In Molecular Dynamics simulations, time characteristics and length of the simulation an important thing to consider [8]. Another use is to understand chemical problems in more detail.

The system is heated to a certain temperature, equilibrated density, pressure, volume, and energy as well production is carried out during the desired time [10]. Some properties of molecules can be calculated more easily by computational means compared with the experimental method [9]. Steps that need to be considered before carrying out simulations are system preparation including molecules, ions, solvents, and ligands. Application of molecular dynamics to systems the solvent/solute allows this to be done calculation of system properties such as diffusion coefficients or a radial distribution function for use in statistical mechanics calculations. In general solvent/solute calculation scheme begins with a system consisting of a number of molecules with initial position and velocity. The main part of the methodology simulation is the availability of the potential energy function accurate way to model the properties of the system being studied. Potential energy functions can be constructed through quantum mechanical methods (Quantum Mechanics, QM) or molecular mechanics (Molecular Mechanics, MM) [11].

At stage preparation, adjustments are made as closely as possible to the circum stances of the experiment to be carried out, one of which is the physical properties the chemistry of the molecules to be simulated, the choice of solvent, and the type of water that will be used taken into account. Next, minimization is carried out energy for molecules to become stable. Therefore, it needs to be done carefully study of computational chemistry theory of molecular dynamics, to minimize costs and time. The study was carried out, namely testing the DTBDTP ligand complex with LTJ (La, Tb, and Lu) by using simulated water as a solvent explicitly to obtain the appropriate ligand for extracting La, Tb, and Lu. This research It is hoped that this will explain the mechanism of DTBDTP ligand selectivity towards ligands DTBDTP in the separation of rare earth elements (La, Tb, and Lu) to obtain recovery results better to increase efficiency extraction in the laboratory.

Method

Material

The materials used for this research are DTBDTP ligands and REEs complexes (La, Tb, and Lu) with DTBDTP ligands.

Instrumentation

These are divided into two groups, namely devices hard (hardware) and software (software). The hardware consists of a PC (Personal Computer) with specifications as follows: Core i7 CPU 980 @3.33 GHz 980 processor, 8GB RAM, NVIDIA Ge Force GTX GPU 980 4GB, 2 TB hard disk, and software used is Biovia Discovery Studio Visualizer 2016, AMBER18, Amber Tools 17, Linux operating system, Visual Molecular Dynamics (VMD).

Procedure

This method is a reconstruction modeling carried out by Saqib and Siddiqi [12].

Preparation of DTBDTP Ligand

The DTBDTP ligand structure was created using BIOVIA Discovery software Studio 2016 and energy optimization was carried out. The ligand structure created is then saved in pdb file format.

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Preparation of La, Tb, and Lu Complex Structures with DTBDTP Ligands

The ***DTBDTP*** ligand structure that was created was then connected to each central atom of La, Tb, and Lu using BIOVIA Discovery Studio 2016 software, and energy optimization was carried out and then saved in pdb file format.

Simulation of Molecular Dynamics of La, Tb, and Lu Complexes with Ligands and Three Waters

Molecular dynamics simulations were carried out on the La, Tb, and Lu complexes with the prepared *DTBDTP* ligands. The input file for the molecular dynamic simulation was prepared using the LEaP module and adding n-hexane as an organic solvent in AmberTools 17 which includes minimization, heating, equilibration, and production using the pmemd module in the AMBER 18 program. This simulation was carried out using explicit solvent for 100 ns with timesteps of 1 fs.

Analysis of Molecular Dynamics Simulation Results

An analysis of the results of molecular dynamics simulations of the La, Tb, and Lu complexes with DTBDTP ligands in a two-solvent system was carried out, including molecular dynamics trajectory analysis and visualization using VMD software. The results obtained were then compared with the results of donor atomic distance analysis, RDF, and energy of the La, Tb, and Lu complexes with DTBDTP ligands.

Results and discussions

Molecular Dynamics Simulation Results

Molecular dynamics simulations were carried out on the REE complex (La, Tb, and Lu) with the prepared DTBDTP ligand. Input files for molecular dynamics simulations were prepared using the LEaP module in AmberTools 17. Structure minimization was carried out using the AMBER18 program. Molecular dynamics simulations are carried out in several stages, namely input file preparation, parameterization, minimization, heating, equilibration, production, and analysis. Molecular dynamics simulations were carried out in this two-solvent system because this research will later be applied to extraction in the laboratory, so by carrying out this simulation, it is hoped that the stability, movement and distribution of the REE complex (La, Tb, and Lu) with the DTBDTP ligand in the water solvent and n-hexane can be observed. One of the advantages of molecular dynamics simulations is that water and organic solvent molecules can be added explicitly to the system. The organic solvent used is n-Heksane.

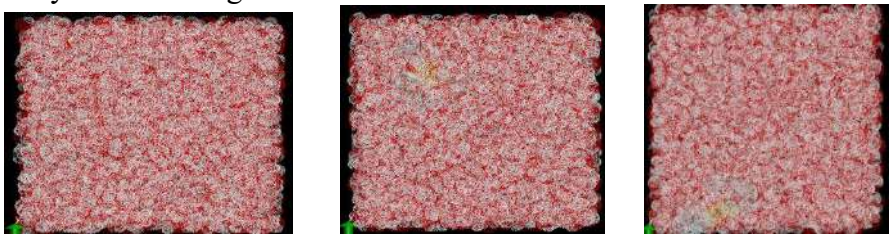

Figure 1. Molecular dynamics simulation in a water solvent system, (a) La- DTBDTP complex in water BOX, (b) Tb- DTBDTP complex in water BOX, (c) Lu- DTBDTP complex in water BOX

Next, the LTJ complex (La, Tb, and Lu) with the DTBDTP ligand was simulated for molecular dynamics which included minimization, heating, equilibration, and production using the pmemd

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module contained in the AMBER18 program package. Analysis of the results of molecular dynamics simulations was carried out for each REE complex structure (La, Tb, and Lu) with the DTBDTP ligand in a two-solvent system from themolecular dynamics trajectory using VMD software. The results obtained were then compared with the results of donor atomic distance analysis, RDF, and energy of the REE complex (La, Tb,and Lu) with the DTBDTP ligand.

1. RDF Analysis of REEs (La, Tb, and Lu) with DTBDTP Ligands

RDF (Radial Distribution Function) analysis was used to observe the distribution of REE complex compounds (La, Tb, and Lu) with the DTBDTP ligand. RDF or radial distribution is a function symbolized by g(r), defined as: $g(r) = \rho(r)/\rho$ where $\rho(r)$ is a molecular density and ρ is the total density. This function g(r) is the probability of finding the molecular contact distance (r) with a solvent. This RDF function will depend greatly on its density (ρ). If the molecular contacts have a high density, then the value of the distribution function g(r) will be high.

RDF analysis was chosen because it is more universal for finding out how to represent a molecule with more than one solvent system. Because the REE complex (La, Tb, and Lu) with the DTBDTP ligand does not form a stable complex, in this RDF analysis only the distribution of the central atom of the REE (La, Tb, and Lu) with the DTBDTP ligand in water and n-solvents is compared. hexane. The results are shown in the Figure Below.

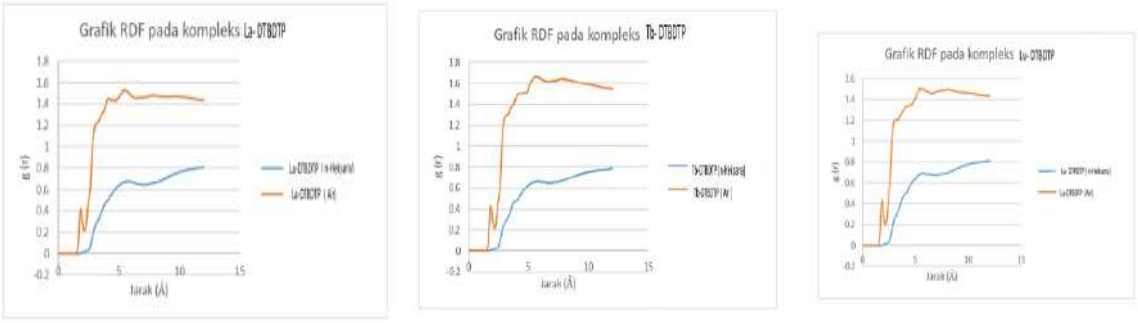

Figure 2 a. Comparison graph of RDF in La with DTBDTP ligand
b. Comparison graph of RDF in Tb with DTBDTP ligand
c. Comparison graph of RDF in Lu with DTBDTP ligand

Figures 2 (a) to (b) show that all REE's central atoms (La, Tb, and Lu) are more distributed in the water solvent compared to the organic solvent. Likewise, DTBDTP ligands are more distributed in water solvents compared to organic solvents. However, the difference in the distribution of the DTBDTP ligand is not too great, the difference is only around 0.45. This is because the DTBDTP ligand is slightly soluble in water but completely soluble in organic solvents. So, it can be concluded that the DTBDTP ligand has semi-polar properties.

2. Energy Analysis

Energy analysis was carried out to determine the stability of the REE complex (La, Tb, and Lu) with the DTBDTP ligand from the energy of the REE complex (La, Tb, and Lu) with the DTBDTP ligand. The DTBDTP ligand has the highest stability. In this energy calculation, the GBSA (Generalized Born Surface Area) method is used, which can be used to calculate the interaction energy of charges in solvent media and several terms on the surface, such as hydrophobic

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interactions, van der Waals interactions, and so on [13]. The results of energy calculations for the LTJ complex (La, Tb, and Lu) with the DTBDTP ligand are shown in the following table.

Table 1. Calculation of energy for the REE complex (La, Tb, and Lu) with th DTBDTP ligand using theGBSA (Generalized Born Surface Area) method

LTJ	Δ G (Kkal/mol)	Standard Deviasi	Standard Eror
La	98,23	8.65	1.00
Tb	-50.45	10.90	0.78
Lu	-75.01	13.25	0.60

From these results, it can be seen that the energy values of all complexes are relatively large. This is following the results of the distance analysis of the LTJ central atom (La, Tb, and Lu) with the S donor atom, so, indeed, this complex does not form a stable complex.

3. Distance Analysis of LTJ Center Atoms (La, Tb, and Lu) and S Atoms in DTBDTP Ligands

This analysis is carried out to determine how much movement the complex bond has between the central atom and the ligand. Analysis of the distance between the LTJ center atoms (La, Tb, and Lu) and the S donor atom in the DTBDTP ligand was carried out. If during the molecular dynamic simulation, the movement does not show significant fluctuations, then the REE complex compound (La, Tb, and Lu) with the DTBDTP ligand is a stable complex. Fluctuations in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DBDTC ligand can be seen in the following graph.

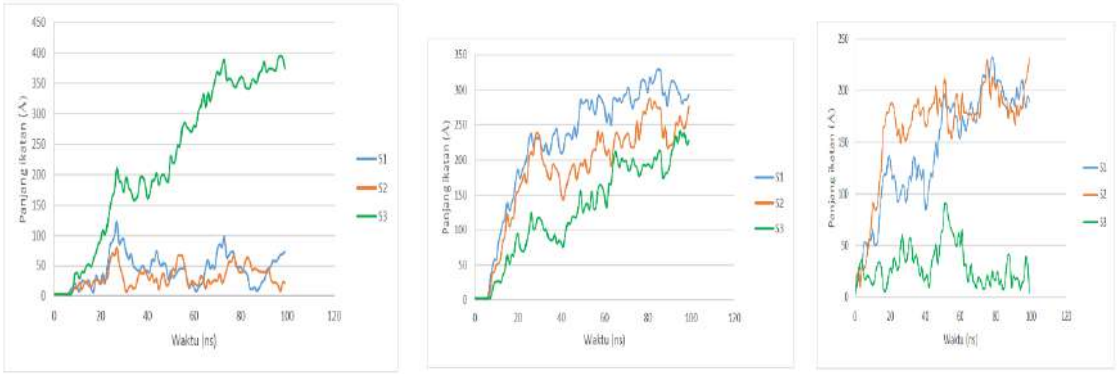

Figure 3 a. Distance graph between La-S in the La- DTBDTP complex. Simulation results for 100 ns
b. Distance graph between Tb-S in the Tb- DTBDTP complex. Simulation results for 100 ns
c. Distance graph between Lu-S in the Lu- DTBDTP complex. Simulation results for 100 ns

Figure 3 (a) to (c) shows changes in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DTBDTP ligand (Å) to time (ns). S1 refers to the S donor atom of DTBDTP ligand number 1. S2 refers to the S donor atom of DTBDTP ligand number 2, and S3 refers to the S donor atom of DTBDTP ligand number 3. Based on this graph, all LTJ complexes (La, Tb, and Lu) with the DTBDTP ligand do not form a stable complex. This can be seen from the high fluctuation in the distance of the LTJ central atom (La, Tb, and Lu) with the S donor atom in the DTBDTP Sligand. So, it can be concluded that in less than 10 ns, all the ligands have been released

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from the complex as indicated by the significant increase in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DTBDTP ligand. So, with these results, the LTJ complex (La, Tb, and Lu) with the DTBDTP ligand cannot form a stable complex and has experienced decomposition over the length of time of the molecular dynamics simulation.

Conclusions

1. It is predicted that the REE complex (La, Tb, and Lu) with the DTBDTP ligand and three waters can be used in the separation of rare earth metals because it is more efficient because it has greater stability compared to the REE complex with another ligand.

2. Predicted the selectivity of the REE complex (La, Tb, and Lu) with DTBDTP and three waters, in order from the least stable to the most stable, namely Lanthanum, Terbium and Lutetium, proven based on the bond energy value, namely 98.23; -50.45 and -75.01 Kcal/mol. So the smaller the radian size of the atom, the smaller the bond energy value and the more stable it is.

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Preparation and characterization of polystyrene sulfonate (PS-S) catalyst from styrofoam waste and its catalytic activity in palm oil hydrolysis

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Abstract. *The hydrolysis process is typically conducted under elevated temperatures and pressures, necessitating substantial expenses; thus, there is a demand for process innovation aimed at reducing energy consumption. Simultaneously, the escalating volume of Styrofoam waste poses challenges in terms of decomposition, leading to significant environmental repercussions. Consequently, specific strategies are essential to transform this waste into alternative, more beneficial products, such as a catalyst material for cation exchange resins via a sulfonation procedure. Within this investigation, a polystyrene sulfonate (PSS) catalyst was derived from discarded Styrofoam and subsequently utilized as a catalyst in the hydrolysis reaction of palm oil. The procedures entail the extraction of polystyrene from the styrofoam waste, the fabrication of a polystyrene sulfonate resin catalyst, and the evaluation of its efficacy in the palm oil hydrolysis process. The resultant PS-S catalyst exhibits a sulfonation degree of 21.34% with a cation exchange capacity of 2.166 meq/g. Analysis using FTIR spectroscopy reveals absorption peaks at 1215 and 1031 cm^{-1}, corresponding to the vibrational of the SO_3 bond in the sulfonate group. TGA results show that the sulfonation process increases the thermal resistance of PSS compared to unsulfonated polystyrene. The outcomes of the hydrolysis of palm oil unveiled a yield of 84.7%, comprising primarily palmitic acid (35.55%), oleic acid (33.32%), and lauric acid (23.86%).*

Keywords: cation exchange resin, hydrolysis, polystyrene, sulfonation, styrofoam

Introduction

Plastic packaging constitutes a significant share of total global plastic production. Expanded polystyrene (EPS), or styrofoam, derived from petroleum, is widely used for insulation and packaging. Its non-biodegradable nature poses an environmental hazard when disposed of improperly. In addition, burning this waste emits dangerous greenhouse gases. As a result, various initiatives, including recycling and waste conversion strategies, have been established to reduce this waste. Thus, developing efficient recycling methods for Styrofoam waste is very important. A promising strategy involves the synthesis of new materials through the conversion of chemical waste, in particular producing polystyrene sulfonate resin catalysts from styrofoam.

Sulfonation refers to the replacement of sulfonate groups in organic compounds using certain sulfonating agents. This process is seen as a viable method to increase the ion exchange capacity for polystyrene waste. Incorporation of sulfonic acid groups into polymers produces polystyrene sulfonate (PSS). PSS has applications in drug and heavy metal adsorption, biomass valorization, organic synthesis, flocculation, and photocatalysis [1]. Thus, investigating alternative applications for Styrofoam waste is a valuable strategy to reduce its global environmental impact. As a heterogeneous catalyst, PSS offers many benefits, including being environmentally friendly, non-corrosive, and reusable. Furthermore, the macroporous structure and sulfonic acid groups enhance its catalytic efficacy [2], [3].

In this discovery, PSS functions as a catalyst in the hydrolysis of palm oil. Palm oil is an important commodity in Indonesia, with annual production growth. Currently, Southeast Asia, particularly Indonesia and Malaysia, produces around 84% of global palm oil supplies [4]. Despite meeting domestic demand, most palm oil is exported as crude palm oil (CPO). To increase export value, it is very important to convert CPO into higher value-added products, thereby improving the economy. Hydrolysis of palm oil into fatty acids and glycerol is a strategic method to increase its economic value [5].

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The dominant hydrolysis technique is the Colgate-Emery method, requiring high temperature and pressure (250 °C and 50 atm) [6]. However, such conditions can cause decomposition of fatty acids, reducing product quality. Alternative methods using enzyme catalysts are advantageous because of their mild operating conditions. Nevertheless, enzyme applications face disadvantages, including longer reaction times and higher biocatalyst costs [7]. Consequently, the development of heterogeneous acid catalysts, especially polystyrene sulfonate-based catalysts, is necessary. Previous research by Luo et al. demonstrated that polystyrene catalysts with sulfonate groups showed effective catalytic performance in the hydrolysis of tannic acid, in addition to benefits such as easy separation, high stability and reusability [8].

Therefore, in this research, polystyrene sulfonate was synthesized from Styrofoam waste as a catalyst in the fatty acid hydrolysis process. These results are expected to be able to produce alternative catalysts with good catalytic activity and support the utilization of waste for more cost effective processes.

Material and Methods

Materials

The materials used in this study were styrofoam waste obtained from household disposal, the oil sample used was RBDPO (Refined Bleached and Deodorized Palm Oil). Other materials used are chloroform (E. Merck), sodium sulfate (E. Merck), methanol (E. Merck), dichloromethane (E. Merck), ethanol (E. Merck), sulfuric acid p.a 98%, nitric acid (HNO_3), distilled water (H_2O), sodium hydroxide (E. Merck), oxalic acid (E. Merck), and phenolphthalein indicator.

Preparation of Polystyrene from Styrofoam waste

Dissolve 10 grams of used styrofoam that has been cleaned in 100 mL of chloroform and then filter. The filtrate was purified by adding it slowly to a beaker containing 500 mL of methanol and then stirring continuously, until the temperature reached 40 °C. The polystyrene precipitate obtained was filtered and dried at 60 °C for 1 h.

Preparation of Polystyrene sulfonate by homogeneous sulfonation

A quantity of 10 grams of polystyrene was dissolved in 100 mL of dichloromethane solvent, then 100 mL of 98% H_2SO_4 was added. Homogeneous sulfonation was carried out using the reflux method with a heating temperature of 40 °C for 4 h. To stop the sulfonation process, the synthesized sulfonated polystyrene was added slowly into 600 mL of methanol. The solution formed was added slowly with boiling distilled water until a white precipitate formed. The remaining acid is neutralized with running water until no sulfate remains. PSS was dried at 60 °C for 1 h.

Hydrolysis

A predetermined amount of surfactant, deionized water, and catalyst were added to the flask. A certain amount of palm oil has been heated, poured into the flask. The reaction time is set to zero, when the desired temperature is reached. Experiments were carried out under various conditions of palm oil to water molar ratio (1.0 : 3.0-1.0 : 9.0), catalyst loading (0.30-0.50 g/g, based on palm oil weight), surfactant dosage (0.005-0.015 g/g, based on the weight of palm oil), and the reaction temperature at 100 °C. The resin catalyst is separated by filtration when the first stage of the hydrolysis reaction is completed. The precipitated fatty acid mixture shows two phases, the fatty acid-rich phase is at the top and the glycerol-rich phase at the bottom, and these two phases are

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separated with a separating funnel. The remaining fatty acid-rich phase was washed with hot deionized water (50 °C) under light stirring, until the pH value of the wash water was neutral. Then, the fatty acid-rich phase was evaporated under reduced pressure in a rotary evaporator (70 °C, 90 kPa) for 30 min to ensure that the remaining water was removed [9].

Characterization

PSS cation exchange resin was characterized by FTIR (Shimadzu), Thermal analysis was characterized with TGA Shimadzu Model DTG-60, and the degree of sulfonation and cation exchange capacity were calculated. Analysis of the degree of sulfonation (%DS) can be determined using the acid-base titration method [10]. A quantity of 0.2 g of polystyrene sulfonate cation exchange resin was dissolved in 20 mL of chloroform and stirred for 2 h while stirring continuously. Then titrated with 0.1 N NaOH in alcohol and added 1% phenolphthalein indicator in alcohol. Meanwhile, the ion exchange capacity was carried out by immersing the PSS in 1 N HNO_3 solution, then filtering, washing with distilled water at a temperature of 60 °C for 4 h. After drying, the PSS was weighed to a certain weight and soaked for 24 h in 100 mL of 0.05 N NaOH. Then, the mixture was filtered and the filtrate was titrated against a 0.05 N oxalic acid solution with phenolphthalein indicator.

Result and Discussion

Catalyst Preparation

PS is separated from Styrofoam waste using chloroform and precipitated in 5 times the amount of methanol as the solvent. The pure PS obtained is in the form of white colored fibers. After weighing, the yield was 98%. In this research, PSS cation exchange resin preparation was carried out using the homogeneous sulfonation method, which uses a reflux reactor system. After weighing, the yield was 99%. Cation exchange resin (PSS) is in the form of a white powder that is slightly yellow from the initial color, as shown in Figure 1. The degree of sulfonation of PSS was obtained at 21.34%, meaning that only around 21.34% of the benzene groups were substituted by sulfonate groups. The sulfonation of polystyrene waste demonstrated the substitution of the $-H^+$ radical by a strong acid resin functional group. The oxygen in sulfuric acid, due to its higher electronegativity, forms an electrophile by attracting an electron. Consequently, the polymer matrix undergoes attack, resulting in the formation of sulfonated polystyrene [11].

Meanwhile, the cation exchange capacity of PSS carried out in this research obtained a cation exchange capacity of synthesized polystyrene sulfonate of 21.66%. This shows the maximum number of meq cations that can be absorbed by 1 g of PSS heterogeneous catalyst under equilibrium conditions. The cation exchange capacity of the PSS heterogeneous catalyst is 2.166 meq/g.

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Figure 1. Stages of Polystyrene Preparation from Styrofoam waste: a) Styrofoam and b) Polystyrene (PS) c) Polystyrene Sulfonate Cation Exchange Resin

FT-IR analysis

Identification of PS and PSS functional groups was carried out using FTIR. in the wave number range 400-4000 cm^{-1}. A comparison of the FTIR spectra of the polystyrene catalyst before and after sulfonation is shown in Figure 2, and the vibrational interpretation is summarized in Table 1.

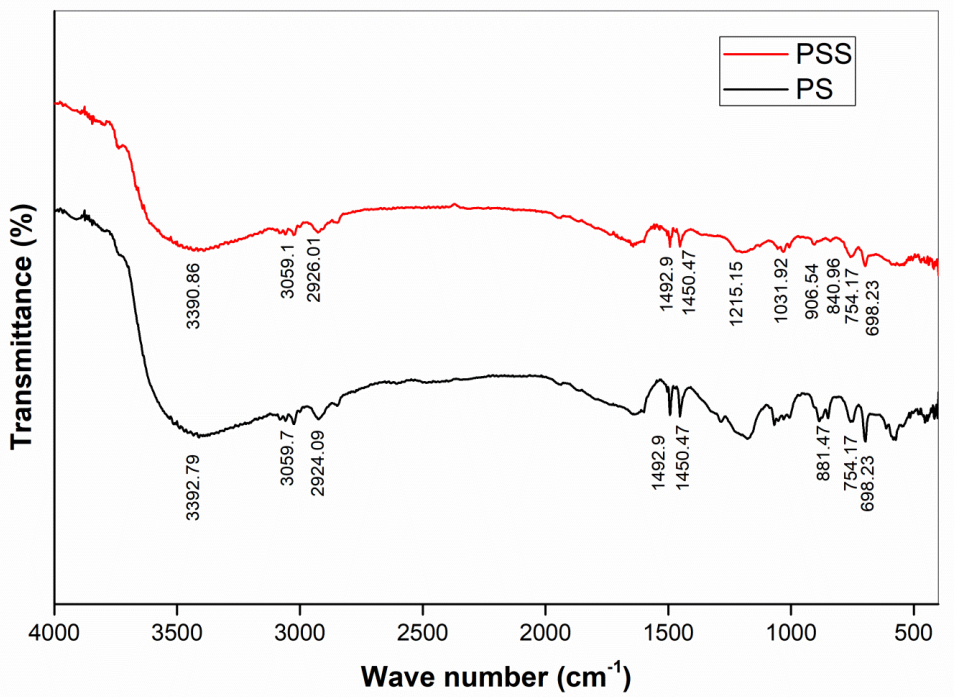

Figure 2. Comparison of FTIR spectra of PS and PSS

Table 1. Interpretation of IR spectra and vibration types of PSS catalysts

Wavenumber (cm^{-1})	PS	PSS	Interpretation
3200-3600	3392.79	3390.86	O-H
3010-3095	3059.7	3059.1	C H stretching vibration and in-plane bending vibration of benzene ring
2850-2970	2924.09	2926.01	stretching vibrations of the aromatic and aliphatic C-H groups
1452, 1492	1450.47, 1492.9	1450.47, 1492.9	skeletal stretching vibrations of the benzene ring
1190-1200		1215.15	asymmetric stretching modes of O=S=O
1000-1050	-	1031.92	symmetric stretching vibration of the $–SO_3^-$ ion
640-757	698.23, 754.17	698.23, 754.17	Benzene

Based on Figure 2, in general the FTIR spectra of PS and PSS catalysts show the presence of similar absorption peaks, especially the characteristic absorption of polystyrene. The broad band

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appears at wave number around 3200-3600 cm^{-1}, is the representative O-H stretching vibration in water. The existence of this absorption band is shown at the wave number 3392.79 cm^{-1} in PS, and 3390.86 cm^{-1} in PSS. Furthermore, the absorption band at 3059 cm^{-1} is attributed to the C-H stretching vibration, and at 2924.09 cm^{-1} (PS) and 2926.01 cm^{-1} (PSS) shows the stretching vibrations of the aromatic and aliphatic C-H groups **[12]**. The absorption bands at 698.23 cm^{-1} and 754.17 cm^{-1} are caused by the absorption of the benzene group. After experiencing sulfonation, there are several new absorption peaks that appear, namely at 1215 and 1031 cm^{-1}, each of which is an asymmetric stretching absorption mode of O=S=O **[8]** and symmetric stretching vibration of the $–SO_3–$ ion. This is in line with what was reported by Wang et al. **[2]**. Moreover, based on Manurung et al., Infrared absorption at 1034.95 cm^{-1} is a vibration due to the presence of C-H bonds on the benzene ring which is influenced by symmetrical vibrations of the sulfonate groups (S=O=S stretch) **[13]**. This also correlates with the report by **[14]**. The presence of this absorption band proves that the sulfonate group has been substituted into polystyrene. The band bound to para-substituted benzene (840 cm^{-1}) confirms the aromatic cycle substitution **[15]**. The emergence of $-SO_3H$ proves that sulfonated polystyrene resins can be exchanged and have the potential to be used as catalysts.

Thermal Analysis

Thermal analysis was carried out using TGA. A comparison of the TGA curves of the two catalyst samples is shown in Figure 3. Based on Figure 3, there are quite significant differences in the curves of the two catalyst samples. The PS catalyst appears to experience 3 times mass loss, namely in the temperature area <100 °C at 31.24%, 200-300 °C at 9.43%, and 300-500 °C at 53.6%. Meanwhile, the PSS catalyst appeared to only experience a significant mass decrease twice, namely at <100 °C by 20.73%, and at 300-500 °C by 60.33%. Mass decreases below 100°C due to dehydration and elimination of other volatile elements [16]. Meanwhile, the temperature range of 200-550 is the decomposition temperature of polystyrene [17]. There is also a significant difference in the mass of the sample at the end of the curve, namely at a temperature of 600 °C, where the PS catalyst has a final mass of 2.3%, while the PSS catalyst is 17%. This strengthens the notion that the sulfonation process has increased the crystallinity of the resin catalyst so that it has better thermal resistance compared to the initial polystyrene resin that was not sulfonated. This is in line with Wolska et al. who reported that dehydration combined with SO_3 elimination and consequently the crosslinked sulfones formation. Crosslinked polymers possessing $R–SO_2-R$ moieties are known for their high thermal stability [18].

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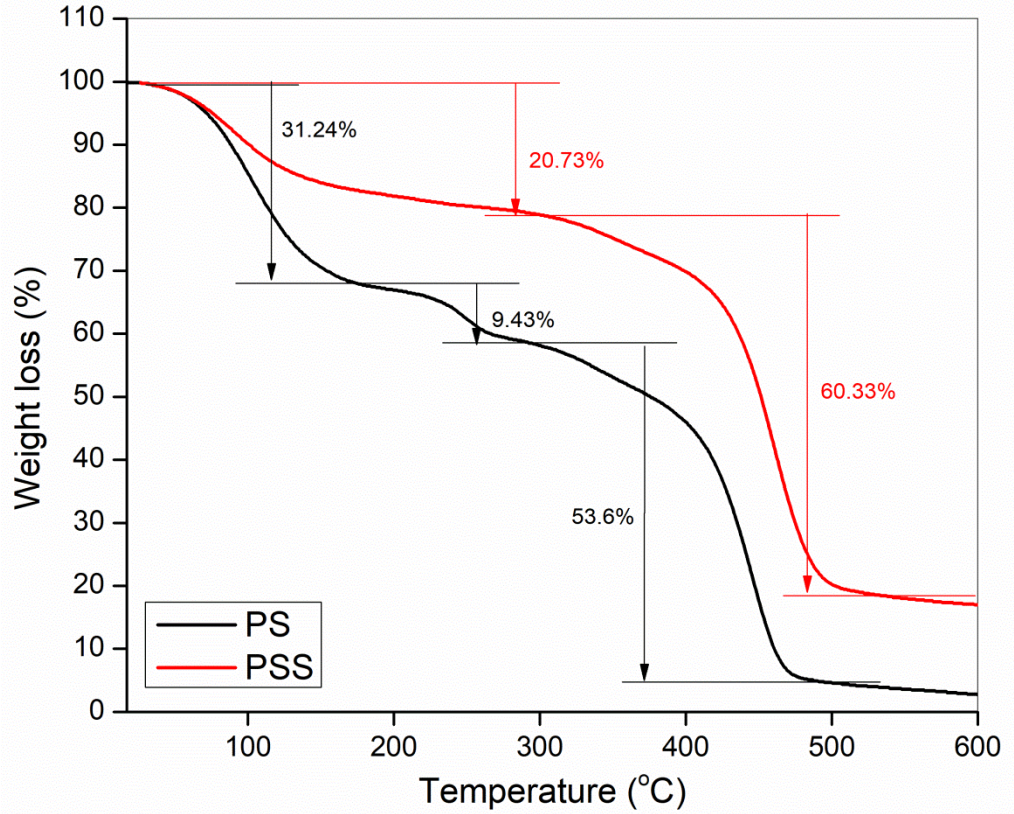

Figure 3. TGA curve of PS and PSS catalysts

Hydrolysis of RBDPO

The activity test of the PSS catalyst was carried out in the hydrolysis (splitting) reaction of fatty acids from palm oil (RBDPO). Catalyst activity is viewed from the performance of the catalyst in converting reactants into derivative products, namely fatty acids. The results of hydrolysis of palm oil obtained a yield of 84.7%. The resulting fatty acid products were further analyzed using GC-MS to determine the fatty acid content contained as shown in Figure 4 and summarized in Table 2.

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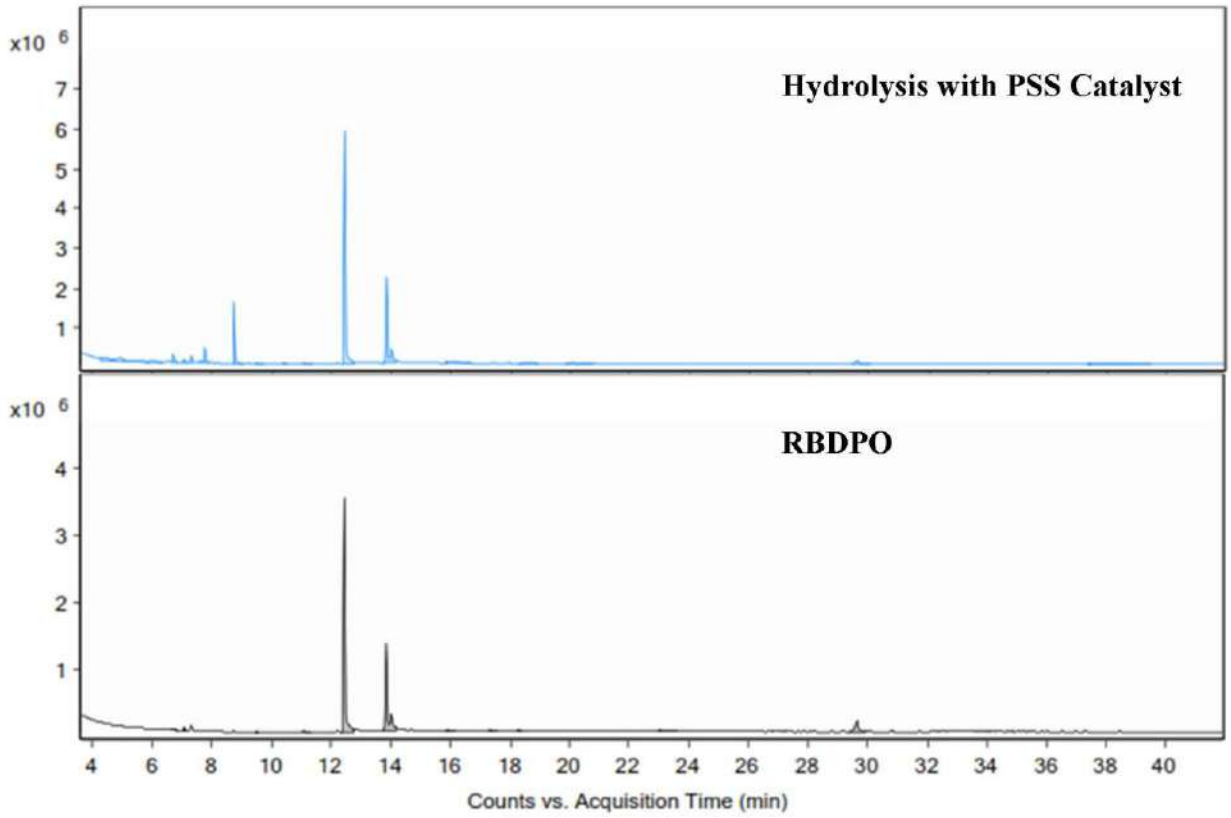

Figure 4. GC-MS chromatogram of RBDPO palm oil samples and hydrolysis products with a PSS catalyst

Table 2. Fatty acid content in RBDPO and hydrolysis products

Fatty acid type	Formula	RBDPO (%)	Hydrolysis product (%)
Palmitic acid	$C_{16}H_{32}O_2$	57.87	35.55
Oleic acid	$C_{18}H_{34}O_2$	32.59	33.32
Lauric acid	$C_{12}H_{24}O_2$	-	23.86
Total		**90.46**	**92.73**

Based on the results of GC-MS analysis in Figure 4, the fatty acid content in the initial sample changed after the hydrolysis process. The RBDPO sample was dominated by two types of fatty acids, namely palmitic acid (57.87%) and oleic acid (32.59%) with a total of 90.46%. After undergoing hydrolysis the total fatty acids increased to 92.73%. Apart from that, the fatty acid content changed with the lauric acid content amounting to 23.86%, while the palmitic acid content decreased to 35.55% and oleic acid increased to 33.32%. This change indicates that the triglyceride component has split into a fatty acid component with a smaller number of carbon atoms.

Conclusion

In this study, a polystyrene sulfonate (PS-S) catalyst was synthesized from discarded Styrofoam and employed in the hydrolysis of palm oil. The PS-S catalyst achieved a sulfonation degree of 21.34% and a cation exchange capacity of 2.166 meq/g. FTIR spectroscopy identified absorption peaks at 1215 and 1031 cm^{-1}, indicating the presence of the SO_3 bond in the sulfonate group. The

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emergence of -SO_3H proves that sulfonated polystyrene resins can be exchanged and have the potential to be used as catalysts. TGA findings indicate that sulfonation enhances the thermal stability of PSS relative to unsulfonated polystyrene. The hydrolysis of palm oil yielded 84.7%, primarily comprising palmitic acid (35.55%), oleic acid (33.32%), and lauric acid (23.86%). These results show good potential for the development of polystyrene sulfonate-based catalysts in the hydrolysis process of vegetable oils.

Acknowledgments

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The effect of storage time at room temperature on phytochemical screening and toxicity testing of acetone and ethyl acetate extracts of tinuktuk

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Abstract. *Tinuktuk is one of the Simalungun ethnic herbs consumed by postpartum mothers. Phytochemical screening and toxicity tests have been carried out to analyze the class of secondary metabolite compounds contained in tinuktuk and determine the toxicity potential of acetone and ethyl acetate extracts of tinuktuk. The stages of this study include phytochemical tests which include flavonoid, saponin, alkaloid, steroid/terpenoid, and tannin tests. Furthermore, toxicity tests of acetone and ethyl acetate extracts were carried out using the BSLT method. The results of phytochemical analysis on tinuktuk show that the acetone extract of tinuktuk contains flavonoids, saponins, terpenoids alkaloids, and tannins, while the ethyl acetate extract contains saponins, alkaloids, terpenoids, and tannins. The*

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results of toxicity testing of the LC50 value of the tinuktuk ethyl acetate extract at zero weeks storage was 32.878, five weeks storage was 42.942, and ethyl acetate extract of tinuktuk as a control at zero weeks storage was 32.357, at five weeks storage 42.681. While the LC50 value of the main tinuktuk acetone extract at zero weeks storage was 40.70052, at five weeks storage it was 49.511 and the tinuktuk as a control in acetone extract at zero weeks storage was 43.354, at five weeks storage it was 66.527. Thus, the ethyl acetate extract of tinuktuk has a lower LC50 value compared to the acetone extract of tinuktuk.

Keywords: Tinuktuk, Phytochemical Screening, Toxicity, Acetone, Ethyl Acetate

Introduction

Indonesia is a country with biodiversity, especially in terms of agricultural products and spices. This is supported by Indonesia's geographical situation which has a tropical climate with high average yearly rainfall. Indonesia has around 30,000 types of plants, and society generally uses around 800–1200 types of plants as raw materials for medicine [1]. Raw materials for medicinal plants come from various sources, most of which still depend primarily on natural forests, although several types have been cultivated. This needs to be an important note because it is estimated that around 80% of the world's people still use plants as a source of medicine, which means the need for medicinal plants tends to be high.

Spices and herbs are biological resources that have long been important in human life. Spices are parts of plants that are used as seasonings, flavor enhancers, fragrances, and limited food preservatives. Spices are plants or parts of plants that are aromatic and are used in food with the main function of providing flavor. A part from being related to food, spices have long been used as herbal medicine, cosmetics, and antimicrobials. Spices are plant parts that come from stems, leaves, bark, tubers, rhizomes, roots, seeds, flowers, or other parts of the plant body These plant body parts contain phytochemical compounds produced by plants as part of the plant's metabolic processes [3]. In general, herbs are plants that are well known and associated with their use in maintaining vitality and healthy growth as well as curing various diseases. Exploration of the potential of herbs as medicinal plants is currently increasingly confirming the important role of herbs now that they have been reported to have health benefits and an important role as medicinal plants.

Tinuktuk is generally recommended for all pregnant women because it is believed to have the ability to improve and reduce nausea and vomiting after giving birth. However, the use of this type of tinuktuk in the culture of the Simalungun tribe is starting to decrease due to the rapid progress of human knowledge in areas related to health and medicinal effects. The decline in the use of tinuktuk does not necessarily mean that the Simalungun community is less willing to accept the impacts it causes. Most Simalungun people understand that tinuktuk is very beneficial for their health. Unfortunately, many Simalungun people use treatment recommended by doctors because only a few people can make this type of tinuktuk and it is difficult to find them [4].

Phytochemical screening is a method used to study the active ingredients of compounds contained in a sample. This includes learning about chemical structure, biosynthesis, natural distribution, biological functions, isolation, and comparison of the composition of chemical compounds from various types of plants. Phytochemistry screening has revealed the presence of glycosides, triterpenoids, flavonoids, alkaloids, tannins, steroid, anthraquinones [5].

Geographical location, temperature, climate, and soil fertility of a particular region are important indicators of the presence of chemical compounds in a particular region. Plant samples used in

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phytochemical tests can include leaves, stems, fruit, flowers, and roots which have medicinal properties and are used as ingredients in modern and traditional medicine formulations [6].

Toxicity is one of the tests carried out to assess the safety of a chemical compound, both the compound itself and the compound contained in other materials such as food. Toxicity is defined as the study of the nature and mechanisms of the toxic effects of various substances on living creatures and other biological systems, the working mechanisms underlying toxic effects can usually be identified through various changes at the subcellular level. Parts that are potentially affected by toxicants are the nucleus, mitochondria, lysosomes, endoplasmic reticulum, other subcellular structures, and the plasma membrane. This mechanism can also be classified based on the chemical properties of various target molecules in the form of proteins, lipid coenzymes and nucleic acids. On the other hand, carbohydrates are rarely affected by toxicants [7].

Material

The ingredients used in this study included red ginger color, black pepper, zanthoxylum acanthopodium DC, galangal, etlingera elatior, shallots, garlic, candlenut, and Himalayan salt. Chemicals: Acetone, Ethyl Acetate, distilled water, Mayer's reagent, Dragendroff's reagent, Bourchardat's reagent, Hydrochloric Acid, Magnesium, Amyl Alcohol, $FeCl_3$ 1%, Anhydrous Acetate, and Sulfuric Acid

Methods

Making Tinuktuk

Tinuktuk production involves several stages. Dry ingredients like black pepper, zanthoxylum acanthopodium DC, and candlenut are roasted at 60 °C for 20 minutes. This process is repeated for each treatment variation. Red ginger, galangal, shallots, and garlic are peeled, washed, sliced, and ground. Etlingera elatior is washed, drained, and ground, with its juice used to grind shallots and garlic. Red ginger and galangal are ground with the shallot and garlic juice, then the juice is squeezed and collected. Ground black pepper, zanthoxylum acanthopodium DC, candlenut, shallot and garlic fibers, red ginger, galangal fibers, pressed water, and stir until well mixed. Himalayan salt is added and stirred again. The mixed tinuktuk is pounded again, with a ratio of red ginger to black pepper of 30:70.

Tinuktuk Extraction

The initial maceration process was carried out by weighing 50 grams of tinuktuk and put into an Erlenmeyer flask, then adding 300 ml of solvent (the ratio of tinuktuk to solvent is 1: 6). Manual shaking was carried out every 12 hours for 5 minutes during the maceration process, so the extract was still mixed with the solvent. Furthermore, the extract was filtered using coarse filter paper, producing filtrate I and pulp. Then the dregs were added to the solvent as much as 50 ml of stirred for 5 minutes, then filtered with coarse filter paper and produced filtrate II. Filtrate I and II were mixed and filtered with Whatman filter paper No. 1. The extract obtained was put into an evaporator flask to remove the solvent contained in the extract so that a thick extract was obtained. The results of mixing the two extracts were evaporated at a temperature of ± 40 °C with a pressure of 100 mBar. Evaporation was stopped when all the solvent had evaporated, which was indicated by the absence of solvent vapor droplets. The thick extract obtained was put into a sample bottle [8].

Screening Phytochemicals Compound Metabolites Secondary
Flavanoid Compound Group Test

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Take 0.5 grams of extract, and add two drops of 5% $FeCl_3$ solution. The occurrence of a color change to greenish or blue-black indicates the presence of flavonoids [9].

Saponin Compound Group Test

Take a sample of 0.5 grams and then put it in a test tube and add 10 ml of heated distilled water then cool it and shake it vigorously for 10 seconds, foam appears for no less than 10 minutes as high as 1-10 cm, 1 drop of 2N hydrochloric acid is added, if the foam does not disappear, it shows the presence of saponins [6].

Tannin Compound Group Test

A sample of 0.5 grams was taken and dissolved with 10 ml of aqudest, then filtered using filter paper. Furthermore, the filtrate obtained was taken as much as 2 ml and then added 2 drops of $FeCl_3$ reagent 1%. If a blue or blackish-green color is formed, it indicates the presence of tannins[7].

Alkaloid Compound Group Test

A 0.5-gram sample was weighed, then 1 ml of 2N hydrochloric acid and 9 ml of distilled water were added, heated in a water bath for 2 minutes, cooled, and filtered. Filtrate is used for alkaloid tests. Three test tubes were taken and 0.5 ml of filtrate was put into each test tube. The first tube added 2 drops of Mayer reagent, the second tube added 2 drops of Dragendorff reagent and the third tube added 2 drops of Bourchardat. The formation of a yellow precipitate in the first tube, an orange precipitate in the second tube, and a brown precipitate in the third tube indicate the presence of alkaloids [7].

Steroids/Terpenoids

Take 0.5 grams of extract added with 10 drops of anhydrous acetate then add 2 drops of concentrated sulfuric acid shake and wait a few minutes, the formation of red and purple colors indicates positive terpenoids, and the emergence of green and blue colors indicates positive steroids [7].

Toxicity Test

Larvae were prepared by taking 0.5 grams of A. salina Leach eggs and then hatched by immersing them in 1000 mL of artificial seawater, then irradiated using a 5-watt incandescent lamp for 48 hours. The artificial seawater used was made by dissolving 20 grams of salt into 100 mL of distilled water. The test solution was made by weighing 0.5 grams of extract to make a concentration of 2000 ppm dissolved in a 250 ml flask, then from the 2000 ppm test solution was diluted to produce concentrations of 800 ppm, 600 ppm, 400 ppm, 200 ppm, and 100 ppm [8].

Solutions with concentrations of 800 ppm, 600 ppm, 400 ppm, 200 ppm, and 100 ppm were put into different test tubes of 3 mL and 2 mL of artificial seawater with each concentration repeated 3 times. Then, 10 shrimp larvae that were 2 days old were added to each tube. The number of larvae that died at the concentration after 24 hours was calculated and compared with the control [8].

Percent mortality is calculated with the following formula:

$$\%\ death = \frac{number\ of\ deaths\ - number\ of\ control\ deaths}{initial\ larval\ count\ (10)}\ x\ 100\% \quad (10)$$

The LC50 value is obtained from the calculation of the linear regression equation, which is obtained from the log concentration as the X-axis and the percent mortality of A. Salina which is converted to the probit value as the Y-axis [8].

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Results and Discussion

Tinuktuk Extraction

The tinuktuk sample extraction process uses the maceration extraction method. The maceration process is a fairly simple extraction process or method without a heating system known as cold extraction. This method was chosen because the cold extraction method has many advantages compared to other extraction methods, including the procedures and equipment used being simple and thus being able to preserve natural materials that are not heat resistant

The solvent used in the maceration extraction method in this research is the semi-polar solvent ethyl acetate and acetone. Using the appropriate solvent is also very important because the correct solvent can bind the active substances contained in the sample. The solvents chosen were ethyl acetate and acetone because these solvents are semi-polar solvents that can dissolve semipolar compounds in cell walls such as flavonoids [10].

The duration of maceration is 24 hours with 3 repetitions. The longer the extraction time, the more likely it is for the solvent and the material to come into contact, so the extract yield can increase to the saturation point of the solution. However, a long extraction process can affect the amount of extract produced. Maceration time that exceeds the optimum causes a decrease in the content of the extracted compounds [11]. The samples were macerated using a brown bottle and covered with aluminum foil so that the solvent did not evaporate. Stored in a closed room and protected from exposure to sunlight. This process also requires occasional stirring to increase contact between the sample and the solvent so that the active compounds contained can be more efficiently released and dissolved into the solvent.

The maceration process in this study used a ratio of 1:6, namely a 220-gram tinuktuk sample, soaked using 1,320 mL of ethyl acetate solvent. And using 796 mL of acetone solvent using a tinuktuk sample of 132 grams. Maceration was carried out with 3 repetitions to maximize the process of extracting chemical compounds contained in the Tinuktuk sample. During the maceration process, the solvent is changed every day so that the secondary metabolite compounds in tinuktuk can be completely extracted until the color of the extract begins to fade and maximum ethyl acetate and acetone extract is obtained [12].

The extract obtained from the evaporation process was 19.235% ethyl acetate extract and 42.947% acetone extract. Yield is the comparison of the dry weight of the product produced with the weight of the raw material. A high yield value indicates the large number of bioactive components contained.

Phytochemical Screening

The evaporated thick extract was tested qualitatively with the aim of identifying secondary metabolite compounds contained in the sample.

Table 1. Phytochemical Screening Results of Flavonoid Group

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Greenish discoloration occurs
Ethyl Acetate Extract of Tinuktuk	-	-	-	-	-	-	Produces a yellow color

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Acetone Extract of Tinuktuk	+	+	+	+	+	+	Greenish discoloration occurs
Ethyl Acetate Extract of Tinuktuk as a control	-	-	-	-	-	-	Produces a yellow color

Its presence is indicated by the symbol (+) and its absence by the symbol (-).

Table 2. Phytochemical Screening Results of Saponin Group

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Froth does not disappear
Ethyl Acetate Extract of Tinuktuk	+	+	+	+	+	+	Froth does not disappear
Acetone Extract of Tinuktuk as a control	+	+	+	+	+	+	Froth does not disappear
Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	Froth does not disappear

Its presence is indicated by the symbol (+) and its absence by the symbol (-).

Table 3. Phytochemical Screening Result of Tannin Group

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Color change to blackish green
Ethyl Extract of Tinuktuk	+	+	+	+	+	+	Color change to blackish green
Acetone Extract of Tinuktuk as a control	+	+	+	+	+	+	Color change to blackish green
Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	Color change to blackish green

Its presence is indicated by the symbol (+) and its absence by the symbol (-).

Table 4. Phytochemical Screening Results of Alkaloid Group with Mayer Reagent

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Formation of yellow white precipitate
Ethyl Acetate Extract of Tinuktuk	+	+	+	+	+	+	Formation of yellow white precipitate
Acetone Extract of Tinuktuk as a control	+	+	+	+	+	+	Formation of a yellow-

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Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	white precipitate Formation of a yellow-white precipitate

Table 5. Phytochemical Screening Results of Alkaloid Group with Dragendorff Reagent

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Formation of the orange precipitate
Ethyl Acetate Extract of Tinuktuk	+	+	+	+	+	+	Formation of the orange precipitate
Acetone Extract of Tinuktuk as a control	+	+	+	+	+	+	Formation of the orange precipitate
Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	Formation of the orange precipitate

Table 6. Phytochemical Screening Results of Alkaloid Group with Bourchardat Reagent

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Formation of brown sediment
Ethyl Acetate Extract of Tinuktuk	+	+	+	+	+	+	Formation of brown sediment
Acetone Extract of Tinuktuk as a control	+	+	+	+	+	+	Formation of brown sediment
Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	Formation of brown sediment

Its presence is indicated by the symbol (+) and its absence by the symbol (-).

Table 7. Phytochemical Screening Results of Steroid/Terpenoid Groups

Extract sample	0th week	1st week	2nd week	3rd week	4th week	5th week	Description
Acetone Extract of Tinuktuk	+	+	+	+	+	+	Brown-black discoloration occurs
Ethyl Acetate Extract of Tinuktuk	+	+	+	+	+	+	Produces a reddish color
Acetone Extract of as a control	+	+	+	+	+	+	Brown-black discoloration occurs
Ethyl Acetate Extract of Tinuktuk as a control	+	+	+	+	+	+	Produces a reddish color

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Its presence is indicated by the symbol (+) and its absence by the symbol (-).

Flavonoid Group Compound Test

The test for the presence of flavonoid compounds was carried out by adding two drops of 5% $FeCl_3$ solution to 0.5 grams of sample in a test tube. The test results showed positive for the presence of flavonoids in the acetone extract and the ethyl acetate extract showed negative for the absence of flavonoids contained. Flavanoids are more soluble in acetone solvent because of their higher polarity compared to ethyl acetate. Ethyl acetate solvents that have semipolar properties are not effective in attracting flavonoid compounds that have polar properties and more effective acetone solvents that have the same polarity properties as flavonoid compounds, namely polar [13]. Flavonoids are one group of secondary metabolites and are one of the largest classes of phenol compounds produced naturally by plants. Flavonoids are polyphenolic compounds so they are mildly acidic and can dissolve in bases because polyhydroxy compounds are also polar. So it can dissolve in polar solvents such as methanol, ethanol, acetone, water, butanol, dimethyl sulfoxide, and dimethyl formamide. The presence of glycoside groups bound to flavonoid groups tends to cause flavonoids to dissolve in ethanol. Flavonoids are also solvents that dissolve compounds ranging from less polar to polar [14].

Saponin Group Compound Test

Test for the presence of saponin compounds is carried out by adding 10 ml of distilled water which is heated then cooled then shaken vigorously for 10 seconds, foam appears in no less than 10 minutes as high as 1-10 cm, add 1 drop of 2N hydrochloric acid, if the foam does not disappear it shows the presence of saponins. The test results showed positive for both solvent extracts because they produced foam for 10 minutes. Saponin has two groups with different properties, namely a hydrophilic group and a hydrophobic group. The addition of HCl to the saponin test causes an increase in the polarity of the saponin compound resulting in a change in the location of the constituent groups. In this situation, the polar (hydrophilic) groups will face outward and the non-polar (hydrophobic) groups will face inward and form a structure called a micellar structure. The foam produced in the saponin test is caused by the presence of glycosides which can form foam in water and hydrolyze into glucose and other compounds. This situation forms foam which is a sign of the presence of saponin compounds in the extract [15].

Tannin Group Compounds Test

Test for the presence of tannin compounds by adding 10 ml of distilled water, then filtering using filter paper. Next, 2 ml of the filtrate obtained was taken and then 2 drops of 1% FeCl3 reagent were added. If a blackish-blue or green color forms, it indicates the presence of tannins. The test results showed a positive blackish-green solution. The formation of a blackish-green color after adding $FeCl_3$ is due to the phenolic compounds contained forming complex compounds with Fe^{3+} ions [24]. Tannin is a macromolecular compound of polar polyphenol compounds. Generally, tannin compounds will dissolve in polar solvents. However, semi-polar solvents can attract tannin compounds in tinuktuk extract, it is suspected that the hydroxyl groups in tannin compounds can bond with methoxyl groups or hydroxyl groups in semi-polar solvents [16].

Test for Alkaloid Group Compounds

Test for the presence of alkaloid compounds by adding 1 ml of 2N hydrochloric acid and 9 ml of distilled water to the extracted sample, heating it over a water bath for 2 minutes, cooling it, and then filtering. The filtrate is used for alkaloid testing. Take 3 test tubes, then put 0.5 ml of filtrate into each test tube. In the first tube, 2 drops of Mayer's reagent were added, in the second tube 2

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drops of Dragendorff's reagent were added and in the third tube 2 drops of Bourchardat were added. The formation of a yellow precipitate in the first tube, an orange precipitate in the second tube, and a brown precipitate in the third tube indicates the presence of alkaloids

The test results showed positive in both solvent extracts, which was marked by the formation of precipitates, alkaloids are semi-polar compounds so in this sample the presence of these compounds was visible, the addition of HCl was carried out to attract alkaloid compounds in the extract because alkaloids are basic so the addition of an acid like HCl, salts will form so that the alkaloids will be separated from other components of plant cells which are also extracted by distributing them into the acid phase. The alkaloid test in this study used three reagents, namely Mayer's reagent, Bouchardat's reagent, and Dragendroff's reagent. Positive results for alkaloids in the Mayer test are indicated by the formation of white to yellow precipitates. The precipitate is thought to be a potassium-alkaloid complex. In making Mayer's reagent, a solution of mercury (II) chloride plus potassium iodide will react to form a red precipitate of mercury (II) iodide. If excess potassium iodide is added, potassium tetraiodomercurate (II) will be formed. Alkaloids contain nitrogen atoms which have lone pairs of electrons so they can be used to form coordinate covalent bonds with metal ions. In the alkaloid test with Mayer's reagent, it is estimated that the nitrogen in the alkaloid will react with the K^+ metal ion from potassium tetraiodomercurate (II) to form a potassium-alkaloid complex which precipitates. Positive results for alkaloids in the Dragendorff test are indicated by the formation of an orange precipitate. The precipitate is potassium-alkaloid. In making the Dragendorff reaction, bismuth nitrate is dissolved in HCl so that the hydrolysis reaction does not occur because bismuth salts are easily hydrolyzed to form bismuth ions (BiO^+). For Bi3+ to remain in the solution, acid is added to the solution so that the equilibrium will shift to the left. Next, the Bi^{3+} ion from bismuth nitrate reacts with potassium iodide to form bismuth (III) iodide which then dissolves in excess potassium iodide. Testing alkaloid compounds with the Dragendorff reagent uses nitrogen atoms to form coordinating covalent bonds with K+ ions which are metal ions. Positive results in the Bouchardat test are indicated by the formation of a brown precipitate. The precipitate formed occurs due to the presence of a coordinating covalent bond between the K+ metal ion and the alkaloid so that a potassium-alkaloid complex is formed which precipitates [25]. Bouchardate reagent contains potassium iodide and iodine [17].

Steroid/Terpenoid Compound Test

Test for the presence of Steroid/Triterpenoid group compounds by adding 10 drops of acetic anhydrous then adding 2 drops of concentrated sulfuric acid then shaking and waiting a few minutes, the formation of red and purple colors indicates positive terpenoids, the appearance of green and blue colors indicates positive steroids. The results of testing for steroid compounds, ethyl acetate extract, and acetone gave positive results.

The results of the phytochemical screening test showed that the extract of the test sample was not detected to contain steroids. In comparison, terpenoid compounds were detected in turmeric ethyl acetate extract, turmeric acetone extract, and turmeric ethanol extract. In addition, terpenoid compounds were also seen in the acetone extract of Lombok chili. Triterpenoids are compounds composed of long chains of C30 hydrocarbons which cause these compounds to be non-polar. Triterpenoid compounds with cyclic structures in alcohols, aldehydes, or carboxylic acids with OH groups cause these compounds to be semi-polar. In steroid and triterpenoid testing, compound analysis is based on the ability of the mixture to form a color with concentrated H_2SO_4 in acetic acid anhydride solvent. The results obtained showed positive results, with the formation of a turquoise ring indicating the content of steroid compounds and a brownish ring indicating the scope of triterpenoids [18].

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The introduction of acetic anhydride into the Liebermann-Burchard test facilitates air absorption and promotes acid oxidation in the presence of sulfuric acid. This is because the acid oxidation reaction is hampered if there is still water in the reagent. During testing of steroid compounds, ethyl acetate extract gave positive results. Specifically, the addition of acetic anhydride and concentrated sulfuric acid resulted in the formation of a green circle, this is in line with the findings of [19] Their research shows that the polarity and characteristics of ethyl acetate are consistent with steroid compounds, because steroids are lipid derivatives that are resistant to hydrolysis. The introduction of acetic anhydride into the Lieberman-Burchard test facilitates air absorption and promotes acid oxidation in the presence of sulfuric acid. This is because the acid oxidation reaction is hampered if there is still water in the reagent [20].

Toxicity Test

Toxicity tests are carried out using the BSLT method, a test that can detect the spectrum of bioactivity contained in crude plant extracts. Active compounds contained in plants are almost always toxic at high doses, therefore the killing power of active compounds against animal organisms can be used to screen plant extracts that have bioactivity and also monitor bioactive fractions during fractionation and purification. This toxicity test can be determined from the number of deaths of A. salina Leach larvae. Due to the influence of extracts or natural compounds on the given concentration. Brine Shrimp Lethality Test can show cytotoxicity and pharmacological activities such as antimicrobial, antioxidant, antitumor, pesticide, etc. This is a fast, cheap, reliable bioassay, and the results obtained are often associated with cytotoxic activity which is a key requirement for antitumor drugs [21]. The test animal used was Artemia salina because it has a response to chemical compounds similar to mammals, such as DNA-dependent RNA polymerase and this organism has a Na^+ and K+-dependent ATPase transport system [22]. An extract can be said to be toxic or potentially anticancer if it has an LC50 value (concentration capable of killing 50% of shrimp larvae) of less than 1000 ppm after 24 hours of contact time. In this study, the samples tested were ethyl acetate and acetone extracts from tinuktuk.

Tinuktuk extract solution was made into a stock solution of 2000 ppm by weighing 0.5 grams of extract. Then dilution was carried out with varying concentrations of the extract used for the toxicity test, namely 800, 600, 400, 200, and 1000 ppm, as well as a control of 0 ppm. The aim of making concentration variations was to determine the effect of several concentration variations on the death of A. Salina L. The control created was a control without extract. Furthermore, shrimp larvae that were 24 hours old were subjected to a toxicity test on each sample. Samples of the main tinuktuk and tinuktuk as a control in ethyl acetate extracts at zero weeks and five weeks and the main tinuktuk and tinuktuk as a control in acetone extracts at zero weeks and five weeks.

Table 8. Toxicity Test Results of Tinuktuk and tinuktuk's control in Ethyl Acetate Extracts

Sample	Concentration	Log Concentration	Number of Test Larvae	Number of dead larvae	Percent Mortality (%)	Probit Value	LC50
Ex. Ethyl Acetate T. T (Week 0)	800	2.903	30	30	100.000	8.719	32.878
	600	2.778	30	30	100.000	8.719	
	400	2.602	30	29	96.666	6.826	
	200	2.301	30	28	93.333	6.490	

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	100	2.000	30	28	93.333	6.490	
Ex. Ethyl Acetate T. T (Week 5)	800	2.903	30	30	100.000	8.719	42.941
	600	2.778	30	29	96.666	6.826	
	400	2.602	30	29	96.666	6.826	
	200	2.301	30	28	93.333	6.490	
	100	2.000	30	27	90.000	6.281	
Ex. Ethyl Acetate tinuktuk's control (Week 0)	800	2.903	30	30	100.000	8.719	32.357
	600	2.778	30	29	96.666	6.826	
	400	2.602	30	29	96.666	6.826	
	200	2.301	30	28	93.333	6.490	
	100	2.000	30	27	90.000	6.281	
Ex. Ethyl Acetate tinuktuk's control (Week 5)	800	2.903	30	30	100.000	8.719	42.681
	600	2.778	30	28	96.666	6.490	
	400	2.602	30	28	96.666	6.490	
	200	2.301	30	27	90.000	6.281	
	100	2.000	30	26	86.666	6.107	

Table 9. Toxicity Test Results of Aceton Extracts of Tinuktuk and tinuktuk as a control

Sample	Concentration	Log Concentration	Number of Test Larvae	Number of dead larvae	Percent Mortality (%)	Probit Value	LC50
Ex. Aceton Tinuktuk (Week 0)	800	2.903	30	29	96.667	6.826	40.7005
	600	2.778	30	28	93.333	6.490	
	400	2.602	30	2	90.000	6.281	
	200	2,301	30	27	90.000	6.281	
	100	2.000	30	27	86.667	6.108	
Ex.Aceton Tinuktuk (Week 5)	800	2.903	30	28	93.333	6.490	49.512
	600	2.778	30	27	90.000	6.281	
	400	2.602	30	26	86.667	6.107	
	200	2.301	30	26	86.667	6.107	
	100	2.000	30	25	83.333	5.966	
Ex. N-hexane Tinuktuk's control (Week 0)	800	2.903	30	28	96.667	6.826	43.3541
	600	2.778	30	29	93.333	6.491	
	400	2.602	30	28	86.667	6.108	
	200	2.301	30	26	83.333	5.967	
	100	2.000	30	25	83.333	5.966	
Ex. N-hexane Tinuktuk's control (Week 5)	800	2.903	30	28	93.333	6.491	66.527
	600	2.778	30	27	90.000	6.282	
	400	2.602	30	25	83.333	5.966	
	200	2.301	30	24	80.000	5.8416	
	100	2.000	30	23	56.6667	5.7257	

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Total mortality (mortality) was calculated by adding up the larvae that died for each concentration. The average larval death is the result of the total number of larval deaths at each concentration divided by the total number of larval deaths at each concentration divided by the total number of initial larvae at the same concentration. The concentration calculation is obtained by averaging the deaths at each concentration multiplied by 100% [23].

The mortality of Artemia salina Leach larvae in each test tube for each concentration of tinuktuk extract is shown in the table.

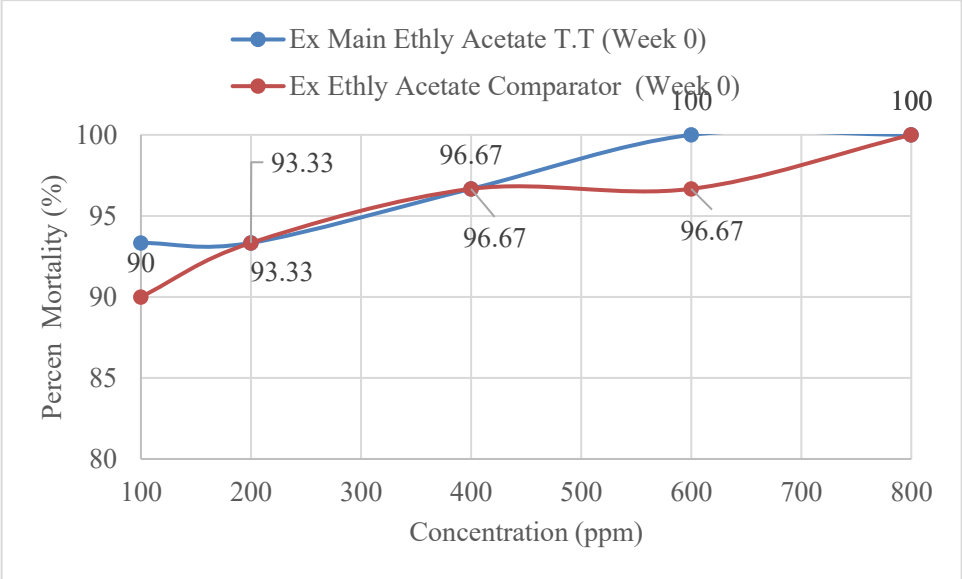

Figure 1. Relationship Graph of Tinuktuk Ethyl Acetate Extract Concentration In Week 0 and Percent Mortality

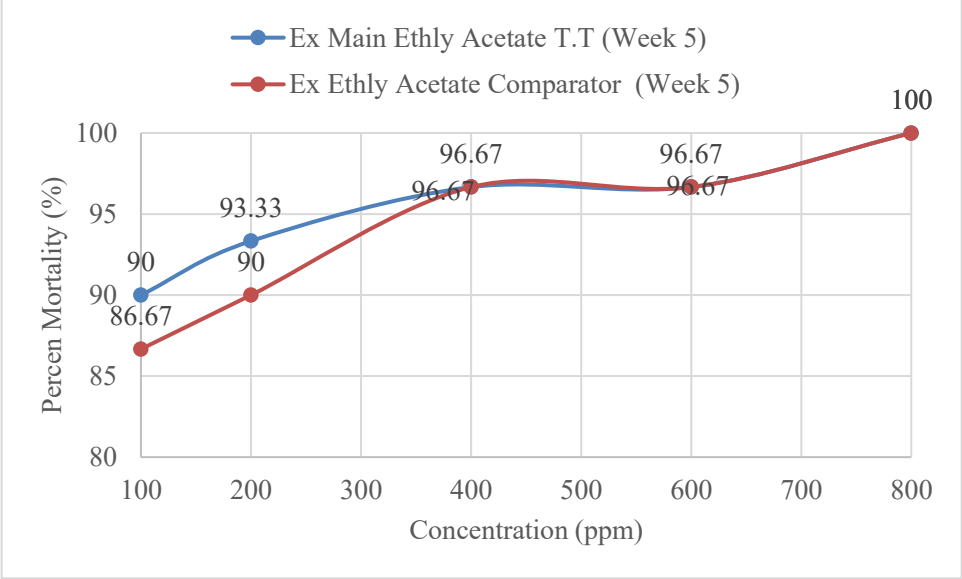

Figure 2. Graph of the Relationship between the Concentration of Tinuktuk Ethyl Acetate Extract in Week 5 and Percent Mortality

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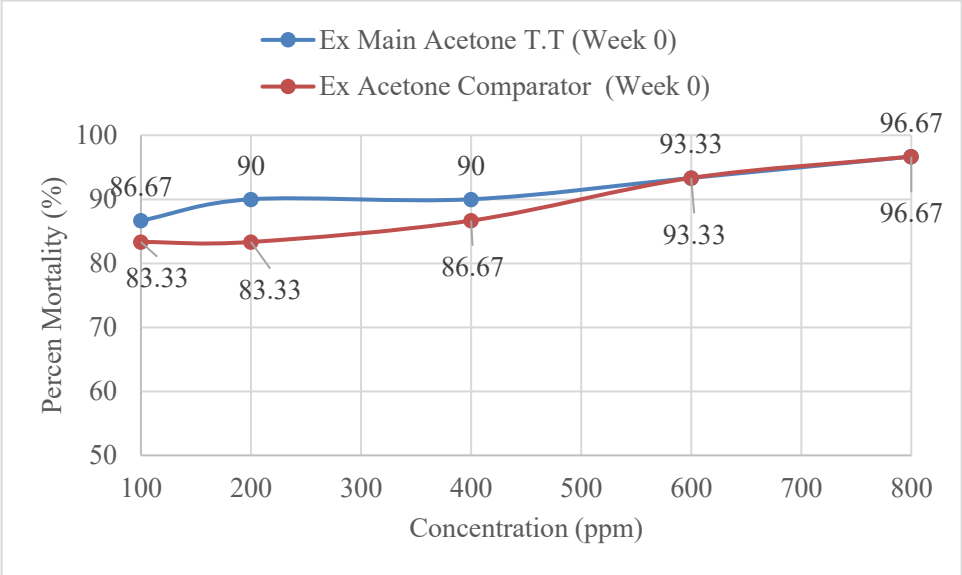

Figure 3. Relationship Graph of Acetone Extract Concentration of Tinuktuk in Week 0 and Percent Mortality

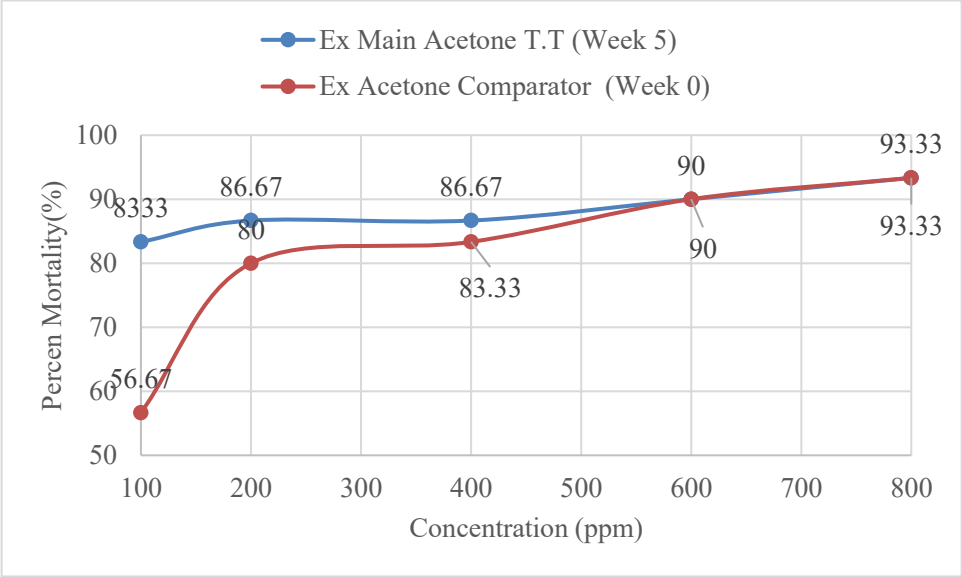

Figure 4. Graph of Relationship between the Concentration of Tinuktuk in Acetone Extract in Week 5 and Percent Mortality

The 4 graphic images, show that the higher the ppm concentration of ethyl acetate and acetone tinuktuk extract, the greater the number of deaths from Arthemia Salina L. Ethyl acetate and acetone extracts are said to be toxic because the LC50 values obtained in the Tinuktuk in ethyl acetate extract at week 0 storage were 32.878 and in week 5 were 42.942, and the tinuktuk's control in ethyl acetate extract at week 0 storage was 32.357 and in week 5 it was 42.682. And in the tinuktuk in acetone extract at week 0 storage the LC50 value was 40.701 and at week 5 it was 49.512, In tinuktuk's control in acetone extract at week 0 storage, the LC50 value was 43.354 and in week 5 was 66.527.

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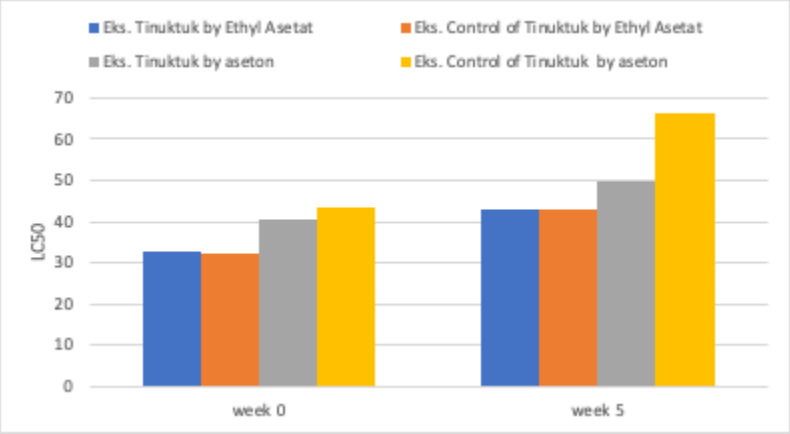

Figure 5. Relationship Graph of Storage Duration of Tinuktuk to LC50

By carrying out the BSLT test, the exact LC50 value of tinuktuk extract can be determined, an acute toxicity parameter based on probit analysis. LC50 is the concentration of a chemical compound in the air or in the air that can cause 50% death in a population of test animals or certain living creatures. If the LC50 value is less than 1000 µg/ml it is said to be toxic, conversely, if the LC50 value is greater than 1000 µg/ml it is said to be non-toxic. The level of toxicity will give meaning to its potential activity as an anticancer. The lower the LC50 value, the more toxic a compound is.

From the LC50 value of tinuktuk extract, it can be seen that all ethyl acetate and acetone extracts of tinuktuk at zero weeks of storage and five weeks of storage are toxic to A. Salina L. shrimp larvae because they have LC50 values < 1000 ppm. Based on the sequence of LC50 values of Tinuktuk extract with zero weeks of storage, the Tinuktuk extract has a smaller LC50 than the Tinuktuk as a control. Based on the sequence of LC50 values of tinuktuk extract for five weeks of storage, it shows that the tinuktuk extract has a greater LC50 compared to the tinuktuk as a control [24].

The existence of these toxic properties is closely related to the compounds contained in the acetone and ethyl acetate extracts of tinuktuk such as flavonoids, saponins, steroids, alkaloids, and tannins. Flavonoid compounds function as inhibitors of tumor or cancer proliferation by inhibiting protein kinase activity and inhibiting signal transduction pathways from the cell membrane into the cell nucleus. alkaloid compounds act as tubulin inhibitors that inhibit protein polymerization into microtubules so that the cell cycle stops at metaphase which causes cells to undergo apoptosis. Saponin compounds experience antibacterial mechanisms by reducing the activity of digestive enzymes and food absorption (stomach poisoning), while tannin compounds in anticancers as stomach poison make enzyme activity by the formation of protein complex bonds to sulfate enzymes that can cause digestive disorders and damage cell walls [24].

Conclusion

There was no effect of storage time on the phytochemical compounds of both ethyl acetate and acetone extracts because no changes occurred during the phytochemical screening test from zero weeks, one week, two weeks, three weeks, four weeks, and five weeks of storage.

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Ethyl acetate solvent has a lower LC50 value compared to acetone solvent. The LC50 value of the main tinuktuk ethyl acetate extract at zero weeks of storage was 32.878, at five weeks of storage was 42.942 and the tinuktuk's control in ethyl acetate extract at zero weeks of storage was 32.357, at five weeks of storage was 42.681. Meanwhile, the LC50 value of the main Tinuktuk acetone extract at zero weeks of storage was 40.7001, at five weeks of storage 49.512, and the Tinuktuk's control in acetone extract at zero weeks of storage was 43.354 and at five weeks of storage was 66.527.

Acknowledgments

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Combination of extracted secang (caesalpinia sappan l), ginger (zingiber officinale), and mint leaves (mentha piperita l) in inhibiting the growth of breast cancer cells (MCF7)

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Abstract. *Breast cancer is one of the main causes of cancer death among women. Efforts to search for effective and safe therapies to treat breast cancer continue, including exploring the use of natural ingredients. C. sappan, Z. officinale and M. piperita L are plants that have been used in traditional medicine. The aims of this study is to evaluate effect of the mixture of C. sappan L, Z. officinale and M. piperita L extracts in inhibiting the growth of MCF7 breast cancer cells. The method of anticancer activity was analyzed by means of Microculture tetrazolium (MTT) assay. The ratio of combination of C. sappan, Z. officinale, and M. piperita L extracts are (1) 3 : 5 :1 and (2) 5 : 3 : 1. The results showed that the two combinations of C. sappan, Z. officinale and M. piperita L extracts showed moderate activity, with the best activity shown in a ratio of 3: 5: 1 with IC_{50} 68.42 (µg/mL). The combination of C. sappan, Z. officinale and M. piperita L leaf extracts showed promising potential as a complementary therapeutic strategy for breast cancer treatment.*

Keywords: *C. sappan* L; *Z. officinale*; *M. piperita* L; MCF7

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Introduction

Malignant tumors or cancer is one of the diseases with a high mortality rate worldwide. In Indonesia, according to a report released in December 2020 on the official WHO website, through the International Agency for Research on Cancer (IARC), the number of cancer cases reached nearly 400,000, with almost 10 million deaths recorded in 2020. According to data from the Indonesian Ministry of Health in 2022, the incidence rate of cancer in Indonesia is 136 cases per 100,000 people [1]. Women are at a higher risk for cancer, with breast cancer, cervical cancer, and lung cancer being the most prevalent types diagnosed [2].

Cancer treatment typically involves chemotherapy, surgery, and radiotherapy; however, these methods often result in various side effects. Therefore, there is a need for alternative treatments that do not have adverse effects. One preventive or therapeutic approach that can be pursued is natural substance-based therapy. Plants are a rich source of chemical compounds that can be utilized for various medicinal purposes. Secang (*Caesalpinia sappan*), ginger (*Zingiber officinale*), and mint leaves (*Mentha piperita* L) are three natural ingredients known to possess various biological effects.

The secang plant (*Caesalpinia sappan L.*) is known for its bioactivity, exhibiting properties such as antioxidant and antimicrobial effects [3-5]. Importantly, extracts from secang wood also demonstrate cytotoxic properties against 4Ti breast cancer cells [6]. Ginger (*Zingiber officinale Roscoe*) is one of the most widely used spices in various food and beverage recipes. Ginger has multiple functions, including antioxidant, anti-inflammatory, antimicrobial, anticancer, antiobesity, antidiabetic, antinausea, antiemetic, antiallergic, neuroprotective, hepatoprotective, cardiovascular protective, and respiratory protective properties [7]. The bioactive components of *Z. officinale Roscoe* are primarily attributed to its essential oil compounds, such as gingerol, shogaol, and zingerone. The mint plant *(Mentha piperita L.*) is an aromatic herb widely used for room fragrance, food decoration, and medicinal purposes. *M. piperita L*. exhibits biological effects, including antioxidant, antimicrobial, antiviral, anti-inflammatory, biopesticidal, larvicidal, anticancer, radioprotective, genotoxic, and anti-diabetic activities [8]. Therefore, natural substance-based therapy is increasingly gaining attention as an alternative or adjunct in breast cancer treatment. *C. sappan L., Z. officinale Roscoe, and M. piperita L*. are three natural ingredients known to possess various biological effects that may be beneficial in cancer therapy.

Materials And Methods

Sample Extraction

C. sappan L, Z. officinale, and M. piperita L were obtained from a herbal medicine store. The samples were extracted using ethanol. The extracts were concentrated using a rotary evaporator. Subsequently, three combinations of extracts from *C. sappan L, Z. officinale, and M. piperita L* (CZM) were prepared in the following ratios: (1) 3:5:1 and (2) 5:3:1. Cisplatin at a concentration of 16.24 µM was used as the positive control.

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Cytotoxic Activity Testing

The cytotoxic activity was assessed using the MTT assay method [9]. The MCF7 breast cancer cells were cultured in Roswell Park Memorial Institute Medium (RPMI) (Gibco 11875-093). Subsequently, the combinations of concentrations of *C. sappan L, Z. officinale Roscoe, and M. piperita L* extracts were applied to these cells. Cisplatin (EDQM C2210000) was used as the positive control. The absorbance was measured using a Multimode Reader (Tecan Infinite M200 PRO) at wavelengths of 595 and 600 nm. The percentage of cell viability was determined from the obtained absorbance data using the formula.

$$\text{cell viability (\%)} = + \frac{(\textit{absorbance of treated cell} - \textit{absorbance of the media control})}{\textit{absorbance of control cells} - \textit{absorbance of the media control}} \times 100\%$$

The IC_{50} value was obtained from the linear regression equation $y=a + bx$. The graph was plotted with the concentration of the test samples (ppm) on the x-axis and the percentage of viability on the y-axis.

Results and discussion

The MTT assay is a method for assessing cytotoxicity. Cytotoxicity testing using cell culture is an important indicator for evaluating the toxicity of a substance or compound. The principle of the MTT assay method involves measuring the formed formazan crystals. Formazan crystals are purple, water-insoluble crystals. The formation of formazan crystals results from the reaction between MTT salt and the succinate dehydrogenase system found in the mitochondria of living cells.

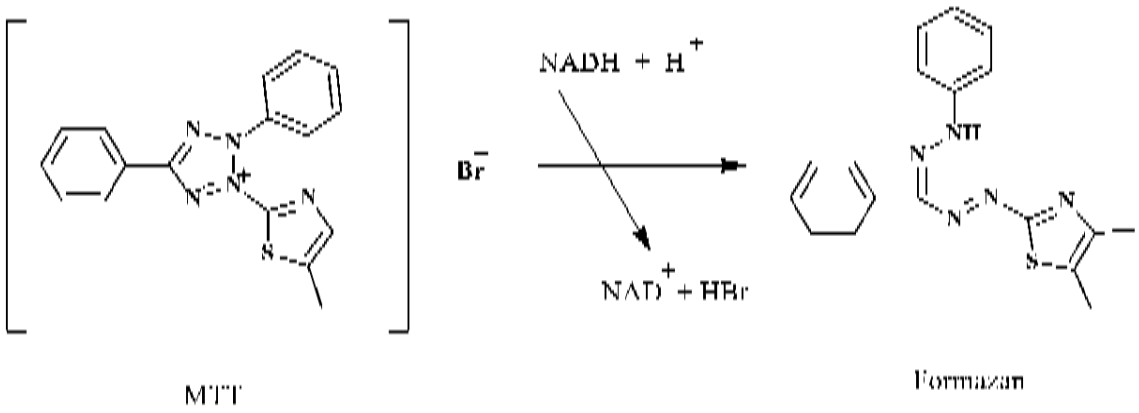

Figure 1. Reaction of MTT Reagent in Formazan Crystal Formation

The number of active cells undergoing metabolism is directly proportional to the purple color formed [10]. The following color changes occur in a 96-well plate, which can be observed through its absorbance values at a wavelength of 570 nm for pink and 600 nm for blue. As the concentration

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increases, the color in the medium becomes more intense. This is due to the reaction that leads to the formation of purple formazan crystals. Living cancer cells can produce moreformazan crystals than dead cancer cells.

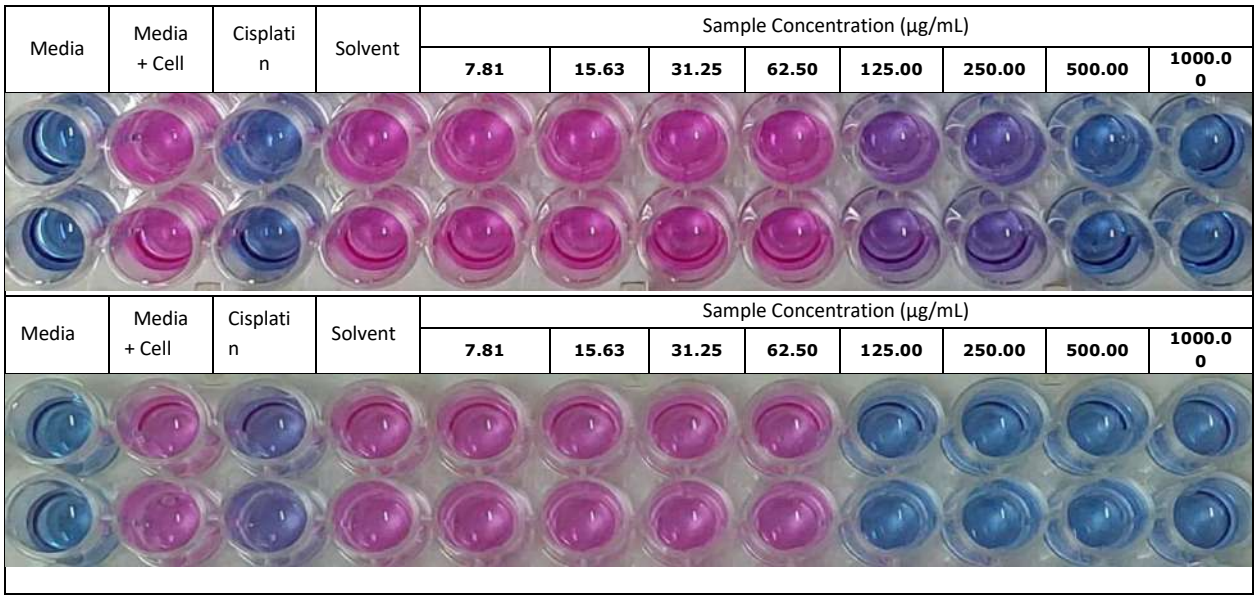

Figure 2. Documentation of Well Plate Results for Samples CZM-351 (a) and CZM-531 (b)

The results of absorbance measurements of the combinations of *C. sappan L, Z. officinale Roscoe, and M. piperita* against breast cancer cells at ratios of 3:5:1 and 5:3:1 are summarized in Table 1 and 2.

Table 1. Absorbance Results for Sample CZM-351

	Media	Media + Sel	Cisplatin	Solvent	Sample Concentration (µg/mL)							
					7.81	15.63	31.25	62.50	125.00	250.00	500.00	1000.00
Absorbance 570nm	0.5479	0.8672	0.6123	0.8112	0.8869	0.8788	0.8690	0.8567	0.6861	0.6588	0.6144	0.5426
	0.5615	0.8706	0.6103	0.8495	0.8950	0.8799	0.8673	0.8591	0.6872	0.6590	0.6158	0.5455
Absorbance 600nm	0.6345	0.1835	0.5836	0.2232	0.1850	0.1852	0.1984	0.2380	0.4422	0.4691	0.6231	0.6359
	0.6559	0.1851	0.5868	0.2395	0.1815	0.1853	0.1987	0.2309	0.4482	0.4659	0.6265	0.6392
Difference of Absorbance	-0.0866	0.6837	0.0287	0.5880	0.7019	0.6936	0.6706	0.6187	0.2439	0.1897	-0.0087	-0.0934
	-0.0944	0,6855	0.0235	0.6100	0.7135	0.6946	0.6686	0.6282	0.2390	0.1931	-0.0107	-0.0937
% of living cells		112.28	17.29	98.40	114.93	113.72	110.39	102.86	48.50	40.64	11.86	-0.42
		112.55	16.53	101.60	116.61	113.87	110.09	104.24	47.78	41.13	11.57	-0.46
Rate % of living cells		112.41	16.91	100.00	115.77	113.79	110.24	103.55	48.14	40.89	11.72	-0.44
SEM		0.13	0.38	1.60	0.84	0.07	0.15	0.69	0.36	0.25	0.15	0.02
Data Normalization % of Living Cells		112.41	16.91	100.00	115.77	113.79	110.24	103.55	48.14	40.89	11.72	-0.44

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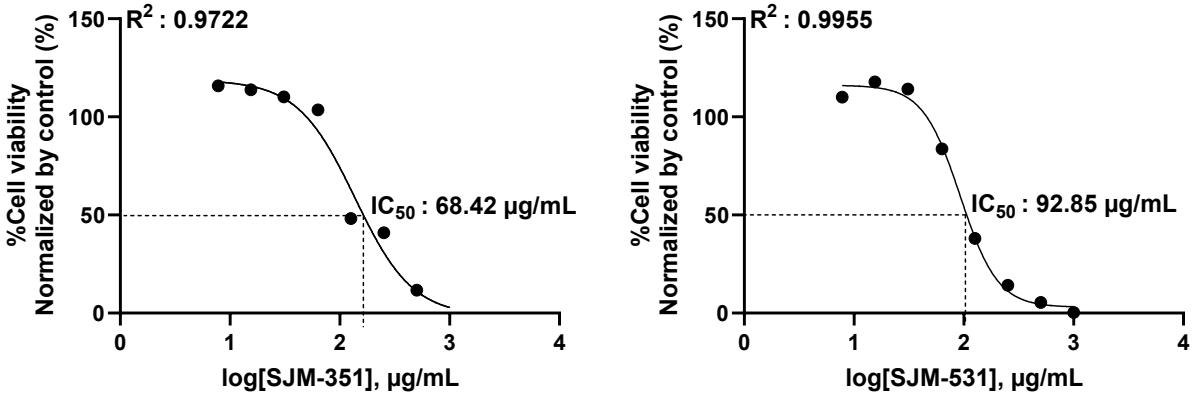
Table 2. Absorbance Results for Sample CZM-531

	Media	Media + Sel	Cisplatin	Solvent	Sample Concentration (µg/mL)							
					7.81	15.63	31.25	62.50	125.00	250.00	500.00	1000.00
Absorbance	0.577	0.8514	0.6156	0.8424	0.8503	0.9279	0.8910	0.7961	0.6811	0.5866	0.5467	0.5464
570nm	0.5654	0.8750	0.6226	0.8409	0.8517	0.9009	0.8977	0.8224	0.6704	0.6041	0.5644	0.5400
Absorbance	0.6490	0.1844	0.5833	0.2395	0.1803	0.1903	0.1966	0.3181	0.5148	0.5685	0.6015	0.6382
600nm	0.6610	0.1893	0.5891	0.2431	0.1812	0.1908	0.1944	0.3267	0.4950	0.6127	0.6219	0.6311
Difference of	-0.0913	0.6670	0.0323	0.6029	0.6700	0.7376	0.6944	0.4780	0.1663	0.0181	-0.0548	-0.0918
Absorbance	-0.0956	0.6857	0.0335	0.5978	0.6705	0.7101	0.7033	0.4957	0.1754	-0.0086	-0.0575	-0.0911
% of living cells		109.61	18.12	100.37	110.04	119.78	113.56	82.7	37.44	16.08	5.57	0.24
		112.30	18.30	99.63	110.11	115.82	114.84	84.92	38.75	12.23	5.18	0.34
Rate % of living cells		110.95	18.21	100.00	110.07	117.80	114.20	83.64	38.09	14.15	5.38	0.29
SEM		1.35	0.09	0.37	0.04	1.98	0.64	1.28	0.66	1.92	0.19	0.05
Data Normalization % of Living Cells		110.95	18.21	100.00	110.07	117.80	114.20	83.64	38.09	14.15	5.38	0.29

Note: The concentration of Cisplatin used in the test was 43.18 µM.

Based on the data in Table 1 and 2, a graph was created plotting the log of concentration against cell viability.



(a) (b)

Figure 3. Graph of (a) SJM-351 and (b) SJM-531 Sample Test Result

Based on the graph in Figure 3, the IC_{50} values were determined as 68.42 µg/mL for the CZM-351 combination and 92.85 µg/mL for the CZM-531 combination. When IC_{50} values are between ≥ 30 µg/mL and < 100 µg/mL, the activity is categorized as moderate [11]. Thus, all combinations of *C. sappan L, Z. officinale Roscoe, and M. piperita* exhibit moderate anticancer activity, with the best IC_{50} found in the 3:5:1 combination ratio. Compared to the cytotoxic activity of individual extracts against MCF7 cells, methanol extract of *C. sappan L* has shown an IC_{50} value of 48 µg/mL [12], *Z. officinale Roscoe* of the Fulbaria variant showed an IC_{50} of 34.8 µg/mL [13], and aqueous

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extract of *M. piperita* exhibited cytotoxic effects with an IC50 of 45 ± 1.5 µg/mL [14], all indicating moderate activity. Therefore, the combination effect does not increase activity, as it remains in the moderate range. Although the activity is categorized as moderate, cell morphology observations using a microscope (Figure 4) at a concentration of 62.5 µg/mL showed nearly all cells dead, indicated by reduced cell density, bright cell appearance, and disrupted or slightly blurred cell membranes.

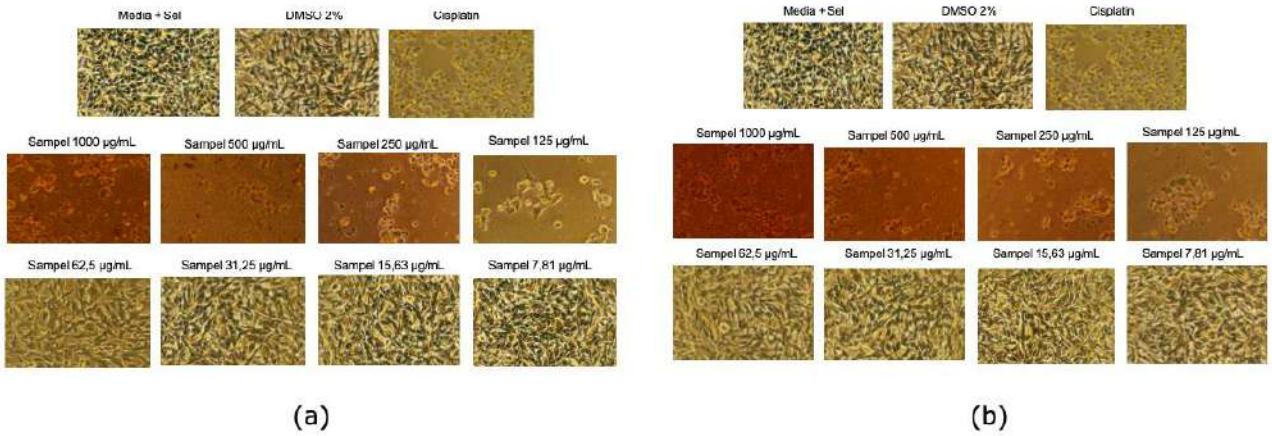

Figure 4. Documentation of MCF-7 Cell Morphology for CZM-351 (a) and CZM-531 (b) Sample Testing

The anticancer activity of *C. sappan L, Z. officinale Roscoe, and M. piperita* is due to their secondary metabolites. *C. sappan L* contains brazilin and brazilein as its main components, which are flavonoids with a homoisoflavonoid structure [15]. Flavonoid compounds have various mechanisms to inhibit cancer cells. Brazilin inhibits cancer cell growth by inducing apoptosis and inhibiting cell proliferation [16].

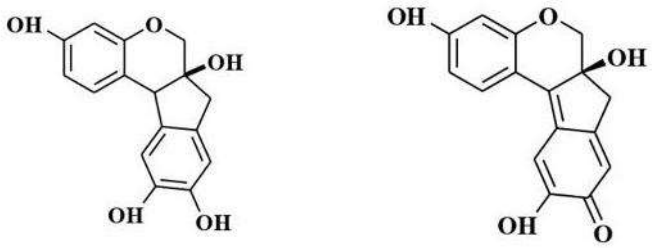

Figure 5. Structure of Brazilin (a) and Brazilein (b)

Z. officinale Roscoe contains gingerol and shogaol as its main components, which impart the spicy flavor to ginger. Gingerol and shogaol are homologous phenolic ketone compounds.

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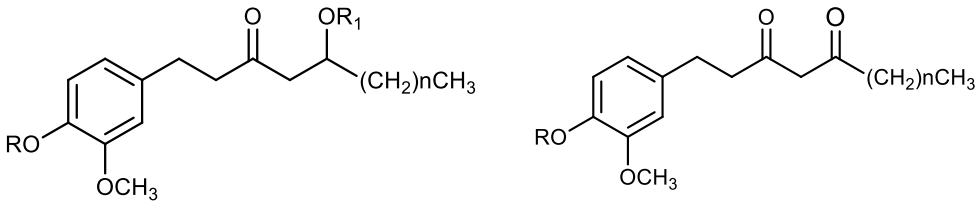
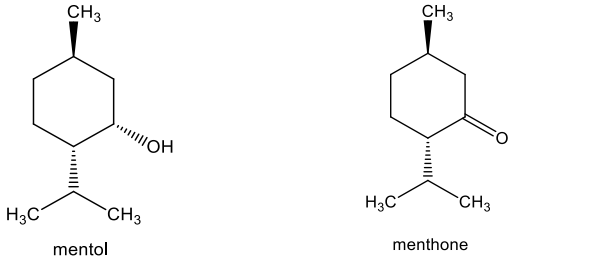


(a) (b)

Figure 6. Structure of Gingerol (a) and Shogaol (b)

Gingerol is unstable at high temperatures and will dehydrate to form shogaol, with 6-shogaol being the primary form [7]. The mechanism of action of 6-shogaol on breast cancer cells involves the induction of paraptosis, a non-apoptotic pathway effective in cancer cell death [17-18]. Other studies have shown that 6-shogaol exhibits anticancer activity against breast cancer by inhibiting the reduction of cell invasion through metalloproteinase-9 [19], 2. Additional findings indicate that 6-gingerol stimulates apoptosis by increasing the regulation of NAG-1 cell cycle arrest and G1 phase regulation through downregulation of cyclin D1 [20-21]. Meanwhile, the main components of the essential oil from *M. piperita* leaves are menthol (35-55%) and menthone (15-30%), which are terpenoid compounds.



(a) Menthol (b) Menthone

Figure 7. Menthol and Menton Structure

Terpenoid compounds can inhibit cancer cells through various mechanisms. Menthol has been shown to exhibit cytotoxic activity by inhibiting cell proliferation, inducing apoptosis, and promoting autophagy through the activation of caspase cascades, modulating BAX and p53/MDM2, and regulating autophagy via the ATG3/mTOR signaling pathway [22].

Data on the combination of *C. sappan* L, *Z. officinale* Roscoe and *M. Piperita* extracts shows anticancer activity against MCF 7 cancer cells. Therefore, the combination of these three herbal ingredients can be used as a complementary ingredient in the treatment of breast cancer.

Conclusion

The combination of *C. sappan* L, *Z. officinale Roscoe* and *M. piperita* extracts with a ratio of 3: 5: 1 showed moderate cytotoxic activity against MCF7 breast cancer cells.

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The production of bioethanol from durian (*durio zibethinus*) seed using simultaneous saccharification fermentation (SSF)

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Abstract. Durian is one of the commodities in the North Sumatera Province, whose after-use wastes, such as durian seeds, can cause pollution on the land. This research investigates efficient ways to produce bioethanol from durian seed. The method implements simultaneous saccharification and fermentation. Bioethanol hopefully can be made into renewable energy. In the previous project, we also attempt to produce bioethanol from durian seed using separate hydrolysis and fermentation. In the current project, the first step is to prepare durian seed flour. The second step is focused on determining the cellulose level in durian seed flour. In this case, the cellulose level is around 2.98%. Bioethanol production employs alpha-amylase enzyme. The last stage of bioethanol production is the distillation and adsorption of water using adsorbent. The distillation is performed in many cycles to gain a higher

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purity of bioethanol. Finally, bioethanol is tested using Jones reagent, giving a bluish color solution indicating the presence of ethanol in the solution. The experiments demonstrate that the adsorption enhances water removal.

Keywords: (Bioethanol, renewable energy, Durian Seed, Hydrolysis using Enzyme)

Introduction

Along with the times, the fulfillment of energy needs is increasing along with population growth. Today's energy use is largely dependent on fossil fuels to facilitate activities in many sectors, such as household, transportation, industrial, commercial, agricultural, and other sectors [1]. Petroleum as one of the fossil fuel energy sources and its non-renewable nature has an important role in running the wheels of daily human life. According to the International Energy Institute, oil production in Indonesia in 2019 was 781 thousand million barrels per day. However, in 2020, production decreased to 742 thousand barrels per day. Oil production continues to decline until 2023, the production will be 638 thousand million barrels per day. Meanwhile, petroleum consumption has increased from 2019 by 1584 thousand barrels per day to 2023, petroleum consumption will reach 1604 thousand million barrels per day [2].

To overcome the energy source crisis in the future, more environmentally friendly energy sources such as bioethanol have been developed. In general, bioethanol is widely used as a raw material in the chemical industry, antifreeze components in radiators, the alcoholic beverage industry, fuel oil and disinfectants. Bioethanol is also able to be an octane booster, meaning that alcohol can increase the octane value with a positive impact on fuel efficiency and save engines. Another function is as an oxygen generating agent, because it contains oxygen so that it completes combustion with a positive effect of minimizing air pollution, even bioethanol functions as a fuel extender that can save the use of fossil fuels.

Bioethanol (C_2H_5OH) is a liquid ethanol produced by fermentation using vegetable raw materials. Bioethanol can be made from biomass containing sugars, starch, or cellulose that has been processed into glucose. Ethanol or ethyl alcohol is a colorless liquid that is volatile, flammable, water-soluble, non-carcinogenic, and in the event of pollution does not have a significant environmental impact. Bioethanol has advantages when compared to fuel oil, including having higher oxygen of 35% while BM of 16.6% so that it can burn perfectly, has a high octane number of 18 while BM is 8 and has a CO_2 emission content of 0.89% while fuel is 2.5% so that the use of bioethanol is more friendly.

Due to the accumulation of organic waste, there is an idea to increase economic value of organic waste [3]. One of the organic wastes that of concern in North Sumatera is durian seed. It is interesting if the durian seed can be converted to something more expensive in price. The carbohydrate content in durian seed is around 46%. This is an indication durian seed flour can be processed into bioethanol [4]. There are several parameters in the process of bioethanol conversion that can be modified. The parameter of reaction that needed to be focus on are fermentation duration, pH, the types of bacteria, and the hydrolysis agent. There is study of using different types of bacteria such as saccharomyces cerevisiae and aspergillus niger. Raju et al indicated that the yield of bioethanol related to the starch content in durian seed [5]. Serr et al concluded that there are optimum pH and temperature for production of bioethanol from durian seed [6]. The implementation of ultrasonic wave and enzyme also useful in bioethanol production from durian

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seed [7]. Ginting et al indicated that hydrolysis of durian seed flour can be done by using sulfuric acid [8].

This project is working on making bioethanol from durian seed using simultaneous hydrolysis and fermentation (SSF). This method is utilized enzyme for the hydrolysis process and for the liquefaction process. In this project the enzyme used is enzyme alfa amylase and enzyme glucoamylase. The purpose of this project is to see whether there is an improvement in the bioethanol quality if enzyme is employed. The characterization methods are using FTIR (Fourier Transformation Infra-Red) and GC-MS (Gas Chromatography and Mass Spectrometry).

Experimental Set Up

The method for producing bioethanol from durian seed is simultaneous saccharification and fermentation (SSF). The first step is sun dried the clean durian seed and diminished until small particle. Hence the sample preparation resulted in durian seed flour (DSF). The durian seed flour will undergo several steps before the bioethanol is acquired. The first step is liquefication process. In this process enzyme alfa amylase will be utilized to process the durian seed flour. The purpose of liquefication is to mix the durian seed flour and alfa amylase enzyme at low temperature and the resulting product is starch. The temperature used is around 80-90℃. The second step is saccharification. In this proceed glucose-amylase enzyme is used. Saccharification is a process to convert carbohydrate in this case durian seed flour into simple glucose. The third step is the fermentation. The saccharification result from the durian seed flour is then fermented using saccharomyces cerevisiae that already in immobilized form. The fourth step is to purify the fermented solution using simple distillation. The distillation is followed by adsorption process. In this project, there are two types of adsorbents that used. The adsorbent used are CaO and activated Carbon. The purified bioethanol is then followed by determination of the physical characteristics and identification of the functional group using FTIR and GC-MS.

Results and Discussions

In this paper the focus is making bioethanol from durian seed flour and followed by physical characterization, functional group identification and further analyze bioethanol using GC-MS. The process of creating durian seed flour is also explained. Figure 1 show the sample preparation of durian seed flour. The drying process only under the sun and took around 7 days to be entirely dry. Before the drying process, the durian seed need to be clean. The purpose of cleaning is to make sure there is no more durian meat presence. The creation of durian flour is to validate the next process. The smaller the durian seed particle, the easier for the enzyme to digest it. This is like surface area theory. Enzyme is basically a catalyst, and enzyme will be more effective if the particle is smaller.

There are two types of enzymes used in this procedure. Furthermore, enzyme alfa amylase and enzyme glucoamylase work together so that the breaking of the carbohydrate is more effective. The motivation of using alfa amylase is to convert longer chain carbohydrate into a shorter chain. This process is followed by using enzyme glucoamylase that can convert terser chain into glucose. Combining two enzymes will help the fracturing process of carbohydrate and the glucose is formed. Before the hydrolysis process, the reducing sugar percentage and the cellulose level is determined. The process to measure reducing sugar is called Lane-Eynon method [9]. In the Lane-

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Eynon method the durian seed flour is mixed with copper sulfate and methylene blue. The mixing solution is then titrated with standard sugar solution. The volume of sugar solution needed to make the mixing solution change color is the end point. The end point is used to compute the reducing sugar level. The reducing sugar for durian seed flour is around 0.45% and the percentage of cellulose is 2.98%. Both numbers concluded that durian seed flour is mainly consist of starch. Hence no delignification process is needed. This is also the reason of using enzyme alfa amylase.

Figure 1. The making of durian seed flour.

Figure 2 exhibits the three steps of producing bioethanol. First the making of starch with the help of enzyme alfa amylase and followed by saccharification and fermentation. In the saccharification, glucoamylase enzyme is used. Previous project, durian seed flour was hydrolyze using sulfuric acid. The FTIR result from bioethanol with acid as a hydrolysis agent is not good. The peak that corresponds to C-C bond is missing [8].

In the fermentation process, the immobilized cell of saccharomyces cerevisiae (IM saccharomyces cerevisiae) is used [10]. IM saccharomyces cerevisiae will have a longer lifetime compared to free cell of saccharomyces cerevisiae. After the fermentation, the process will be followed by distillation and adsorption by CaO and activated carbon. It is concluded that the most suitable adsorbent is CaO. The activated carbon adsorbs less compared to CaO. This is also proven by the density value. Using activated carbon, the density is 0.967 $\frac{g}{nL}$ whereas using CaO, the density is 0.879 $\frac{g}{mL}$. The density of bioethanol with activated carbon is close to the density of water. The density value is a sign that the bioethanol is not pure enough.

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Figure 2. The three process of producing bioethanol.

Figure 3 exhibits the positivity test of bioethanol. The process is utilizing Jones Reagent that contained $K_2Cr_2O_7$. The changing color from yellow to blue color in Figure 3 indicates that there is bioethanol in the solution. The basic principle of the positivity test is reduction and oxidation reaction. This concludes that the bioethanol truly exists from the fermentation process of durian seed flour. The next step is identifying the functional group in bioethanol using FT-IR. Identification using FTIR will be a solid prove that durian seed flour is a good source for bioethanol production.

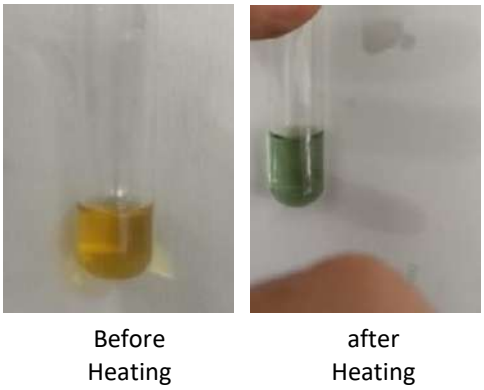

Figure 3. The positivity test of bioethanol.

Figure 4 shows how the difference in adsorbent do not affect the functional group. The FTIR spectrum is overlap. This means both of CaO and activated carbon did not destroy the stability of bioethanol. Peak that are visible in figure 4 are 3351 cm^{-1}, 1535 cm^{-1}, 1409 cm^{-1}, and 1024 cm^{-1}. The peak at 3351 cm^{-1} corresponds to OH bond. Furthermore, there are two peaks that corresponding to CO stretching such as 1535 cm^{-1}, 1409 cm^{-1}.The CO bond is situated at 1024 cm^{-1}

FTIR spectrum bioethanol from durian seed has different characteristics compared to pure ethanol. The reason of the difference is because bioethanol from durian seed flour is a result of the carbohydrate breaking. Also, the purification process for durian seed bioethanol is still far from perfect. The bioethanol is purified using simple distillation. Hence the process is not complete due

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to the azeotrope properties between bioethanol and water. C-H bonds from literature are in the 2900 cm^{-1}. [11]There are broad peak that situated from 2800 – 3500 cm^{-1}. This indicate that the C-H bond is overlap with the O-H bond. The overlap is due to the water level in bioethanol.

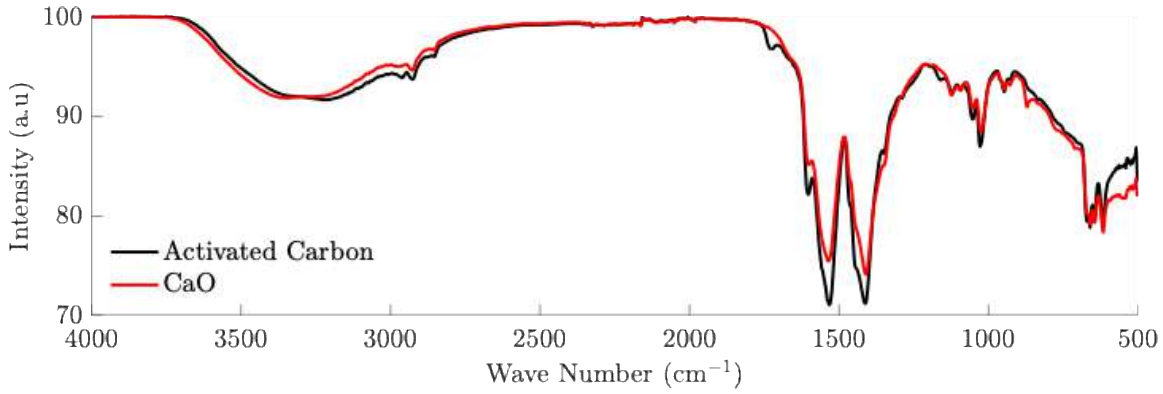

Figure 4. The FT-IR Spectrum from fermentation results of durian seed with SSF adsorbed using CaO. There are four major peak that visible from the GC-MS spectra.

The purification that still need to be improved are proven by the GC-MS spectrum. Figures 5 and 6 are GC-MS spectrum of bioethanol from durian seed. Figure 5 is bioethanol with CaO as an adsorbent whereas Figure 6 is bioethanol with activated carbon as adsorbent. There 4 dominant peaks from figure 5. The peaks are identified as trichloromethane, dodecanoic acid, histamine dihydrochloride, and dodecanamide. There are three reasons of all these compounds visible in the GC-MS analysis. The first reason is the breaking process is not complete. Second, the bioethanol is already degraded since the analysis process take a longer time. Third, the simple distillation is not sufficient to purify bioethanol.

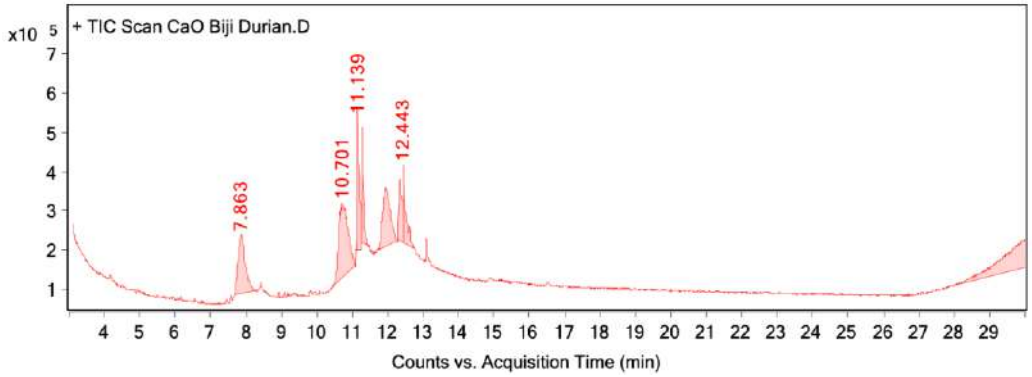

Figure 5. GC-MS Spectrum from fermentation results of durian seed with SSF adsorbed using CaO. There are four major peaks that visible from the GC-MS spectra.

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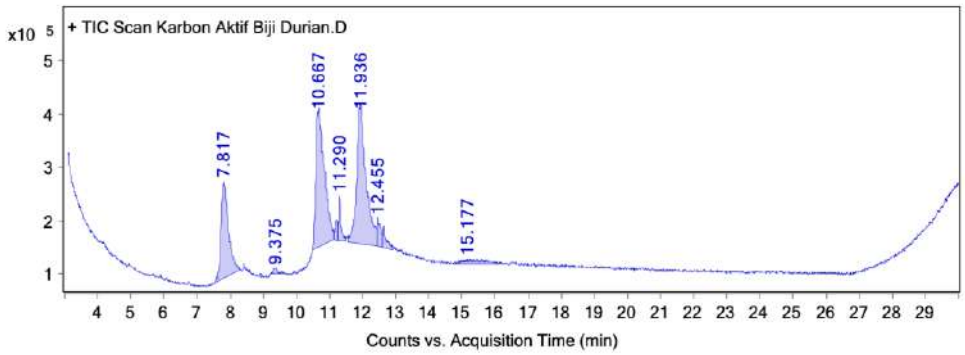

Figure 6. GC-MS Spectra from fermentation results of durian seed with SSF adsorbed using Activated Carbon. There are seven major peaks that visible from the GC-MS spectra.

Conclusions

Durian seed flour is a prospective source for bioethanol production. The utilization of alfa amylase enzyme and glucoamylase enzyme is proved to be better compared to simple hydrolysis using acid. For bioethanol from durian seed flour have the density of 0.879 $\frac{g}{mL}$ for using CaO as an adsorbent. Furthermore, the density of bioethanol is 0.967 $\frac{g}{mL}$ with activated carbon as an adsorbent. This concluded that CaO is a better adsorbent compared to activated carbon. Moreover, Simultaneous saccharification and fermentation (SSF) method is better compared to separation hydrolysis and fermentation (SHF).

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Optimization of performance and mechanical properties catalytic converter from pulp waste and rice husk ash as a motor vehicle exhaust gas converter

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Abstract. *Rice husk ash with a silica content of 86.90-90.30% can be used as a basic material for the synthesis of zeolite X. Meanwhile, pulp solid waste containing natural materials that make up ceramics such as clay, lignin, feldspar and silica can be used as a material for making converters. The combination of zeolite X from rice husk ash and converter from pulp waste produces a new material called catalytic converter. Synthesis of zeolite from rice husk ash was carried out through hydrothermal reaction at temperatures of 70 and 120℃ for 3 and 8 hours in alkaline conditions. The manufacture of catalytic converters from solid pulp waste with the addition of synthetic zeolite X is carried out through the stages of mixing, molding and burning. The results of zeolite characterization using infrared spectroscopy show that the zeolite formed is zeolite X which is at a wave number of 430.12; 601.79; 742.59; 1008.77; 1654.92 and 3450.65 cm^{-1}. This is confirmed by the results of powder X-ray diffraction characterization which shows the highest peak at the 2Θ angle of around 27.85° with a purity and crystallinity level of 75 and 68% respectively. A catalytic converter with a zeolite to pulp waste mixing ratio of 4:5 with a number of 7 holes in the molding has the most optimal performance, with a CO, HC and CO_2 gas absorption capacity of 53.22; 56.29*

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and 59.15% respectively and an increase in oxygen of 43.08%. This catalytic converter has resistance around 85 ℃ and 0.12 MPa.

Keywords: zeollite X, pulp waste, catalytic converter, adsorption, conversion

Introduction

Pulp production by PT. Toba Pulp Lestari Tbk, which is located in Porsea, Tobasa Regency, North Sumatra Province, leaves around 7 tons of solid waste/day. Accumulating pulp solid waste causes soil and air pollution which disturbs the surrounding community due to having to breathe bad smelling air every day. Therefore, efforts are needed to handle solid pulp waste. The results of the analysis of the chemical composition of solid pulp waste show that it contains ceramic constituents such as clay ($Al_2O_3 \cdot 2SiO_2.2H_2O$), feldspar ($KAlSi_3O_8$, $NaAlSi_3O_8$, $CaAl_2Si_2O_8$) and quartz (SiO_2) which allows pulp waste to be used as a material for making porous ceramics motor vehicle exhaust gas converter [1].

Motor vehicle exhaust gas is the largest source of air pollution, reaching 60-70% compared to industry which is around 10-15%. The rest comes from households, burning rubbish, forest or field fires. Pollutants emitted by motor vehicles and which have an impact on human health include carbon monoxide, nitrogen oxides, hydrocarbons, sulfur dioxide, lead and carbon dioxide [2-6]. It is hoped that the use of converters in motor vehicle exhaust can absorb and convert dangerous motor vehicle exhaust gases into ones that are safe for the environment. The converter from pulp waste is able to absorb CO, CO_2 and HC gases from motor vehicle exhaust gas respectively 36.21; 25.64 and 36.47% [7]. The converter's absorption capacity from pulp waste is still relatively low so it needs to be increased.

To increase the efficiency and performance of the converter, it is necessary to add a catalyst such as zeolite to the manufacturing process. The use of synthetic zeolite is better than natural zeolite because synthetic zeolite has a higher level of purity and pore uniformity than natural zeolite [8-9]. Until now, several types of zeolites that have been successfully synthesized include zeolite A [10], zeolite X [11-13] and zeolite Y [14-15]. Zeolite is an aluminasilica compound that can be synthesized from natural materials and even waste containing silica such as rice husk ash. The results of chemical composition analysis using XRF (X-ray Fluorescence) show that in rice husk ash there are elements Si, Al, Fe and Mg respectively around 88.2; 2.1; 2.5 and 0.9%. By using rice husk ash, zeolite X has been successfully synthesized through a hydrothermal reaction in alkaline conditions [13].

To overcome air pollution caused by motor vehicle exhaust gases and utilize solid pulp waste and rice husk ash, a catalytic converter has been successfully made from zeolite X and pulp waste with a weight ratio of 1:1; 1:2; 1:3 which was later optimized to 1:5; 2:5; 3:5; and 4:5. The quality of the synthesized zeolite X was measured using infrared spectroscopy and X-ray diffraction. Meanwhile, the catalytic performance of the converter is measured based on the absorption and conversion of CO, CO_2, HC and NOx gases using a gas analyzer.

Method

Chemicals, Equipment and Instruments

Chemicals consist of rice husk ash waste, pulp solid waste, sodium hydroxide pellets (NaOH p.a (Merck), anhydrous aluminum oxide (Al_2O_3 pa (Merck)), Sodium Ethylene Diamine Tetra Acetate (Na_2EDTA p.a (Merck)), aquabides (H_2O IKA) and distilled water (H_2O). The equipment used consists of mortar and pestle, 200 mesh sieve, beaker, magnetic stirrer, tongs, spray bottle,

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filter paper number 42, round bottom flask, Leibig cooler and magnetic stirrer hot plate, stainless steel blender, converter mold and furnace. The characterization instruments used include Transformation Infrared Spectroscopy (FTIR-8400 Shimadzu), X-Ray Diffractometer (XRD model Bruker D8) and Automobile Emission Gas Analyzer (Gasboard-5020).

Research Procedures

Synthesis of Zeolite X from Rice Husk Ash

Zeolite synthesis refers to a procedure previously carried out by Jahro [13]. A total of 20 g of rice husk ash, 28.98 g of NaOH, 17.3 g of Al_2O_3 and 1 g of Na_2EDTA as well as 300 mL of aquabides were stirred in a 500 mL beaker using a hot plate. magnetic stirrer at room temperature at a speed of 600 rpm for 10 hours. The mixture was left to sit for approximately 12 hours. Then the hydrothermal process is carried out by refluxing the mixture successively at a temperature of 70 °C for 3 hours followed by a temperature of 120 °C for 8 hours. The solid substance resulting from the synthesis is filtered and washed using distilled water until the pH of the water coming out of the filter paper is around 7. Then, the synthesized solid was dried in an oven at 120°C for 3 hours repeatedly until a constant weight was obtained. The synthesized solid was then characterized using infrared spectroscopy (FTIR) and X-ray diffraction (XRD).

Making a Catalytic Converter from Pulp Waste and Zeolite

Each pulp waste consisting of grit, dreg and biosludge is dried, then ground and sieved using a 100mesh sieve. Next, the three ingredients with the same weight are mixed and stirred until homogeneous and ready to be used as material for making a catalytic converter. Zeolite X was added to the pulp solid waste mixture with a weight ratio of 1:1, 1:2 and 1:3. Add a little water to the mixture while stirring until homogeneous. Then the mixture is put into a cylindrical stainless mold with a diameter and height of 6 and 10 cm respectively with the number of holes of 7. The treatment of variations in the weight ratio of zeolite X to pulp waste was optimized with a ratio of 1:5, 2:5, 3:5 and 4:5 optimize the analysis of the effect of zeolite X on the performance and mechanical properties of the catalytic converter.

Characterization

To determine the framework structure of the synthesized zeolite, infrared spectroscopic measurements were carried out using Fourier Transform Infrared Spectroscopy (FTIR-8400 Shimadzu) in the wave number region of 300–4000 cm^{-1}. Then the infrared spectrum of the synthesized zeolite was compared with the infrared spectrum of standard zeolite X.

Meanwhile, to determine the crystallinity and purity of the synthesized zeolite, powder X-ray diffraction measurements were then carried out using a Bruker D8 model diffractometer at a wide diffraction angle (2θ): 4 – 40°. Then the diffractogram of the synthesized zeolite was compared with the standard zeolite X diffractogram.

Meanwhile, to determine the absorption and conversion capacity of the catalytic converter, it was measured using a Gasboard-5020 gas analyzer. Absorption capacity and conversion capacity are carried out by comparing the CO, HC, CO_2 and O_2 contents in the exhaust gas without and using a catalytic converter. Catalytic converter testing was carried out for 1-2 minutes for each catalytic converter.

Results and Discussion

Zeolite Synthesized from Rice Husk Ash

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The results of the analysis of the chemical composition of rice husk ash using X-ray fluorescence showed the presence of SiO_2, K_2O, and CaO respectively around 94.0; 2.48 and 1.63% as well as other oxides such as MgO, P_2O_5, MnO, Fe_2O_3, ZnO, Rb_2O and SrO in small amounts as shown in Table 1.

Table 1. Chemical composition of rice husk ash

No.	Component	Result	Unit
1	SiO_2	94.0	mass%
2	K_2O	2.48	mass%
3	CaO	1.65	mass%
4	P_2O_5	0.905	mass%
5	MgO	0.587	mass%
6	SO_3	0.177	mass%
7	MnO	0.102	mass%
8	Fe_2O_3	0.0757	mass%
9	ZnO	0.0156	mass%
10	SrO	0.0082	mass%
11	Rb_2O	0.0037	mass%

The silica content in rice husk ash is in accordance with the results of previous researchers who found that rice husk ash usually contains between 86.9-98% silica which is produced from open burning or extraction [16]. The high silica content means that rice husk ash can be used as a main ingredient in zeolite synthesis.

Infrared spectroscopy of the synthesized zeolite shows absorption in four wave number regions: 440-540, 500-650, 750-820 and 1000-1120 cm^{-1} as can be seen in Figure 1.

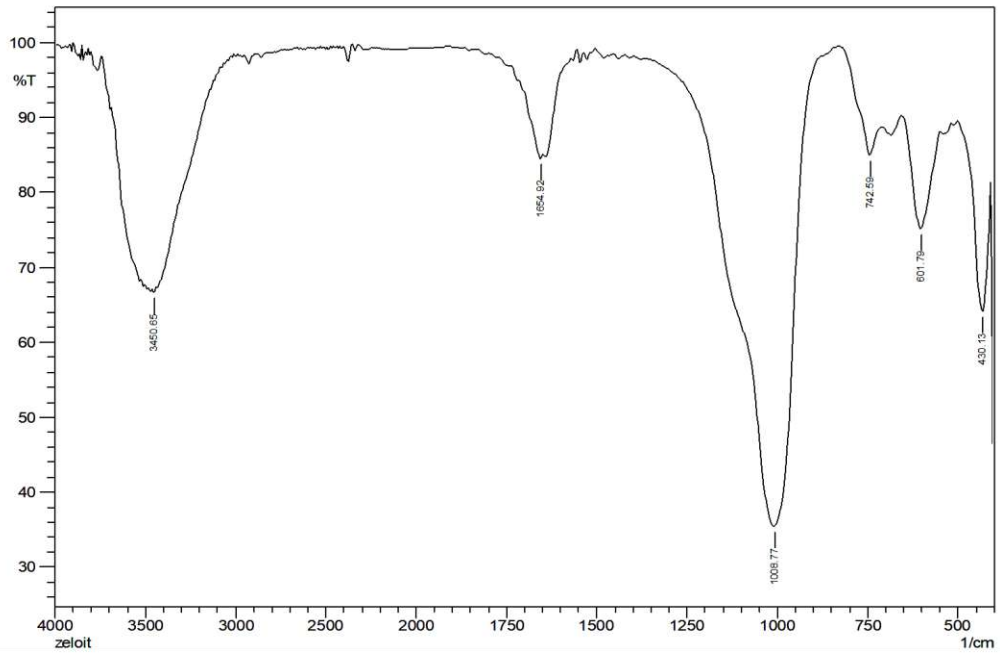

Figure 1. Infrared spectrogram of zeolite synthesized from rice husk ash

The presence of strong infrared absorption at a wave number of 1008.77 cm-1 marks the

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internal asymmetric stretching vibration of O-Si-O or O-Al-O from the zeolite X framework [11,15]. The infrared absorption at a wave number of 742.59 cm^{-1} indicates the existence of external symmetrical stretching vibrations of O-Si-O or O-Al-O [17]. Meanwhile, absorption at a wave number of 601.79 cm^{-1} marks double ring vibration (D6R) which is characteristic of zeolite X [13]. The presence of hydrated water in the synthesized zeolite X shown by absorption at a wave number of 1640 cm^{-1} which marks the H-O-H bending vibration [11]. This is reinforced by the presence of wide absorption at a wave number of 3457 cm-1 which indicates the presence of O-H stretching vibrations from water in the synthesized zeolite [18-19]. The absorption at wave number 440.70 cm^{-1} marks the bending vibration of -Si-O-Al- which indicates the reaction between alumina and silica in small amounts [20].

To determine the purity and crystallinity of zeolite carried out through diffractogram analysis of the results of X-ray diffraction measurements. The purity and crystallinity of zeolite gets better as the number of diffraction peaks typical of zeolite X increases. In addition, high peak intensity and good separation between peaks are characteristics of materials with good crystallinity.

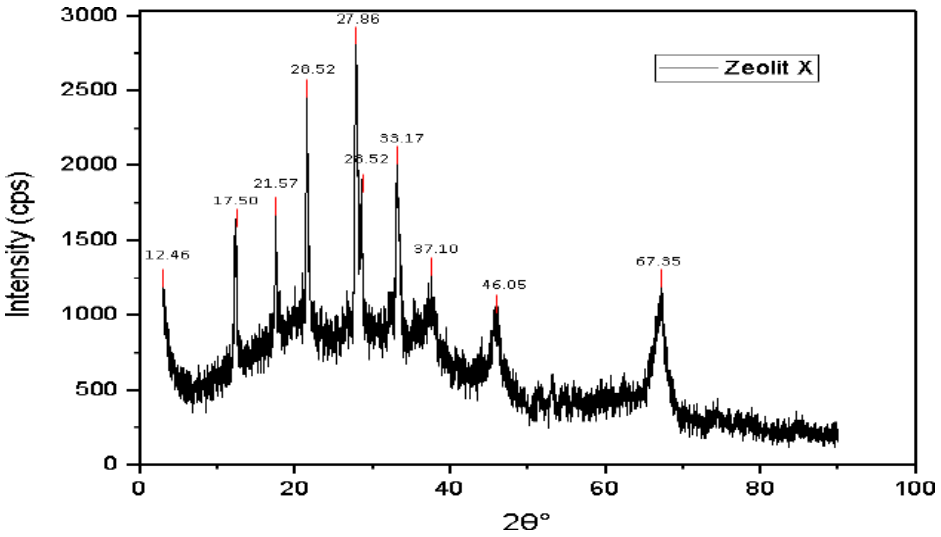

Figure 2. Diffractogram of Zeolite X synthesized from rice husk ash

In Figure 2 it can be seen that the typical diffraction peaks of zeolite X appear at an angle of 2θ = 12.46; 17.50; 21.57; 27.85; 28.52; 33.17° with the highest peak intensity at peak 2θ = 27.85°. This is in accordance with the results of previous research conducted by Jahro [13]. However, the appearance of diffraction peaks that are not typical of zeolite X at angles 2θ = 46.05 and 67.35° and there is a 2θ angle shift in several diffraction peaks typical of the synthesized zeoite X compared to the 2θ angle in JCPDS as shown in Table 2. This is an indication of the presence of impurities or other substances in the synthesized zeolite X sample. In Table 2 it can be seen that the number of typical main peaks that appear in the diffractogram of synthetic zeolite is 6 peaks from the 8 peaks that should be in JCPDS so that it can be determined or estimated that the purity level of the synthesized zeolite X is around 75%. Then, based on the highest intensity of the typical zeolite peak X angle 2θ° = 27.85, it can be calculated that the degree of crystallinity is around 68%. The presence of diffraction peaks other than the typical peak of zeolite X indicates the presence of other substances in the zeolite sample and related to crystallinity it can be determined

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that zeolite [13]. This level of purity and degree of crystallinity fulfills the requirements for the use of zeolite X synthesized from rice husk ash as a catalyst in converters from pulp solid waste.

Table 2. Comparison of the number and angle of 2Θ diffraction peaks in the JCPDS and synthesized zeolite X diffractograms

Peak number	Angle of 2Θ (°)	
	JCPDS	Diffractogram of synthesized zeolite X
1	10.00	-
2	11.73	12.46
3	16.50	17.50
4	21.80	21.57
5	26.65	27.57
6	27.20	28.52
7	31.98	-
8	33.59	33.17

Catalytic Converter with Varying Weight Ratio of Zeolite X to Pulp Waste 1:1; 1:2 and 1:3

Figure 3. Catalytic converter with varying weight ratio of zeolite X to pulp waste from left to right 1:1, 1:2 and 1:3 with the same number of holes of 5

There are 3 catalytic converters produced from the treatment of variations in the weight of zeolite X on pulp solid waste as shown in Figure 3. The results of measuring the absorption capacity of each catalytic converter for CO, HC and CO_2 gases are summarized in table 3.

In Table 3 it can be seen that under normal circumstances without using a catalytic converter, the exhaust gas coming out of the exhaust contains CO, HC and CO_2 gases of 0.64, 217 and 12.5 ppm respectively.

Table 3. Absorption capacity of catalytic converters with a ratio of zeolite X to pulp waste of 1:1, 1:2 and 1:3 with a total of 5 holes

Nu	Catalytic converter with varying weight of zeolite X for pulp waste	Gas emissions (ppm)			Gas absorbed (%)		
		CO	HC	CO_2	CO	HC	CO_2
1	1:1	0.52	168	9.5	18.75	22.58	24.0
2	1:2	0.47	156	7.8	26.56	28.11	37.6
3	1:3	0.53	157	8.9	17.18	27.64	28.8

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No catalytic converter	0.64	217	12.5	-	-	-

The use of a catalytic converter can reduce the level of each exhaust gas that comes out of the exhaust so that the amount of gas absorbed can be determined, respectively, CO is around 17-27%, HC is around 23-28% and CO_2 is 24-38%. This shows that the hollow structure of the catalytic converter is capable of trapping CO, HC and CO_2 gases in the exhaust gas. A catalytic converter with a zeolite X content of around 33.3% (ratio 1:2) has a higher absorption capacity for CO, HC and CO_2 gases respectively compared to a catalytic converter whose manufacture uses zeolite X as much as 50% (1:1) and 25% (1 :3). This is estimated because the use of zeolite as much as 33.3% means that the zeolite hollow structure works quite effectively together with the pulp waste hollow structure in capturing CO, HC and CO_2 gases and then the zeolite active groups through dipole-dipole interactions (van der waals force) can maintain or bind each of these gases to remain in the cavity which then undergoes a change or conversion reaction which is estimated to take place as follows [21]:

Hydrocarbon gas conversion:

$$C_xH_{4x(g)} + 2xO_{2(g)} \rightarrow xCO_{2(g)} + 2xH_2O_{(g)}$$

Carbon monoxide gas conversion:

$$2xCO_{(g)} + O_{2(g)} \rightarrow 2xCO_{2(g)}$$

Nitrogen oxide decomposition reaction:

$$2NO_{x(g)} \rightarrow N_{2(g)} + xO_{2(g)}$$

Carbon dioxide gas reduction reaction:

$$xCO_{2(g)} \rightarrow xC_{(s)} + O_{2(g)}$$

When more zeolite is used (50%), the presence of zeolite reduces the working power of the converter in capturing CO, HC and CO_2 gases. This is thought to be because the amount or content of the pulp waste mixture in the converter is less. Even though the pulp waste has a larger number and size of cavities which are able to absorb more gas. Meanwhile, if the amount of zeolite used is less (25%), then the amount of zeolite is insufficient to bind or maintain CO, HC and CO_2 gases in the converter cavities so that the gas is released again before undergoing a conversion reaction.

In accordance with the reduction in CO, HC and CO_2 gas levels in the exhaust gas, there is an increase in oxygen gas (O_2) levels which is thought to occur as a result of the decomposition reaction of nitrogen oxides and reduction of carbon dioxide gas. Data on the increase in oxygen in flue gas without and with the use of a catalytic converter with varying weight ratios of zeolite to pulp waste are summarized in Table 4.

Table 4. Increase in oxygen gas in exhaust gas without and using a catalytic converter with varying weight ratios of zeolite to pulp waste

Nu	Catalytic converter with varying weight of zeolite X for pulp waste	O_2 emissions (ppm)	Increase in O_2 emissions (%)
1	1:1	17.72	35.27
2	1:2	18.53	41.45
3	1:3	17.23	31.53
	No catalytic converter	13.10	-

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In conditions without the use of a catalytic converter, the oxygen gas content in the exhaust gas is around 13.1 ppm. When using a converter, the oxygen gas content in the flue gas increases by around 31-41%. This shows that the use of zeolite in converters from pulp waste can increase oxygen gas levels in flue gas in line with the ability of the zeolite active groups to bind each of these gases through dipole-dipole interactions before the gases undergo a reaction.

Optimizing Catalytic Converter Performance by Varying the Weight Ratio of Zeolite to Pulp Waste 1:5; 2:5; 3:5 and 4:5

To increase or optimize the absorption and conversion capacity of the catalytic converter, the weight ratio of zeolite to pulp waste is optimized where the zeolite ratio number is changed from 1 to be 1, 2, 3 and 4 while the pulp waste ratio number is made the same, namely 5 and optimizing the number of holes used in this treatment was 7. There are 4 catalytic converters produced by optimizing the treatment of the weight ratio of zeolite to pulp waste with 7 holes as shown in Figure 4. The results of measuring the absorption capacity of each catalytic converter for CO, HC and CO_2 gases are summarized in Table 5.

Figure 4. Catalytic converter with a weight ratio of zeolite to pulp waste of 1:5, 2:5, 3:5 and 4:5 with a fixed number of holes of up to 7 pieces

In Table 5 it can be seen that the catalytic converter made from zeolite and pulp waste with a weight ratio of 4:5 has the highest absorption capacity for CO, HC and CO_2 gases compared to other catalytic converters.

Table 5. Absorption capacity of catalytic converters with a ratio of zeolite X to pulp waste of 1:5, 2:5, 3:5 and 4:5 with a total of 7 holes

Nu.	Catalytic converter with varying weight of zeolite X for pulp waste	Gas emissions (ppm)			Gas absorbed (%)		
		CO	HC	CO_2	CO	HC	CO_2
1	1:5	0.45	124	4.7	27.42	25.75	33.80
2	2:5	0.38	109	3.7	38.71	34.73	47.89
3	3:5	0.32	85	3.1	48.39	49.10	56.33
4	4:5	0.29	73	2.9	53.22	56.29	59.15
	No catalytic converter	0.62	167	7.1			

This shows that zeolite as a catalyst with its pore structure is able to absorb CO, HC and CO_2

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gases very well. In this study, the catalytic converter with a weight ratio of zeolite to pulp waste of 4:5 was the composition with the highest zeolite content compared to the others so that the zeolite was mixed evenly throughout the catalytic converter. In the catalytic converter, each gas absorbed undergoes an oxidation reaction on HC and CO gas, decomposition on NO gas and reduction on CO_2 gas so that the gas contained in the exhaust gas after passing through the catalytic converter becomes a safer gas such as carbon dioxide (CO_2), water (H_2O) and oxygen [22]. Therefore, the more catalyst used, the greater the absorption and conversion capacity of the catalytic converter because zeolite can provide more active surfaces for absorption and chemical reactions to occur [23].

Table 6. Increase in oxygen gas in exhaust gas without and using a catalytic converter with varying weight ratios of zeolite to pulp waste

Nu	Catalytic converter with varying weight of zeolite X for pulp waste	O_2 emissions (ppm)	Increase in O_2 emissions (%)
1	1:5	18.93	34.35
2	2:5	19.32	37.12
3	3:5	19.93	41.44
4	4:5	20.16	43.08
	No catalytic converter	14.09	

The successful absorption and conversion of each gas is supported by the increase in oxygen gas levels contained in the exhaust gas which is increasingly higher with the increase in the amount of zeolite used as shown in Table 6. The increase in O_2 levels contained in the exhaust gas using a catalytic converter with a zeolite content of 44 % (zeolite to pulp waste ratio 4:5) which is 43.08%, the highest compared to the increase in O_2 levels when using other catalytic converters.

Mechanical Properties of a Catalytic Converter Made with a Weight Ratio of Zeolite X to Pulp Waste of 4:5

The catalytic converter with the highest absorption and conversion capacity is then tested for its mechanical properties in the form of resistance to temperature and pressure. The results of testing the temperature of the catalytic converter by measuring the absorption and conversion capacity at room temperature and then increasing the temperature gradually by around 10°C, it turns out that starting at a temperature of 85°C the conversion and absorption capacity of the catalytic converter has decreased. This shows the catalytic converter has resistance to increasing temperatures below 85°C. This means that to be able to absorb CO, HC and CO_2 gases optimally, the catalytic converter should be used at temperatures below 85 °C. The decrease in the absorption capacity and durability of the catalytic converter when heated to a temperature of 85°C is estimated because in the heating process the zeolite as a catalyst experiences deactivation, where the higher the temperature, the more active sites will be closed, thereby reducing its performance as a catalyst. In addition, a decrease in the performance of the catalytic converter can occur due to dust/dirt that sticks can block gas contact with the active site on the catalyst in the catalytic converter. This is in accordance with the results of previous research which found that heating that was too high caused a decrease in the performance of the catalytic converter in reducing gas emissions. Catalysts can work effectively with ideal operating temperatures [23].

The pulp solid waste in the catalytic converter functions as an adhesive and increases the mechanical strength properties so that it is sturdy and durable. The results of pressure tests on

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catalytic converters with a weight ratio of zeolite to pulp waste of 4:5 show that the catalytic converter can withstand pressures of up to 0.12 MPa. This means that the catalytic converter breaks down into smaller parts or powder if it experiences pressure of more than 0.12 MPa. Therefore, the catalytic converter should be used in conditions where the pressure on the catalytic converter is less than 0.12 Mpa.

Conclusion

In this research, zeolite was successfully synthesized from rice husk ash which functions as a catalyst in a catalytic converter from pulp waste. The ability of the catalytic converter to absorb and convert CO, HC and CO_2 gas is influenced by the ratio of zeolite to pulp waste and the number of holes in the manufacturing process. A catalytic converter with a zeolite content of 44.44% or a weight ratio of zeolite to pulp waste of 4:5 and a number of holes of 7 can reduce the CO, HC and CO_2 gas content and increase oxygen gas coming out of the flue gas the highest compared to other catalytic converters. This catalytic converter has resistance to temperature and pressure of around 85°C and 0.12 MPa respectively.

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Catalytic pyrolysis of high density polyethylene waste into fuel fraction utilizing Ni-Mo catalyst supported by active natural zeolite

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Abstract. Plastic waste presents a significant challenge within the realm of global expansion, necessitating innovative solutions to mitigate its environmental impact. One effective approach to

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managing this waste involves its conversion into fuel fractions via the process of pyrolysis. The utilization of catalytic pyrolysis emerges as a promising strategy for addressing the issue of high density polyethylene (HDPE) plastic waste, while concurrently enhancing the efficiency of energy utilization within the pyrolysis system. The investigation encompasses various phases, including the preparation and activation of catalysts based on natural zeolite, the impregnation of Ni-Mo metal onto active natural zeolites, subsequent oxidation and reduction procedures, and the conduct of HDPE plastic catalytic pyrolysis utilizing the developed catalysts. The production of liquid products from pyrolysis exhibits an augmentation in the presence of a catalyst and is directly proportional to the quantity of catalyst employed. Specifically, the proportions of gasoline and diesel fractions witness an elevation to 21.3% and 63.4% respectively, while there is a notable reduction in the heavy oil fraction, signifying the cleavage of lengthy hydrocarbon chains.

Keywords: catalytic pyrolysis, fuel fraction, high density polyethylene, metal catalyst, natural zeolite

Introduction

Polymer materials, due to their wide array of household and industrial uses, have emerged as a significant element in contemporary society. The worldwide estimates indicate that approximately 1.1 billion tons of plastic are set to be produced by 2050 [1]. Among the various types of plastics, High-density polyethylene (HDPE) stands out as a cost-efficient thermoplastic, holding the position as the fourth most produced plastic worldwide. It comprises approximately 15% of the overall plastic consumption, trailing behind polypropylene, low-density polyethylene, and polyvinyl chloride in terms of volume [2,3]. The increasing demand for plastic products is likely to lead to a rise in plastic waste accumulation in landfills, causing concerns for human and animal health while contributing to environmental pollution problems. Consequently, there is a pressing need for sustainable and effective methods for managing plastic waste to mitigate these challenges [4]. Pyrolysis emerges as a sustainable approach for handling plastic waste, yielding liquid oil as an energy source, as well as solid charcoal and gas as valuable by-products [5]. The utilization of plastic waste for oil production is technically feasible due to its comparable calorific value to oil sourced from biomass, presenting an appealing alternative [6,7]. This method involves the thermal breakdown of complex molecules or extensive hydrocarbon chains into smaller molecules or abbreviated hydrocarbon chains.

Thermal cracking necessitates elevated temperatures and subsequent processing to enhance the quality of the product, resulting in a lower level of popularity for this technique. The thermal pyrolysis of plastics demands high temperatures (350–500 ◦C) to facilitate degradation [6]. The high energy requirements of thermal pyrolysis stem from its low thermal conductivity and endothermic cracking characteristics. Conversely, catalytic cracking of plastic waste presents numerous benefits as it operates at lower temperatures, lowering the activation energy for cracking [2,8,9]. The utilization of a catalyst proves to be more economically advantageous by decreasing the operational requirements of the cracking process, thus reducing costs [6]. Moreover, catalysts provide the flexibility to tailor the selectivity of plastic conversion towards the desired product (e.g. gas, gasoline, or diesel) through the suitable adjustment of the catalyst's acidity and pore structure.

The properties of catalysts, such as the density of acid sites, as well as physical properties including surface area, pore size, volume, distribution, and structure, play a crucial role in influencing catalytic performance [10]. Zeolite catalysts, characterized by alumino-silicate crystal sieves with a three-dimensional framework containing cavities and channels for cations, exhibit ion exchange capability and open pores as their primary features. Among these catalysts, those

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with high acidity demonstrate enhanced activity in the cracking process, leading to increased production of light olefins and decreased heavy fraction content [11]. Such catalysts, with their high acidity, effectively catalyze the degradation of biomass and plastic components, thus reducing the required pyrolysis temperature and enhancing the yield of the desired final product [12]. Research by Dai et al. highlights the superior cracking performance of zeolites (over 90% C5-C12 hydrocarbons) compared to SBA-15 based catalysts, although the liquid oil produced primarily comprises aromatic hydrocarbons, which are undesirable for breaking naphtha into plastic monomers [13]. Additionally, Miandad et al. [7] conducted PE pyrolysis utilizing thermally modified natural zeolite catalysts from Saudi Arabia and acid, resulting in liquid product yields of 40% and 42%, respectively.

Incorporation of metals into catalysts may result in enhanced yields of fuels and chemicals in the output stream. Akubo et al. performed an investigation on catalytic pyrolysis of HDPE employing zeolite Y supported by a transition metal promoter with different metal loadings of Ni, Fe, Mo, Ga, Ru, and Co at 1 wt% and 5 wt%. The presence of metals on the Y-zeolite catalyst leads to an increased production of aromatic hydrocarbons in the resulting oil, particularly with a higher concentration of single-ring aromatic hydrocarbons. Toluene, ethylbenzene, and xylene are primary components of single-ring aromatic compounds, while naphthalene and its alkylated derivatives are predominant in 2-ring hydrocarbons [14]. Ni, a renowned catalyst for water treatment, exhibits a remarkable ability to cleave C-C bonds. The synergy between the catalytic characteristics of Ni and zeolites presents promising opportunities for biofuel synthesis [15]. The outcomes reveal a notable impact of Mo loading on the NZC0 nanocatalyst on the distribution of products. The incorporation of the Mo promoter heightens the aromatization process and aromatic generation (up to 74%) owing to the catalyst's strong acidity[16].

This research demonstrates that the utilization of pyrolysis on plastic waste presents an alternative method for managing plastic waste and a substitute origin of fossil fuels. Past investigations have indicated promising possibilities for utilizing natural zeolites as catalysts in plastic pyrolysis. However, reports regarding the application of natural zeolites, especially those from Sarulla, North Sumatra as catalysts in the catalytic pyrolysis process of plastic waste, especially the HDPE type, are still limited.

Materials and Method

Materials

The materials used in this study include plastic waste, specifically High-Density Polyethylene (HDPE), sourced from domestic waste. Sarulla Natural Zeolite (ZAS) from the village of Sarulla Pahae Jae North Tapanuli, North Sumatra, $Ni(NO_3).6H_2O$ (p.a Merck), $(NH_4)_6Mo_7O_{24}.4H_2O$ (p.a Merck), HCl (p.a Merck), as well as nitrogen gas, oxygen gas and hydrogen gas from PT. Tri Gas Medan, Indonesia.

Catalyst preparation

The catalyst employed in this research was prepared in accordance with the methodology outlined in the study by Sihombing et al. [17]. This particular catalyst is categorized as a bifunctional catalyst built upon zeolite and Ni-Mo metal. The zeolite used is natural zeolite taken from Sarulla Village. North Sumatra. Activation of the zeolite was achieved through a chemical process involving 3N HCl followed by calcination with a stream of Nitrogen gas. The introduction of 0.5wt% Ni-Mo metal each was executed utilizing a wet impregnation technique, succeeded by an oxidation phase under an oxygen flow, subsequently reduced under a hydrogen gas flow.

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Plastic waste preparation

The plastic waste composed of HDPE from various sources was gathered, cleansed with running water, sun-dried to remove moisture thoroughly, and then sectioned into small pieces approximately ± 5 mm.

Catalytic pyrolysis of HDPE waste

An amount of 100 grams of HDPE plastic waste was deposited into the sample container, while the NiMO/ZAS catalyst was placed in a separate catalyst container. The catalytic pyrolysis process of the HDPE plastic waste was conducted within a fixed-bed reactor under a temperature range of 400-500 °C and a pressure of 1 atm for a duration of 1 hour with nitrogen gas as the carrier. The investigation into the catalyst's efficacy was conducted by altering the ratio of catalyst employed, specifically 0%, 1%, 2%, 3%, 4%, and 5%. The vapor product resulting from the reaction is flowed through a silicon hose passing through a condenser and then collected in a product container. The mass (M) of the liquid product phase (Lp), the residue (R), was quantified. The yield (Y) was determined utilizing the subsequent formula:

$$Y_{Lp}(\%) = \frac{M_{Lp}(g)}{M_{bio-oil}(g)} x100 \quad (1)$$

$$Y_{R}(\%) = \frac{M_{R}(g)}{M_{bio-oil}(g)} x100 \quad (2)$$

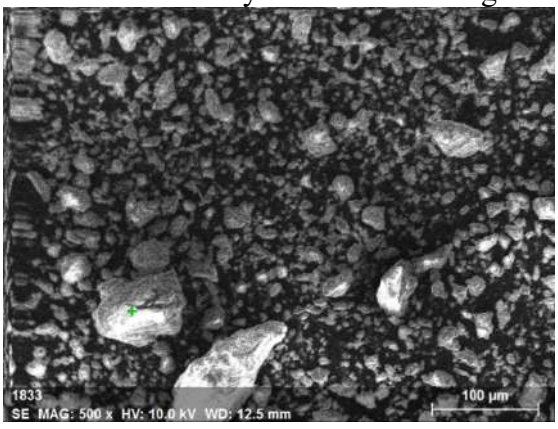
Liquid product analysis

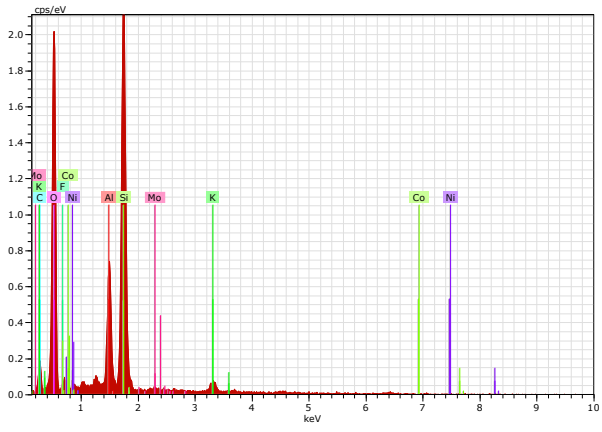
The evaluation of physicochemical characteristics involves the measurement of viscosity with an Ostwald Viscometer, the determination of density using a pycnometer, the assessment of elemental composition (C, H, N, O) with the CHN Analyzer LECO-CHN 628, the determination of acid number through titration, the calculation of HHV based on CHN data using the Sheng and Azevedo equation, and the analysis of compound constitution using GC-MS Model QP2010 Shimadzu.

Results and Discussion

Catalyst characteristics

Referring to Sihombing et al. [18], the NiMo/ZAS catalyst used in this study has a relative crystallinity of 41%, a Si/Al ratio of 4.6, a specific surface area of 52 m^2/g, a total pore volume of 0.14 cc/g, and a pore diameter of 3.32 nm. The surface morphology of the Ni-Mo/ZAS catalyst as a result of SEM analysis is shown in Figure. 1.





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(a) (b)

Figure 1. Surface morphology of the Ni-Mo/ZAS catalyst: (a) SEM micrograph magnification 500 times, and (b) EDX graph

The depiction in Figure 1 illustrates the surface attributes of the active natural zeolite impregnated with Ni-Mo metal under a magnification of 500 times. Upon scrutiny of this visualization, it becomes apparent that the dimensions of the catalyst particles display a tendency to vary, with the presence of larger particles being notable. This disparity in particle sizes signifies a propensity for particle aggregation following the introduction of metal, which is a consequence of the thermal transformations experienced during the oxidation and reduction stages of the catalyst.

Catalytic cracking of HDPE

The pyrolysis process was carried out using a fixed bed reactor at a temperature of 500 ℃ for 3 hours using a 1%, 2%, 3%, 4%, 5% NiMo catalyst and without a 0% catalyst with nitrogen gas flowing. This pyrolysis product is divided into liquid, gas and residue fractions. Comparison of product conversion results obtained from plastic waste pyrolysis is shown in Figure 2.

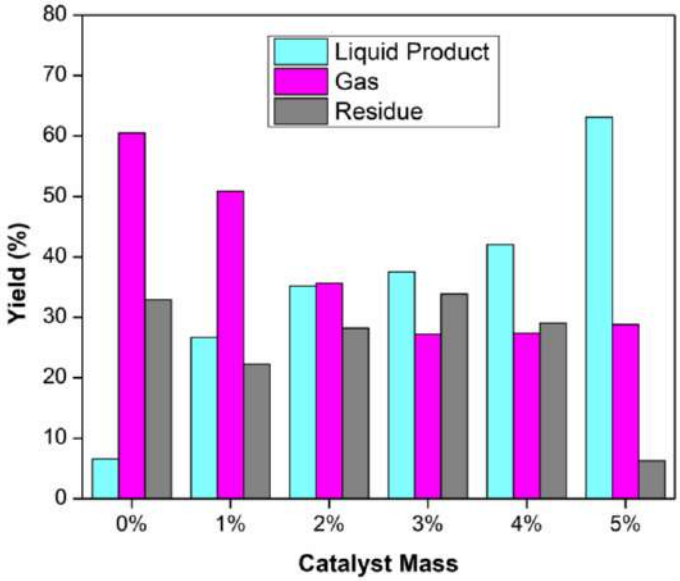

Figure 2. Distribution of plastic pyrolysis products with several catalyst ratios

The highest yield product was produced at a 5% catalyst concentration of 63.07% and the lowest yield product was 6.6% without catalyst. Then the highest gas product produced at a catalyst concentration of 1% was 50.13% and the lowest gas product was produced at a catalyst concentration of 5% as much as 28.84%. Then the highest residue was seen at a 3% catalyst concentration of 33.9% and the lowest residual product was at a 5% catalyst concentration of 6.31%. So in optimal conditions there is a catalyst concentration of 5% with a product yield of 63.07%, gas 28.84% and residue 6.31%.

Referring to Figure. 2 shows the effect of using a catalyst on the distribution of products produced in the pyrolysis process. Catalyst-assisted pyrolysis produces more liquid products than pyrolysis without a catalyst, and this increases as the catalyst ratio used increases. On the other hand, the gas percentage decreases as the catalyst ratio used increases. The use of 5% catalyst

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appears to show the highest conversion rate due to the least plastic residue left behind. The increase in catalyst mass from 1, 2, and 3% decreased regularly and remained relatively constant up to 5%. After that, the catalyst mass above 3% experienced a significant reduction in residue and an increase in liquid product. In this case, the use of a catalyst appears to provide sufficient active sites for reactants in the gas phase to adsorb on the catalyst surface and undergo cracking. During pyrolysis, condensable vapor and non-condensable gas are formed. Vapor consists of heavier molecules that condense, producing additional liquid product. Lower molecular weight gases, commonly known as non-condensable gas (CO_2, H_2O CO, C_2H_2, C_2H_4, C_2H_6, C_6H_6) do not condense when cooled. In addition, a large amount of non-condensable gas is formed due to secondary cracking of steam. As a result, the final non-condensable gas product is a combination of primary and secondary gas [19,20]. In this research, it can be seen that when the pyrolysis process is carried out without using a catalyst, most of the gas that comes out of the system is non-condensable gas. On the other hand, when using a catalyst, relatively less gas is produced. This is in line with research by Ding et al. [21] who reported an increase in oil yield and a decrease in gas yield in most cases when HY was added. HY zeolite reduces the fraction of most C1-C3 hydrocarbons, while increasing the C4+ gas fraction. These changes indicate that HY promotes the conversion of light gases into relatively larger molecular compounds.

However, unfortunately in this research no further analysis was carried out on the components of the gas produced. Based on Akubo et al. [14], the main gases produced without a catalyst are methane, ethane, ethene, propane, and propene along with lower concentrations of C4 hydrocarbons. However, in the presence of Y-zeolite, the resulting hydrogen concentration is much higher and the C2-C4 hydrocarbon concentration is lower. The effect of adding metal to Y-zeolite is to further increase the hydrogen concentration in the product gas and the higher the concentration of metal addition the more it increases the hydrogen concentration in the product gas.

Referring to Aghamiri et al. [2], in pyrolysis, zeolites function as catalysts to increase pyrolysis vapors and convert them into more valuable products such as fuels and chemicals. Its high acidity allows it to facilitate cracking and isomerization reactions, while its shape selectivity allows it to promote specific reaction pathways. During biomass pyrolysis, lack of oxygen causes the formation of pyrolysis vapors. This steam is then exposed to the zeolite, triggering various reactions such as cracking, isomerization, and dehydration. The resulting products can include a wide range of hydrocarbons and oxygenated compounds, depending on the pyrolysis conditions and the nature of the zeolite catalyst. Furthermore, the liquid product produced in this study was analyzed for its compound content as summarized in Figure 3.

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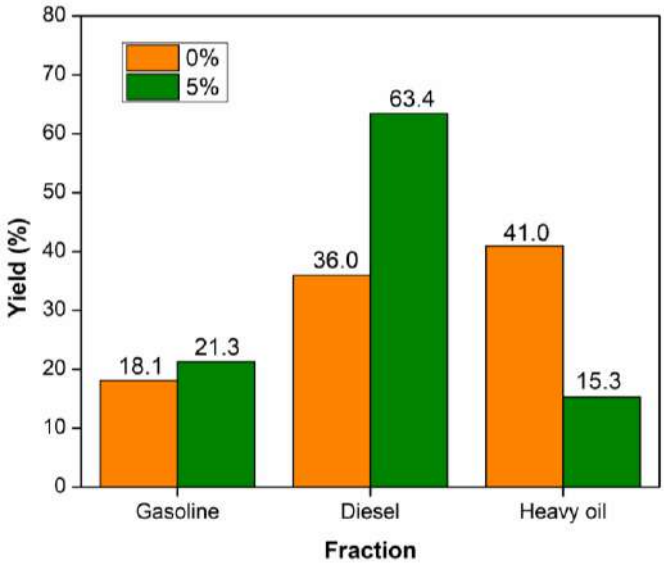

Figure 3. Selectivity of fuel fractions by liquid products catalyzed by 5% Ni-Mo/ZAS

Based on the data presented in Figure 3, it can be seen that the compound components in the pyrolysis results of HDPE plastic without a catalyst using a 5% catalyst are the diesel fraction without catalyst ($C12 - C20$) of 35.96% then the diesel fraction with a 5% catalyst ($C12 - C20$) was 63.4%, while the gasoline fraction ($C8 - C12$) without using a catalyst was 18.1%, then the gasoline fraction ($C8 - C12$) using a 5% catalyst was 21.3% and the heavy fraction ($>C20$) without using a catalyst of 41% then using a 5% catalyst produces a weight fraction ($>C20$) of 15.3%, this shows that the catalyst has an influence on the yield of liquid HDPE products. The pyrolysis process using a catalyst shows a higher yield of the light fraction of the fuel which indicates that catalytic cracking is occurring. These results are in line with research conducted by Silva et al. [22] who reported that based on GC-MS analysis, thermal degradation of HDPE without a catalyst gave rise to products distributed in a wide range of hydrocarbons, from C3 to C22. The use of HZSM-12 as a catalyst produces lighter products, especially from C3 to C10. This behavior may be caused by the strong acid sites on the HZSM-12 zeolite, which promote the cracking of the polymer chains, which are associated with the zeolite pore system. Meanwhile, another report by Sriningsih et al. [23] shows that the liquid yield resulting from hydrocracking of LDPE using natural zeolite-based catalysts consists of hydrocarbon compounds such as isoparaffins, olefins and naphthenes with atomic chains between C6 to C19. The resulting gas can be short chain hydrocarbons (C1 – C4) which can be used as gas fuel.

The utilization of solid acid catalysts in the process of catalytic pyrolysis is commonly linked with a carbocation mechanism. Initially, the plastic waste material goes through pyrolysis resulting in the formation of lengthy carbon chain olefins. Subsequently, these olefins obtain H+ from the surface of the catalyst, leading to the creation of carbocation. This carbocation then experiences fragmentation into smaller hydrocarbon molecules with primary and secondary carbon ions positioned at the β site, followed by isomerization into more thermodynamically stable tertiary carbon ions. Moreover, persistent tertiary carbon ions liberate H^+ back to the catalyst, converting into olefins and other advantageous hydrocarbons [25]. The catalyst's presence led to a decrease in the cracking temperature of the C–C bond through the activation of the carbenium ions mechanism [21].

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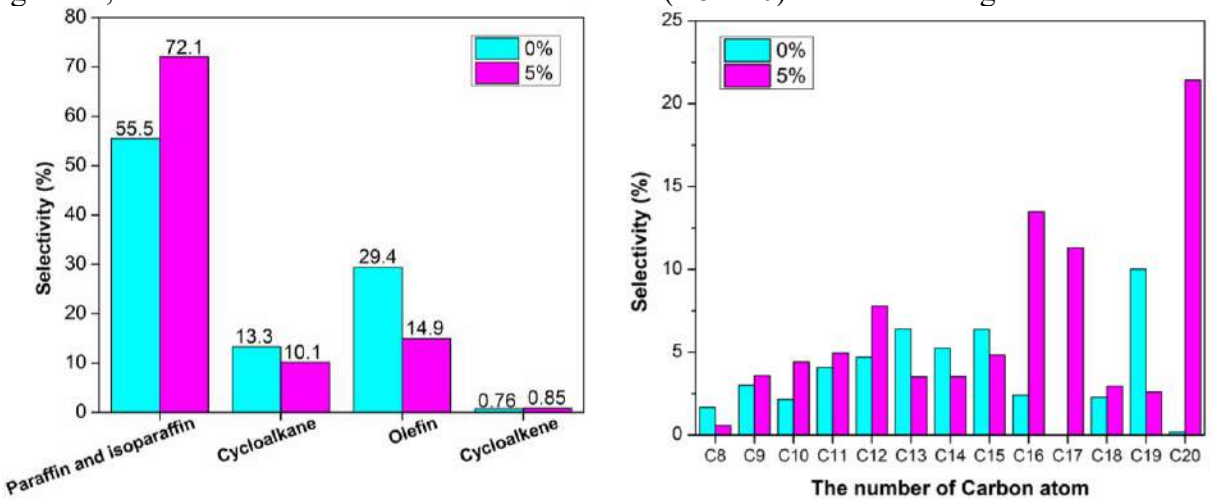
Furthermore, analysis of the compound components contained in the liquid product, both catalyzed and without catalyst, was then grouped based on the type of compound, as shown in Figure 4a, and based on the number of carbon atoms (C8-C20) as shown in Figure 4b.



(a) (b)

Figure 4. Grouping of liquid product content based on (a) type of compound, and (b) number of carbon atoms

Figure 4a shows the difference in the compound content of liquid products produced from pyrolysis without a catalyst and using a 5% catalyst. Paraffin and isoparaffin produced from the catalytic pyrolysis process tend to be higher than thermal pyrolysis. The cycloalkene content also tends to be slightly higher. In contrast, the cycloalkane and olefin content tends to be higher for liquid products produced via thermal pyrolysis. The existence of this difference may indicate the role of catalysts in the pyrolysis process. The higher formation of isoparaffins in the presence of a catalyst indicates the role of the catalyst in the isomerization of alkanes. In bifunctional catalyst systems, acidic sites catalyze isomerization reactions, whereas metals in reforming catalysts promote hydrogen transfer reactions [24]. Branched hydrocarbon compounds such as isoparaffins and aromatic compounds are reported to increase the octane value of fuel so that this content is important for improving fuel quality. This is in line with studies conducted by Ding et al. [21] who reported an increase in the content of aromatics and isomerized aliphatics, increased from 23.5% to 80.4% for LDPE pyrolysis catalyzed by zeolite HY.

Meanwhile, looking at the amount of carbon contained in the liquid product components (based on Figure 4b), it appears that the gasoline fraction, especially from C9-C12, is higher in the presence of a catalyst. Whereas, in the diesel fraction, the most dominant components are C16, C17 and C20. This also seems to be the reason the heavy oil content is reduced significantly with the presence of a catalyst and a high diesel fraction content. Further research needs to be carried out regarding variations in process conditions such as temperature and reaction time so that in the future we can get maximum product with the desired fuel fraction.

Physicochemical properties of liquid product

Analysis of the physicochemical properties carried out on the optimum results of High Density Polyethylene pyrolysis with a 5% NiMo/ZAS catalyst includes elemental content, density, heating value and viscosity. These properties have been summarized in Table 1.

Table 1. Physicochemical properties of liquid product and fuel fractions

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Properties	HDPE 5% catalyst	Gasoline	Diesel
Elemental analysis (%)			
C	85.50	-	-
H	13.68	-	-
N	n.d	-	-
O	0.82	-	-
Density (g/cm^3) ASTM D1298	0.81	0.72-0.74	0.83-0.85
HHV (MJ/kg)	38	46.86	42.51
Kinematic viscosity (cSt) ASTM D 445	1.02	0.775-1.03	2.0-5.3

According to Table 1, the liquid product resulting from pyrolysis retains oxygen compounds and oxygenate compounds generated during the pyrolysis process, constituting approximately 0.82%. The HHV value for liquid products stands at 38 MJ/kg, a figure that falls short of the HHV benchmark for fuel, encompassing both gasoline and diesel fractions [26]. Nonetheless, a comparison with various antecedent studies as documented by Miandad et al.[7] reveals that the utilization of catalysts has facilitated the advent of catalytic pyrolysis of plastic waste. This process exhibits the ability to transform plastic waste into liquid oil exhibiting akin attributes to conventional diesel fuel, including a high heating value (HHV) of 38–45.86 MJ/kg, a density range of 0.77–0.84 g/cm^3, a viscosity range of 1.74–2.5 mm^2/s, and a kinematic viscosity range of 1.1–2.27 cSt. Notably, the density and kinematic viscosity of the acquired liquid products seem to align with the density and kinematic viscosity ranges observed in conventional fuel fractions. The introduction of catalysts impacts the physical characteristics of pyrolysis liquid oil, especially viscosity which serves as a crucial parameter for all petroleum products. Elevated viscosity levels in oil can detrimentally affect engine performance by impeding the process of oil pumping into the engine during operations.

Conclusion

The generation of liquid substances through pyrolysis is enhanced by the presence of a catalyst and is directly proportional to the amount of catalyst utilized. Specifically, the percentages of gasoline and diesel components observe an increase to 21.3% and 63.4% respectively, while there is a significant decrease in the heavy oil component, indicating the breaking of long hydrocarbon chains. Examination of the liquid output reveals a Higher Heating Value (HHV) of 38 MJ/kg, a density of 0.81 g/cm^3, and a kinematic viscosity of 1.02 cSt. Further investigation is required into variations in operational parameters like temperature and reaction duration to optimize the production of the desired fuel fractions in the forthcoming studies.

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Analyzing the difficulties students face in comprehending fundamental concepts in the field of chemical kinetics and chemical equlibrium in the basic chemistry course

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Abstract. *This study analyzed students' understanding of chemical kinetics and equilibrium concepts. The Chemistry Department, FMIPA Unimed, students were randomly selected. A total of 93 students, from two classes (PSPK24E and PSKM24A), participated. The average scores for the two classes were 57,481 and 53,833, respectively, while the overall average was 55.520 (low category).* The average student absorption of reaction kinetics material is 56%. Sub-materials with absorption below 60% are: Basic concepts of reaction rates, Reaction rates and stoichiometry, Reaction rate constants, Determining rate equations and orders, and Determining simple reactions. *orders, Determination of half-lives, and*

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Collision theory. Students typically absorb 50% of chemical equilibrium material. Sub-materials with absorption below 60% are sub-materials. Topics include basic chemical equilibrium concepts, the Law of Chemical Equilibrium, expressions of equilibrium constants, degrees of dissociation, thermodynamics and chemical equilibrium, equilibrium shifts by Le Chatelier's Principle, and catalysts.

Keywords: difficulties students, fundamental concepts, kinetics chemical, and chemical equilibrium

Introduction

Basic Chemistry is one of the basic courses for students in the Chemistry Department. The purpose of this course is to equip students with various basic concepts in the scope of chemistry. The competencies obtained from the Basic Chemistry course can be used as a solid foundation for studying advanced chemistry courses. Good mastery of basic materials will provide reinforcement to students in studying various subsequent chemistry materials. Providing basic materials will make learning in the following materials more meaningful, in accordance with Ausubel's meaningful learning theory.

The material of reaction rate and chemical equilibrium is very important to discuss the sustainability of chemical reactions and the types of interventions that can be done so that chemical reactions can proceed as expected. The application of these concepts is widely carried out in various industries that involve the synthesis of a chemical compound. Mastery of both materials well will make it easier for students to learn chemical concepts at a higher level. The characteristics of both materials are abstract so that we all cannot see with the naked eye various events related to the sustainability of chemical reactions. Various events on a molecular scale can only be detected on a macroscopic scale using chemical instruments or directly. Due to the abstract characteristics of this material, various efforts are needed to create a various molecular modeling that can be sensed by students, so that students can more easily understand these concepts.

Education's success, aimed at improving human resources, is influenced by various factors. One such factor is teachers' ability to use assessments, evaluations, and learning outcomes [1]. Assessment involves collecting data or information using various techniques and sources to support decision-making [2]. This assessment aims to measure the level of achievement of learning objectives that have been determined in the learning plan [3]. The assessment process must be carried out during the learning process using an assessment rubric so that credible and impartial assessment results are obtained [4].

Assessment is the process of finding and interpreting evidence of student performance for use by students and their teachers to identify the extent to which students have absorbed the learning process, what their next goals are, and what needs to be done next to achieve them [5]. Teachers must know student learning development needs to ensure students experience the learning process correctly. Assessment emphasizes the learning process, so data must be collected from real student activities during the learning process.

Analysis of undergraduate chemistry students' difficulties in learning organic reaction mechanisms. Interviews with 12 students using problem-solving tasks on substitution reactions and nucleophilic elimination tested the classification of reaction mechanisms. Results showed that general support may be less useful and tailored support is needed [6]. The ability to propose reaction mechanisms using the electron-pushing formalism (EPF). Several studies have suggested that undergraduate and even graduate students face difficulties when trying to propose mechanisms using the EPF [7]. Analysis of students' difficulties in learning organic chemistry using the Perry

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Intellectual Development Model as a framework revealed that organic chemistry students who function as dualistic thinkers with the complexity of the subject matter [8].

The respondent's ability test revealed seven types of difficulties in the molecular geometry material. The three biggest difficulties were: 71% of students didn't understand the meaning of the Lewis symbol in covalent bonds; 65% didn't understand the effect of free electron pairs on molecular geometry; and 31% didn't understand the types of molecular geometry when asked about naming them [9].

Assessment aims to provide feedback on the progress of student learning, both for students, parents, and teachers and to improve student learning and development [10]. According to Popham [11] and Stecher [12] there are three objectives of assessment, namely (a) to develop learning and teaching, (b) to certify individual abilities, and (c) to evaluate the success of the program. Analysis of student difficulties in understanding conservation problems in chemical reactions obtained results that students have several misunderstandings [13]. Analysis of the topic of atomic orbitals, molecular orbitals, shows that the topics that are not well mastered are atomic orbitals and molecular orbitals with Slater determinants and the atomic orbital approach of atoms with many electrons [14].

Analysis of atomic structure and chemical bonding materials revealed that low mastery was observed in Bohr atomic model (25.95%), Wave mechanics atomic model (24.8%), Atomic properties (33.15%), Ionic bond formation (40.9%), Covalent bond formation (47.5), and Molecular shape (54.33). Sufficient mastery was found in Electron configuration in atoms (73.1), Octet and duplet rules (79.3), and Distinguishing ionic and covalent bonds (78.4). Good and very good mastery was observed in Quantum numbers (91.9), Properties of ionic compounds (91), and Exceptions to the octet rule (81) [15].

Analysis of computational chemistry-based learning media for atomic structure and chemical bonding in Basic Chemistry courses revealed low average scores (34.430) for PSPK23B, PSPK22C, and PSKM22B classes. The most challenging materials included wave mechanics atomic model (72.233), Rutherford atomic model (70.071), and atomic theory development (68.730). Chemical bonding material average score was 36.1 (very low), with lowest score in Properties of ionic compounds sub-material (17.5) and highest in forming covalent bonds sub-material (54.4). The most difficult materials were octet and duplet rules in chemical bond formation (71.055), exceptions to the octet rule in covalent bonds (70.696), and electron domain theory for determining molecular structure (69.838). [16].

Research Method

Location and Time of Research

This research was conducted in August - October 2024 at the Chemistry Department, FMIPA, State University of Medan, North Sumatra.

Population and Sample

The population in this study was all 1st semester students in the Chemistry Department, FMIPA, State University of Medan who took the General Chemistry course. The sample selection was done randomly. The number of samples in this study was 93 students consisting of 2 classes, namely: PSPK24E and PSKM24A. The samples used have represented the Study Programs currently owned by the Chemistry Department, FMIPA, Unimed.

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Research Instrument

The instrument used in this study was a test to determine the level of students' understanding of the concepts in the material of chemical kinetics and chemical equilibrium. The grid of questions on the material of atomic structure and chemical bonds is presented in Table 1.

Table 1. Grid of Test Questions

No	Sub material	Question Number
1	Basic concept of reaction rate	10, 15, 20
2	Reaction rate and reaction stoichiometry	2, 12
3	Rate Law and Reaction Order	1, 11, 21
4	Reaction rate constant	9, 19
5	Determination of Rate Equation and Reaction Order	8, 18, 22
6	Determination of Simple Reaction Order	7, 17
7	Determination of Half-life	24, 25
8	Factors Affecting Reaction Rate	3, 4, 13, 16
9	Collision Theory	6, 14, 30
10	Arrhenius Equation and Activation Energy	5, 29
11	Simple Reaction Mechanism	26, 28
12	Catalyst	23, 27
13	Basic concepts of chemical equilibrium	32, 42, 49
14	Law of chemical equilibrium	38, 48, 53
15	Equilibrium constant and reaction stoichiometry	36, 37, 46, 47
16	Various expressions of equilibrium constants K, Kc, Kp, Kx.	35, 45, 54
17	Equilibrium constant and degree of dissociation	40, 50, 56
18	Factors affecting equilibrium constant	38, 39, 51, 59, 60
19	Thermodynamics and Chemical Equilibrium	34, 44, 52, 57
20	Shift of chemical equilibrium: Le Chatelier's Principle	33, 43, 55, 58
21	Catalyst	31, 41

Results and Discussion

This section presents the research data that has been obtained in this research activity. As stated in the research methodology section, the sample in the research activity consisted of two classes, namely PSPK 24E and PSKM 24A. The learning outcome data for chemical kinetics and chemical equilibrium for class PSPK 24E is presented in Figure 1.

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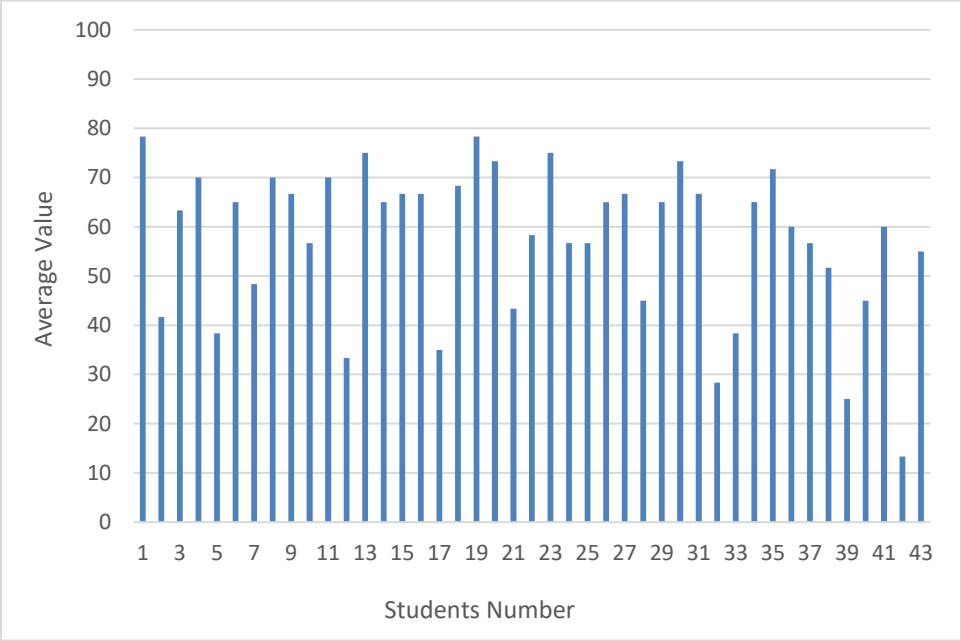

Figure 1. Learning outcomes of chemical kinetics and chemical equilibrium material PSPK24E

The average value of learning outcomes of chemical kinetics and chemical equilibrium material is 57.481 (less category). Based on the results of a more in-depth analysis, it was found that there were 19 students who obtained scores in the less category (scores below 60) and there were even 3 students whose scores were below 30. Data on learning outcomes of chemical kinetics and chemical equilibrium material for class PSKM24A are presented in Figure 2.

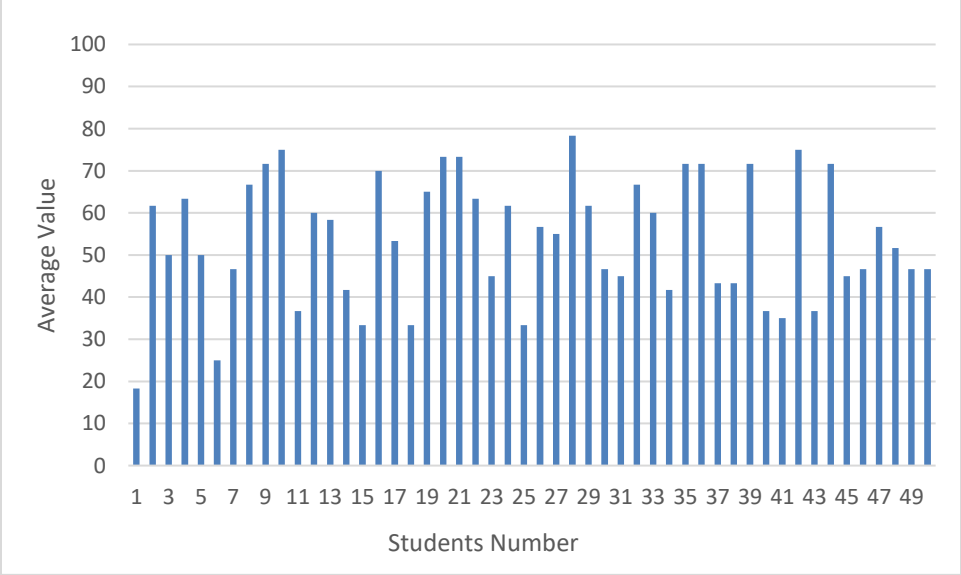

Figure 1. Learning outcomes of chemical kinetics and chemical equilibrium material PSKM24A

The average value of learning outcomes of chemical kinetics and chemical equilibrium is 53.833 (less category). Based on the results of in-depth analysis, 29 people obtained scores in the low category (scores below 60) and even 2 people with scores below 30. The total average score

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of the two classes was 55.520 in the less category. Based on the data on the achievement of the average value of student learning outcomes in chemical kinetics and chemical equilibrium in the less category, various efforts are needed to improve the quality of student understanding of chemical kinetics and chemical equilibrium.

In-depth analysis activities are conducted on sub-topics with low absorption or considered difficult by most students to assess learning outcomes in chemical kinetics and equilibrium. This provides insights to enhance learning in these areas. Table 2 presents students' absorption of chemical kinetics material.

Table 2. Students' absorption of material on chemical kinetics material.

No	Sub material	Percentage of student absorption		
		PSPK 24E	PSKM 24A	Average
1	Basic concept of reaction rate	56	52	54
2	Reaction rate and reaction stoichiometry	50	45	48
3	Rate Law and Reaction Order	67	65	66
4	Reaction rate constant	29	21	25
5	Determination of Rate Equation and Reaction Order	54	38	46
6	Determination of Simple Reaction Order	58	24	41
7	Determination of Half-life	63	39	51
8	Factors Affecting Reaction Rate	82	94	88
9	Collision Theory	60	35	48
10	Arrhenius Equation and Activation Energy	87	47	67
11	Simple Reaction Mechanism	83	48	65
12	Catalyst	86	49	68
	Amount	775	558	667
	Average	65	47	56

The average student absorption of the reaction kinetics material was 56% with an average absorption for the PSPK 24E class of 65% and the PSKM 24A class of 47%. The sub-material with the highest absorption with an average of 88% was the material factors that affect reaction rates. The sub-material with the lowest average absorption with an absorption of 25% was the Reaction Rate Constant. The sub-material with absorption below 60% was the sub-material: Basic Concept of Reaction Rate, Reaction Rate and Reaction Stoichiometry, Reaction Rate Constant, Determination of Rate Equations and Reaction Order, Determination of Simple Reaction Order, Determination of Half-Life, and Collision Theory. Based on these data, it is recommended to improve the quality of learning in these sub-materials. Data on the distribution of student absorption of the chemical equilibrium material is presented in Table 3.

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Table 3. Student absorption of chemical equilibrium material

No	Sub material	Percentage of student absorption		
		PSPK 24E	PSKM 24A	Average
1	Basic concepts of chemical equilibrium	56	47	52
2	Law of chemical equilibrium	59	57	58
3	Equilibrium constant and reaction stoichiometry	61	62	62
4	Various expressions of equilibrium constants K, K_c, K_p, K_x.	29	23	26
5	Equilibrium constant and degree of dissociation	43	46	45
6	Factors affecting equilibrium constant	46	89	67
7	Thermodynamics and Chemical Equilibrium	38	42	40
8	Shift of chemical equilibrium: Le Chatelier's Principle	55	44	50
9	Catalyst	67	45	56
	Amount	454	454	454
	Average	50	50	50

The average data on student absorption of chemical equilibrium material is 50% with an average absorption for PSPK 24E class of 50% and PSKM 24A class of 50%. The sub-material with the highest absorption with an average of 67% is the material factors that affect the equilibrium constant. There are only two sub-materials with absorption above 60%, namely: Equilibrium constant and reaction stoichiometry and Factors that affect the equilibrium constant. The sub-material with the lowest average absorption with an absorption of 26% is Various expressions of equilibrium constants K, K_c, K_p, K_x. Sub-materials with absorption below 60% are sub-materials: Basic concepts of chemical equilibrium, Law of chemical equilibrium, Various expressions of equilibrium constants K, Kc, K_p, K_x, Equilibrium constants and degrees of dissociation, Thermodynamics and Chemical Equilibrium, Chemical equilibrium shifts: Le Chatelier's Principle, and Catalysts. Based on these data, it is recommended to improve the quality of learning in these sub-materials.

Conclusion

The study revealed that the average scores for PSPK 24E and PSKM 24A classes were 57.481 and 53.833, respectively, while the combined average was 55.520. The student absorption of reaction kinetics material averaged 56%, with material factors affecting reaction rates having the highest absorption (88%). The lowest absorption was for the Reaction Rate Constant (25%). Sub-materials with absorption below 60% included Basic Concept of Reaction Rate, Reaction Rate and Reaction Stoichiometry, Reaction Rate Constant, Determination of Rate Equations and Reaction Order, Determination of Simple Reaction Order, Determination of Half-Life, and Collision Theory. Chemical equilibrium material absorption averaged 50%, with material factors affecting equilibrium constants having the highest absorption (67%). Sub-topics with below 60% absorption included Basic concepts of chemical equilibrium, Laws of chemical equilibrium, Various expressions of equilibrium constants, Equilibrium constants and degrees of dissociation, Thermodynamics and Chemical Equilibrium, Shifts in chemical equilibrium: Le Chatelier's Principle, and Catalysts.

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Preparation of biochar catalyst from coconut shell impregnated with nickel metal as a heterogeneous catalyst

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Abstract. *Considering its many resources and ecologically favorable characteristics, biochar has gained attention as a potentially heterogeneous catalyst for a variety of chemical processes. To increase its catalytic activity, nickel metal (Ni) was injected into biochar constructed from coconut shells. This study's primary goal is to create a catalyst based on charcoal that contains nickel. The coconut shells were pyrolyzed at high temperatures while under nitrogen flow to create biochar. A nickel solution with nitrates was then used for impregnation. FTIR, XRD, as well as XRF, were among the analytical methods used to characterize the resultant catalyst. While XRD revealed the existence of the nickel oxide stages on the biochar, FTIR measurements demonstrated alterations in the functional elements on the surface of biochar following nickel impregnation. The effectiveness of the impregnation with a consistent nickel concentration across the charcoal surface was validated by XRF measurements. The study's findings show that coconut shell biochar has the potential to be a useful and sustainable heterogeneous catalyst for waste and energy processing.*

Keywords: *Pyrolysis, Coconut Shell, Biochar, Nickel Impregnation, Heterogeneous Catalyst*

Introduction

The use of renewable raw materials is crucial for sustainable development because of the issues of energy demands and environmental contamination [1,2]. Heat, electricity, liquid fuels, hydrogen, as well as high-value chemicals can all be produced from biomass, a plentiful natural resource comprised of lignocellulose, plants, microalgae, and biowaste of the household, urban, and agricultural sectors, including animal fats [3,4]. Biomass can be broken down into solid carbon residues called biochar and biofuels like syngas and bio-oil using thermochemical decomposition methods like pyrolysis or gasification [5–7]. The thermal breakdown of biomass at moderate temperatures (350–700°C) with little to no oxygen results in the production of biochar, a carbon-rich porous solid [8,9]. The thermochemical procedure employed, and the qualities of the biomass feedstock have a significant impact on the chemical and physical properties of biochar [10–12]. In addition to having an enormous area and high porosity, biochar's customized porosity and functional surfaces allow it to be readily modified as a platform for the manufacture of different functionalized carbon materials owing to its numerous functional surface groups (C-O, C=O, COOH, and OH) [6,13]. These characteristics make biochar an effective adsorbent for soil amendment, activated carbon synthesis, and air and water pollution [14,15].

Given its extensive availability, low cost, enormous surface area (which promotes significant dispersion along with stability for metal phases), durability in basic and acidic media, and other advantageous physical/chemical surface characteristics, biochar (BC) has recently been

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used extensively in heterogeneous catalysis systems, particularly as a metal support [6]. In numerous applications involving a broad range of reactions, such as trans-esterification/esterification, contributing reforming/cracking, gasification/pyrolysis, hydrolysis, electrochemical and photocatalytic reactions, and persulfate/carboxymethyl sulfate oxidation, among others, biochar materials have demonstrated exceptional activity as a catalyst or catalyst support.

Plantation trash and other abundant sources can be used as feedstock for BC [16], bamboo [17], corn straw rice husk [18], and so on which are quite abundant. A natural resource for creating porous carbon, coconut shell serves as one of the possible feedstocks generated from plant waste which is frequently found in tropical regions. Furthermore, KOH, which is present in coconut shell ash, helps to activate the carbon-containing substrate [19]. Finally, it is highly advantageous for the economy and environment to produce catalysts with exceptional performance from low-value waste [20]. The primary issue with employing carbon as a metal support involves the high propensity for metal sintering brought on by the high-temperature breakdown of the oxygen functional groups that comprise the BC surface [21,22]. Conversely, Kim, et al. [23] noted that the structure of activated carbon derived from coconut shells had a low oxygen content, suggesting that it can inhibit metal sintering onto carbon supports. The choice of metals in a heterogeneous catalyst is crucial to the catalytic process providing support. Exceptional catalytic performance and cheap cost have been demonstrated for nickel (Ni) metal [24]. According to Yang et al. [25], Ni-doped biochar generates syngas and hydrogen at 78.2% by weight, 26 mmol H2/g-biomass, and a biomass conversion efficiency of 73%. Ni-based catalysts also perform well in hydrogen gas production applications when it comes to breaking C-C and C-H bonds [26]. Therefore, the goal of this research is to create BC catalysts of coconut shells by modifying them with the inclusion of Ni metal, then characterize them to determine their properties that are utilized in the procedure of steam reforming to produce hydrogen gas.

Method

Materials

Coconut shell (*Cocos nucifera L.*) as raw material, nitrogen gas, KOH (p.a Merck), HCl (p.a Merck), Ni $(NO_3)_2 \cdot 6H_2O$ (p.a Merck), $Fe(NO_3)_3 \cdot 9H_2O$ (p.a Merck), Aquades and Aquabides.

Coconut Shell Biomass Preparation

After being sliced into small pieces, the shell of the coconut is left to dry in the heat of the sun for two days or for 24 hours in the oven at 110 ^oC. The coconut shell pieces are then obtained by drying them in an oven to eliminate the water content.

Coconut Shell Pyrolysis Process

A fixed-bed reactor is used to carry out the pyrolysis process. After inserting the coconut shell, the reactor is placed inside a furnace and heated to 500℃ for two hours while nitrogen gas flows at a rate of ± 5 ml per second. A cooling hose is used to circulate the reaction product. Weighing is done on the obtained biochar and liquid product.

Biochar Catalyst Preparation

A 100-mesh sieve is used to grind and filter the pyrolysis biochar. The amount of 100 g for pyrolysis biochar is neutralized by distilled water after being cleaned with 0.1 M HCl. After that,

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it is dried for 12 hours at 110 °C in an oven. After that, it is activated using 250 ml of distilled water and KOH at a 4:1 (w: w) ratio. Dehydrated for 24 hours at 110 °C in an oven.

Biochar/ Ni (II) Preparation

The wet impregnation approach was used to modify the Pulungan et al. [27] process, which is followed in the catalyst synthesis. The metal loaded has a 1% (w/w) concentration. 10 g of biochar material has been heated at 500 ºC for an hour into nitrogen-gas flow as an average velocity of ± 5 ml/sec is loaded with the metal precursor. After five hours of refluxing and stirring at 80 ºC, the combination of precursors of metal, and biochar is dried in an oven set to 120 ºC. Additionally, this metal-impregnated biochar underwent oxidation for two hours at 500 ºC using oxygen gas flowing at a flow rate of ±5 ml/sec until Ni (II) biochar was produced.

Characterization of Biochar/ Ni (II)

The catalysts with a Fourier-transform Infrared spectroscopy (FT-IR, Shimadzu IR Prestige-21), X-ray diffraction equipment (XRD Shimadzu 6100), and X-ray fluorescence (XRF) were used to analyze the catalyst structure.

Results and Discussion

Structural Analysis

The catalyst molecule structure BC is examined using XRD analysis both before and subsequent modification. The diffractogram of the XRD test results is shown in Figure 1. according to the study [28]. A clear carbon deposit peak at $2\theta = 22.6^{o}$ appeared in all catalysts. Graphite formation is indicated by the diffraction peak at approximately $2\theta = 43.12°$ [29,30]. Further supporting the prevalent minimal graphitization along with the regularity degree of biochar are two broad, low-intensity diffraction peaks found at 22.6 and 43.12° corresponding to the (002) and (100) crystal planes being part of the graphite structure [30,31]. In contrast, the Ni metal peak was detected at $2\theta = 43.5^{o}$ in the BC/Ni catalyst [32]. Nickel (ii) nitrate hexahydrate was broken down during the calcination process, as evidenced by the identification of NiO nanoparticles as the Ni metal that developed on the surface of the biochar [33].

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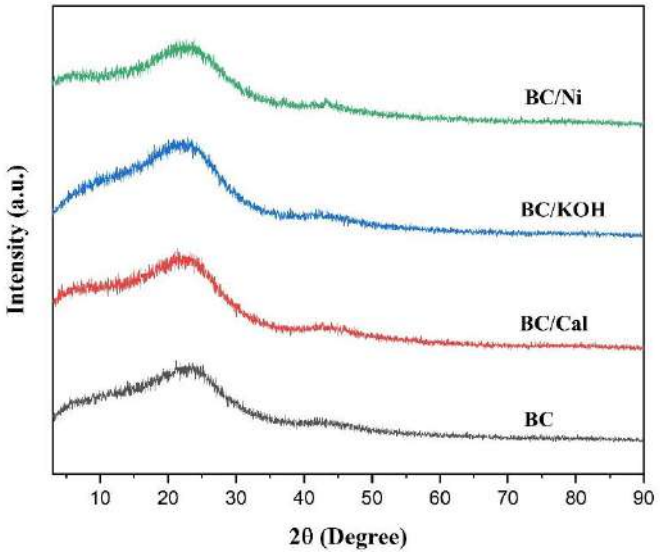

Figure 1. XRD diffractogram analysis of BC, BC/Cal, BC/KOH, and BC/Ni.

Functional Group Analysis

Changes in the BC catalyst's functional groups preceding and following modification are detected using FTIR analysis. The absence of distinctive OH peaks in all catalysts, as seen in Figure 2, indicates the pyrolysis process effectively inhibited the development of the water-based phase in the final biochar. Vibrations from C-H bonds from alkyl and acryl groups were detected by the BC catalyst peak around 2900-3000 cm^{-1}, suggesting the existence of aliphatic components of the biochar structure [34]. Following modification with the inclusion of Ni metal, the vibration associated with the C=O stretching peak was detected at 1690 cm^{-1}. Changes in the BC catalyst's functional groups before and after modification are detected using FTIR analysis. The C=C (aromatic ring) from the lignin structural vibration and the C-O-C vibration from stretching are linked to the peaks at 1579 and 1002 cm^{-1} [35]. Aromatic CH and benzene rings are identified by the peaks at 746, 808, and 860 cm^{-1} [36–38]. The percentages of -C-O-C and C-C bonds increased whereas the content of other functional groups that included oxygen decreased following KOH modification. This suggests that KOH activation dehydrated and decarboxylated the biochar, improving aromatization [39]. Furthermore, upon KOH activation, the strength of the absorption peaks rose, suggesting the creation of additional chemical groups [36]. A large peak at 1224 cm^{-1}, linked to C-O vibrations, and at 594 cm^{-1}, linked to the production of Ni-O-C bonds created by NiO and support by oxygen bridges, were seen in the BC/Ni catalyst enhanced with Ni metal support. Electrostatic attraction and polarization cause cations to interact with components that have π-rich electron configurations in the Ni^{2+}-π association process. The formation of a broad C-O peak in BC/Ni can be seen following the metal adsorption process because the aromatic organization in biochar is the primary π donor in the Ni^{2+} process. The cation-π communication is a strong intermolecular relationship among cations and aromatic systems [34,40].

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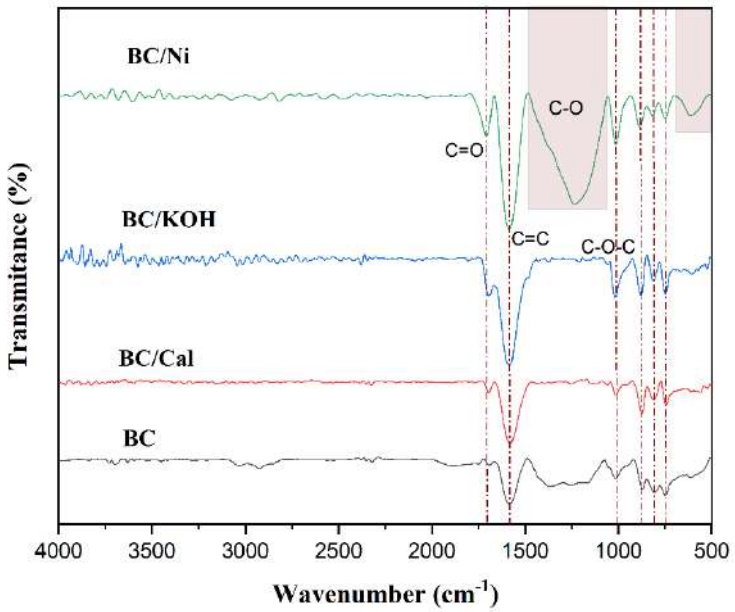

Figure 2. Fourier-Transform Infrared Spectroscopy (FTIR) of BC, BC/Cal, BC/KOH, BC/Ni.

Component Analysis

The elements present in the biochar both before and after alteration were identified by X-ray fluorescence (XRF) analysis, and the results are listed in Table 1. According to Table 1, BC without modification has the highest concentrations of numerous metal minerals, including potassium (2.17%) and aluminum (1.51%). On BC, the metal impregnation procedure has been completed. It is understood that 1.35 % of the BC terrain was made up of metal. The mass achieved is roughly equal to the goal for the metal instilled in BC, which is 1%, and it correlates with the earlier XRD and FTIR data analysis detecting the presence of Ni metal. This indicates that the wet impregnation approach worked in accelerating the metal development process. The abundance of potassium (K), magnesium (Mg), manganese (Mn), to iron (Fe) elements in biochar, in addition to Ni metal, has a beneficial effect on raising the reaction rate to speed up the conversion process and produce gas [41]. Conversely, biochar is regarded as a catalytic support; to a certain degree, it can react with H_2O/CO_2 via the Boundouard reaction or water gas reaction to generate more gas products such as H_2, CO, or CO_2 [32].

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Table 1. Component Analysis of the Catalyst

Components	Mass (%)			
	BC	BC-Cal	BC-KOH	BC-Ni
Al	1.51	1.57	1.41	1.02
Si	0.236	0.124	0.0559	0.230
P	0.159	0.158	0.125	0.205
S	0.0740	0.120	0.0709	0.218
Cl	0.0805	0.0723	0.0570	0.0322
K	2.17	2.00	1.69	0.473
Ca	0.0606	0.0596	0.0445	0.0833
Cr	0.0038	0.0091	0.0012	0.0207
Mn	0.0013	0.0024	0.0006	0.0114
Fe	0.0634	0.0781	0.0192	0.365
Ni	0.0004	0.0040	0.0010	1.35
Cu	0.0034	0.0038	0.0027	0.0090
Zn	0.0012	0.0016	0.0009	0.0053
Sr	0.0012	0.0007	0.0006	0.0007
Ag	0.0001	0.0001	0.0001	-
Cd	0.0012	-	-	-
Zr	0.0001	0.0001	0.0001	0.0002
Br	0.0002	-	-	-
Rb	0.0026	0.0001	-	-
Mo	-	0.0002	-	0.0003
Co	-	-	-	0.0048

Conclusion

In the study's findings, biochar treated with nickel (Ni) and activated with KOH exhibited improved catalytic qualities. The biochar's graphitic structure was validated by XRD analysis, and the modified sample showed extra NiO peaks, a sign of effective nickel impregnation. Following pyrolysis, FTIR examination revealed the loss of OH groups and the rise in aromatic and aliphatic structures because of KOH activation, which fortified the C-O-C and C-C bonds. According to XRF measurements, the biochar's nickel loading was 1.35%, and the catalytic activity was supported by components including K, Mg, Mn, and Fe. All things considered, this altered biochar demonstrated a great deal of promise for catalytic uses in gas generation and conversion procedures.

Acknowledgments

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Bioactivity ethanol extract of gotu kola leaves *(Centella asiatica (L.) Urban)*

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Abstract. Gotu Kola (*Centella asiatica (L.*) Urban) is an Indonesian plant that has bioactivity, which has the potential to be used as a basic ingredient for medicinal plants. In this study, we report the ethanol extract of gotu kola leaves (*Centella asiatica (L.*) Urban) originating from Dolok Nagodang Village, Uluan District, Toba Regency, North Sumatra Province. The activity tests carried out on the ethanol extract of gotu kola leaves were toxicity tests, phytochemical screening, antidiabetic and antibacterial tests against Staphylococcus aureus and Streptococcus pyogenes bacteria. The tests carried out in this research were toxicity tests using the BSLT test, phytochemical test, antidiabetic test (α-amylase enzyme inhibition test), and antibacterial test (inhibition test). The results of the toxicity test at a concentration of 1000 ppm obtained an LC_{50} of 126.03 µg /ml, indicating that it has toxic properties; the results of phytochemical screening, the compounds found were flavonoids, saponins, tannins and steroids; amylase enzyme inhibition test at a concentration of 500 ppm obtained an LC_{50} of 108.79671832 ppm with the acarbose standard; The extract inhibition test against Staphylococcus aureus bacteria at a concentration of 10% obtained 9.1 mm, and for Streptococcus pyogenes bacteria obtained 5 mm.

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Keywords: Gotu Kola leaves *(Centella Asiatica (L.) Urban)*, Toxicity, Phytochemical, Antidiabetic, Antibacterial

Introduction

Utilization of Herbal plants as a material drug has become increasingly popular over the years, liked by the community, which gives motivation to the utilization of herbal medicine that originates from plants for health and creates conditions that encourage the development of studies on plant drugs [1]. Metabolites secondary in plants produce diverse bioactive molecules, making them a source material for various types of herbal medicine. Part of a big drug which originated from a plant developed because its use is liked as a traditional treatment [2]. Various part plant like roots, leaves, bark, wood, and other parts other used as material drug traditional (back) to nature) [3,4]. Society more choose alternative this because considered relative cheaper, can reachable by all over layer public, as well as can more efficient and not cause effect chemistry compared to with usage drug medical [5].

Gotu kola leaves *(C. asiatica L.)* is many wild plants grow as grass found in gardens, fields, edges road as well as rice field embankment, colored green. Plant This originate from area Asia tropical, spread in Asia Southeast, including Also Indonesia, India, Republic People Chinese (PRC), Japan and Australia [6]. Research scientific show efficacy gotu kola among them effect antineoplastic, effects protector ulcer stomach, lowering pressure wall vessels, speed up healing wound, adder lust Eat, fever, snake bite, refreshing the body, lowering fever, cough dry, nosebleeds, increased intelligence, and antithrombosis [7]. Flavonoid content in extract ethanol leaf gotu kola can hinder formation reaction oxidation [8,9]. The presence of content chemistry and bioactivity from plant can be known through phytochemical tests and tests toxicity [10]. *Brine Shrimp Lethality Test* (BSLT) Method is method test activity a compound use animal test in the form of shrimp larvae *Artemia salina leach.* This method has been used since 1956. BSLT method chosen because it is fast, simple, economical and the results can be repeated [11]. Phytochemicals is a compound active medical which found in plant part such as root, wood skin, leaf, flower, seed [12]. Screening Phytochemicals in this research aims to know the group compounds contained in extract ethanol leaf gotu kola *(C. Asian L.).* Leaf properties pegagan which can hinder reaction oxidation it is possible can inhibits the amylase enzyme. In plants that are can hinder amylase enzyme is possible can utilized as material herbal medicine as antidiabetic. Gotu kola own characteristic antibacterial, experts believe gotu kola potential as element simple in treatment traditional [13]. Screening Phytochemicals is method which simple, fast, as well as very selective which can used for identify compound group as well as know existence compound – compound active distributed biological in network plant [14]. Ethanol is good polar solvent for dissolve polar compounds, some plants that have flavonoids compound in general can hinder amylase enzyme [15]. Extract ethanol leaf gotu kola own activity as antidiabetic, this has been reported can lower blood sugar levels induced mice alloxan [16]. This study reports bioactivity extract ethanol leaf

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gotu kola originate from Village Mountain Nagodang, Subdistrict Uluan, Toba Regency, North Sumatra Province.

Methodology

Material

The tools used in this research are a stem mixer, balance analytics, spatula, beaker glass, bottle maceration, rotary evaporator, tube reaction, pipette drops, vacuum, funnel buncher, Erlenmeyer buncher, vials, hot plate, and light incandescent (lighting Larvae *of A. salina*). Digital Scales, Blender, 60 Mesh Sieve, Measuring Cup, Glass Jar, Rotary Evaporator, Paper Filter, Buchner Filter, Autoclave, Bunsen Burner, Erlenmeyer, Stirrer, Water Bath, Petri Dish, Plastic Wrap, Refrigerator, Laminar Flow, Incubator , Cuvette, UV Vis Spectrophotometer, Vortex , Vial Bottle, Micropipette, Pipette Tips, Tweezers, Vernier Caliper, L Rod, Microplate, vial bottle, cotton board, microplate 96, aluminum foil, plastic wrap, needle ose, beaker, spatula, paper packaging . The materials used in this study are: plant leaf pegagan (*Centella asiatica (L.) Urban)* as the sample studied, obtained from Dolok Nagodang Village, District Uluan, Toba Regency, North Sumatra Province. Extraction process compound active from plant leaf pegagan (*Centella asiatica (L.)* Urban) uses n-hexane solvent, ethyl acetate, and ethanol, 1 % $FeCl_3$, 2N HCl, distilled water, reagent dragendorff, acetate anhydrous, H_2SO_4 thick, Na_2SO_4, fluid DMSO 2%, paper filter Whattman, NaCl and Larvae shrimp *Artemia salina Leach.* Potassium Na tartarate, distilled water, α- amylase, phosphate buffer pH 7, Dimethyl Sulfoxide (DMSO), 3.5 dinitro salicylate (DNS), 2M NaOH, starch, acarbose. Mueller Hinton Agar (MHA), MHB (*Mueller Hinton Broth),* distilled water, test bacteria (*Staphylococcus aureus, Propionibacterium acnes, Streptococcus pyogenes*), physiological NaCl, DMSO, blank disk, chloramphenicol, MHB media, MHA media, chloramphenicol and solution 0.5 McFarland standard.

Processing of Gotu Kola Leaves (C. asiatica L.)

The sample used in this study was leaf gotu kola *(C. asiatica L.).* The sample was collected and cleaned of the remaining dirt. After cleaning, the leaves were dried in the sun at room temperature. Then, the dry sample was refined until it became powder [17].

Making Extract Leaf Gotu kola (C. Asian L.)

Extract using the maceration method, with a weighed sample of powder extract from the leaf of Gotu Kola (C. Asian L.), was made. It was placed into a receptacle glass and then soaked with 96% ethanol. Then, the receptacle was closed with aluminum foil and left for 5 days while stirring once in a while. It was then filtered with a paper filter so that the filtrate was produced [18].

Alkaloid Group Compound Test

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About 0.5 mL of extract was dissolved in 1 mL of 2N HCl. Then, it was added to distilled water up to 9 mL, followed by 5 drops of reagent Dragendorff, forming a brick-red sediment to signify the presence of alkaloids.

Flavonoid Group Compound Test

About 2 mL of the extraction was heated and added to ethanol. 0.1 grams of magnesium powder and four drops of HCl were added to the solution. The formed solution, colored red, shows the presence of flavonoids.

Saponin Group Compound Test

About 10 mL of water was added to the extract and heated. Next, the solution was cooled and shaken strongly for 10 seconds. The foam formed for 10 minutes is 1-10 cm high. On the addition of 2N HCl, the foam will disappear.

Steroid Group Compound Test

The extracts were dissolved in 0.5 mL of chloroform and then added to 0.5 mL of sour acetate anhydride. Next, this mixture was dripped with 2 mL of concentrated sulphate acid through the wall tube. When formed, a bluish-green color indicates the presence of steroids.

Tannin Group Compound Test

About 0.5 mL of extract was added to 10 ml of distilled water, which was then supplemented with 3 drops of FeCl3 1%. If the test result is positive for tannin, the mixture will be green-black in color.

Toxicity Test

The solutions of 1000 ppm, 500 ppm, 100 ppm, and 50 ppm concentrations was put into test tubes, each concentration repeated four times. Then, 10 shrimp larvae that had been two days old were added to each test tube. The number of larvae that died at each concentration was counted after 24 hours and compared with the control.

***Test Antidiabetic* [19].**

Preparation of 20 U/ mL α-amylase enzyme solution

About 20 mg of α-amylase was weighed and then dissolved in 10 mL of phosphate buffer pH 7.

Preparation of 0.5% starch solution

About 0.05 grams of starch were weighed, then dissolved in 10 mL of phosphate buffer pH 7. Furthermore, the solution was heated for 5-10 minutes.

Preparation of 3, 5 dinitro reagent salicylate (DNS)

About30 g of potassium Na tartarate were weighed then dissolved with 2 M NaOH up to 20 mL, heated until dissolved (Solution A). Weighed 1.095 g of DNS and dissolved in distilled water up

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to 50 mL (Solution B). Solution A and solution B are mixed, and distilled water is added up to 100 mL.

Preparation of Acarbose solution

About 5 mg of acarbose was dissolved in 10 mL of DMSO (500 ppm) and then diluted into 5 concentrations: 300 ppm, 250 ppm, 200 ppm, 150 ppm, and 100 ppm.

Preparation of the extract solution

About 5 mg of extract from each solvent was dissolved in 10 mL of DMSO to 500 ppm as the stock solution. Then, it was diluted to 400 ppm, 300 ppm, 200 ppm, and 100 ppm.

Extract Solution with Enzyme (S1)

Pipette 50 µL of extract solution of 500 ppm, 400 ppm, 300 ppm, 200 ppm, and 100 ppm, then add 950 µL of phosphate buffer PH 7, then add 500 µL of 0.5% starch solution, and then pre-incubate. in a water bath at 37º C for 5 minutes, 500 µL of enzyme solution was added and incubated at 37º C for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV- Vis spectrophotometer.

Extract Solution without Enzyme (S0)

Pipetted 50 µL of each extract solution of 500 ppm, 400 ppm, 300 ppm, 200 ppm, and 100 ppm, added with 950 µL of phosphate buffer pH 7, then added with 500 µL of 0.5% starch solution and then pre-incubated in a water bath at 37ºC for 5 minutes, 500 µL of phosphate buffer pH 7 was added and incubated at 37ºC for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV- Vis spectrophotometer.

Acarbose Solution with Enzymes

Pipetted 50 µL of acarbose solution of 300 ppm, 250 ppm, 200 ppm, 150 ppm and 100 ppm respectively then added with 950 µL of phosphate buffer pH 7, then added with 500 µL of 0.5% starch solution and then pre -incubated in a water bath at 37ºC for 5 minutes, 500 µL of enzyme solution was added and incubated at 37ºC for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV- Vis spectrophotometer.

Acarbose solution without enzyme

Pipetted 50 µL of acarbose solution of 300 ppm, 250 ppm, 200 ppm, 150 ppm and 100 ppm respectively then added with 950 µL of phosphate buffer pH 7, then added with 500 µL of 0.5% starch solution and then pre -incubated in a water bath at 37ºC for 5 minutes, 500 µL of pH 7

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phosphate buffer solution was added and incubated at 37ºC for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV-Vis spectrophotometer.

Preparation of Control Solution

Pipetted as much as 50 µL DMSO, added with 950 µL phosphate buffer pH 7, then added with 500 µL 0.5% starch solution and then pre-incubated in a water bath at 37ºC for minutes. 500 µL of enzyme solution was added and incubated at 37ºC for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV- Vis spectrophotometer.

Preparation of Blank Solution

About 50 µL DMSO was added with 950 µL phosphate buffer pH 7, 500 µL 0.5% starch solution was added and pre-incubated in a water bath at 37ºC for 5 minutes, 500 µL of pH 7 phosphate buffer solution was added and incubated at 37ºC for 25 minutes. After 30 minutes, 2000 µL of DNS was added and heated in a water bath at 70ºC for 10 minutes, then the absorbance was read at a wavelength (λ) of 498 nm using a UV—Vis spectrophotometer.

Antibacterial Test

Sterilization of Tools

To ensure cleanliness, the tools that will be used in testing were sterilized. Glassware like Erlenmeyer, Petri dish, glass measuring cup, L rod, and wrapped vial bottle with paper were sterilized in an autoclave at 121 ℃ for 15 minutes. After the autoclave process, the tools were left alone for 15 minutes. Ose needle and tweezers were sterilized using this method and burned with fire until glowing.

Production and Breeding Bacteria

About 7 grams of Mueller Hinton Agar (MHA) were dissolved in 180 ml of distilled water, using an Erlenmeyer flask. Solution, then sterilized in an autoclave at a temperature of 121℃ for 15 minutes. After that, the solution was homogenized with the stirrer in a water bath until boiling. Solution was then poured into a sterile petri dish, let stand for 15 minutes, closed with plastic wrap, wrapped with paper, and placed into the refrigerator. MHA media that has been stored in the refrigerator is taken out and left in a laminar flow until it reaches the desired temperature. After reaching the temperature space, test bacteria were taken with a cotton bud and inoculated on MHA media with the zig-zag scratch technique. The media was then incubated in an incubator at 37˚C for 24 hours. This treatment is repeated for every type of test bacteria.

Preparation of MHB Medium

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About 5.25 grams of MHB are added to an Erlenmeyer flask and mixed with 250 mL of distilled water. The solution is then sterilized using an autoclave at 121 ℃ for 15 minutes and heated on a hot plate.

Preparation of Bacterial Suspension

Bacteria test results rejuvenation changed into suspension by adding physiological NaCl until half the vial bottle was filled, then adding 2 ounces of bacteria. The suspension was homogenized using a vortex for 15 seconds. Turbidity suspension was then compared and adjusted with the standard 0.5 McFarland solution.

Determination of inhibition zone diameter

The test solution was prepared in various concentrations: 1%, 2.5%, 5%, and 10%. For 1% concentration, weigh 0.05 g of extract and dissolve in 5 ml of ethanol using a glass measure, then stir until homogenized and transfer to a labeled vial bottle. Repeat this procedure for concentrations of 2.5% (0.125 g extract), 5% (0.25 g extract), and 10% (0.5 g extract), each dissolved in 5 ml of ethanol. Prepare nine petri dishes containing MHA and equipment like a Bunsen burner, an L rod, tweezers, a micropipette, pipette tips, chloramphenicol, DMSO, and a blank disk. Mark a Petri dish with six corresponding lines, extract concentration used, and control positive and negative, with numbers 1 to 6. Prepare a suspension of Staphylococcus aureus, Propionibacterium acnes, and Streptococcus pyogenes bacteria. Sterilize the L rod and tweezers with a burn. Pour 100 µL suspension of Staphylococcus aureus bacteria on each line in the petri dish using micropipettes and pipette tips, then flatten with the L bar. Place chloramphenicol at number 1 (control positive) and blank disks on numbers 2 to 6 using tweezers. Add 200 µL of DMSO to number 2 (control negative) using a micropipette. Add 200 µL of each extract at numbers 3 (1%), 4 (2.5%), 5 (5%), and 6 (10%) using micropipettes and pipette tips, after previously vortexing. Let the petri dish sit for several minutes, then close with plastic wrap and incubate at 37 ℃ for 24 hours. After 24 hours, measure the diameter of the clear zone formed using the term push. Repeat the same procedure for the other three bacteria.

Determination of KHM Value

First, prepare a solution of chloramphenicol, microplate 96, MHB + Suspension bacteria, and suspension bacteria. For MHB creation + suspension, bacteria are incubated in 9x MHB using 1000 μL, then reinserted in 4x MHB using a 200 μL micropipette, then in 1x MHB using a 100 μL micropipette, and finally in 1x bacterial suspension using a 100 μL micropipette, so the total is 9900 μL MHB + 100 μL suspension. For making the Solution, chloramphenicol 3 mL, with 1.5 mg of chloramphenicol solid + 3000 μL of DMSO. So it becomes a 3 mL chloramphenicol solution with a concentration of 500 ppm. Then insert as much as 100 μL of MHB Media into the first row hole of column A-H. Then the 2nd row is inserted with 100 μL of MHB + bacterial suspension from column A-H. Next, rows 3 and 4 are inserted 100 μL of MHB media from column A - H +

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100 **μ**L of chloramphenicol solution from column A - H by inserting 100 **μ**L of MHB media starting from column A - H, then inserting 100 **μ**L of chloramphenicol solution from column A then taken return as much as 100 **μ**L and transferred to column b, and so on. And hole 5 - hole 12 is inserted 100 **μ**L MHB + 100 **μ**L extract and starting from column A - H. Insert 100 **μ**L MHB from column 5 - column 12, then insert 1% extract as much as 100 **μ**L from row 12, then take **μ**the 100 L again using a microtip and micropipette, and then transfer to row 11, then take it again and transfer to row 10, and so on until row 5 and repeat 2 times, and so on with extract 2.5%, 5%, and 10%, and also carried out with 2 x repetitions. Then covered with aluminium foil, and incubated at 37 °C for 24 hours. And do the same with the other bacteria℃

Results and Discussion

Gotu Kola Leaf Extract

The method of extraction used is maceration. Soluble compounds in the solvent will diffuse out of the powder materials and produce a solution extract. This research showed that maceration, a simple, inexpensive, and non-invasive method, does not require complicated equipment. Therefore, this method is widely used to extract compounds from various materials such as plant medicines, spices, and products.

Furthermore, the extraction process is carried out with method maceration with method soak powder simple as much as 400 grams with solvent 96% ethanol in a receptacle for 1x24 hours while once in a while stirred Then replaced solvent new for 3 days. The solvent used in this research is ethanol 96%. Solvent ethanol 96% easily has polar compounds that evaporate, so it is good to use as a solvent. Ethanol 96% can also have high polarity from many other solvents. In this maceration process, repetition is as many as 3 times [20]. The samples that have been macerated and then filtered use a paper filter. The purpose of this is to filter for filtrate and residue. Next, the filtrate obtained from the results filtering is subjected to coagulation using a rotary evaporator. The temperature used in the thickening process is 78°C, so that a heavy extract is obtained, thickened with ethanol as much as 88,578 grams.

The extract obtained was entered into the bottle sample, coated with aluminium foil, and then placed in the refrigerator. This aims to extract avoidance from mushrooms. The yield produced becomes a reference: the longer the extraction time, the bigger the yield that will be obtained. This is because the longer the entry process takes, the more chance there is for interaction between the solvent and the cell material, resulting in larger and growing numbers of compounds that will diffuse out of the cell [21].

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Figure 1. Ethanol Extract of Gotu Kola Leaves

Yield is an essential mark in making a product. Yield results are comparison-heavy, dry products produced with heavy Raw material [22] Ethanol is a solvent used in the extraction process. Group alcohol has its ability to extract compared to other solvents.

Table 1. Pegagan Leaf Extract Yield Results

Types of Solvents	Yield %
Ethanol	4.515%

Phytochemicals

We found steroids, saponins, tannins, and flavonoids by phytochemical screening with the alkaloid test. Steroids and saponins are a triterpenoid group. Tannins and flavonoids are phenolic compounds. The compound metabolite uses secondary reagent dye when testing compound phytochemicals, except in saponin testing.

Table 2. Results of Phytochemical Testing of Ethanol Extract from Pegagan *(Centella asiatica (L.)*.Urban*)*

Group Compound	Ethanol
Alkaloid	-
Flavonoids	+++
Saponins	++
Steroid	+++
Terpenoid	-
Tannin	+

Description : (-) There is no reaction
(+) reaction in amount A little
(+ +) reaction in amount currently
(+ + +) reaction in amount lots

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Identification of alkaloid compound

In the alkaloid test, it is taken extract as much as 0.5 mL then added HCl 2 N 1 mL and heated This aims to for removes proteins where these proteins can give results positive fake on testing [3] Next added with 9 mL of distilled water Then dripped reagent marked dragendrorff with existence sediment because of existence bond between nitrogen in alkaloids and reagent [23].

Figure 2. Results of Ethanol Extract Alkaloid Test

Identification of flavonoids

The flavonoid test was performed by extracting as much as 2 mL of the sample, then adding 5 drops of 5 % $FeCl_3$ solution to the sample. The occurrence of a change in color to greenish or black blue shows the existence of flavonoids. In this test, it was found that the occurrence of color change became black and blue, indicating the presence of positive flavonoids.

Figure 3. Results of the Flavonoid Test of Ethanol Extract

Identification of Saponins

The saponin test, 1 mL of sample was taken. Then added 10 mL of distilled water Then shaken and let stand for 10 minutes, then observed whether formed foam afterwards. Positive results If formed foam for 10 minutes and no is lost after dripped with 1 drop of 2 N HCl. In the test obtained results formed firm foam after 10 minutes kept quiet and not is lost after dripped with 2 N HCl. The emergence of foam showed existence glycosides that have ability to form foam in hydrolyzed water become glucose and compounds others. Compounds that have polar and nonpolar groups

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are active surface, if the saponin is shaken with water can to form micelles, polar groups facing to outside whereas group nonpolar facing to in a state of this is what it looks like like foam [24].

Figure 4. Results of Ethanol Extract Saponin Test

Tannin Identification

On testing tannin, taken as much as 0.5 grams of extract then 10 mL of distilled water was added and $_3$ drops of 1% $FeCl_3$ were added, the appearance of color green or green black showed positive existence tannin. Color change can happen Because existence reaction between compound hydroxyl in tannin with reagent. On testing obtained color green black so that concluded that extract ethanol gotu kola positive contain tannin. 1% $FeCl_3$ reagent is used in a way wide for identify compound phenolic.

Figure 5. Results of Ethanol Extract Tannin Test

Identification of Steroids and Titerpenoids

Extract dissolved in 0.5 mL of chloroform, added with 0.5 mL of acid acetate anhydride. Next, this mixture is dripped with 2 mL of acid sulphate concentrated through the wall tube. If it is formed, color green or bluish shows the presence of steroids. Testing for steroids or triterpenoids is based on the ability compound for to form color red orange or purple for terpenoids and green or blue for steroids with H_2SO_4 concentrated in solvent sour acetate anhydride. In testing obtained color green bluish so that concluded that extract ethanol gotu kola positive contains steroids.

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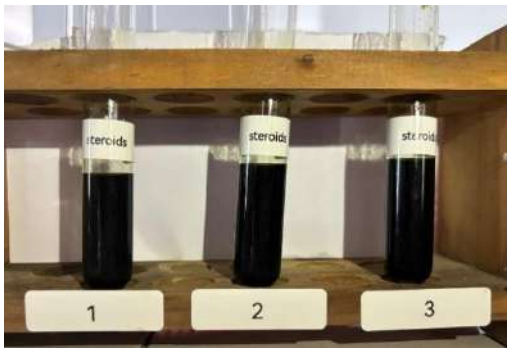

Figure 6. Results of Ethanol Extract Steroid Test

Toxicity Test

The toxicity test aims to know effect toxic from extract rough leaf gotu kola to biological systems, where the results obtained later will used as description in bioactivity test others. In this study, the samples tested is extract ethanol, from leaf gotu kola. Testing toxicity a compound must done for measure toxicity compound and ensure that that estimation dosage used can cause toxicity related with mark security or toxicity that can endanger human health [25]. This test was carried out with making solution stock 2000 ppm. Variation concentration extract used for toxicity testing are 1000, 500, 100, and 50 ppm and control 0 ppm (control negative). Making variation concentration aiming to know the influence from a number of variation concentration to death *A.Salina.* At a concentration of 0 ppm only retail with sea water artificial and without addition extract. Control negative done to see response death in *Artemia salina* larvae tested based on sample and not due to solvent used.

Furthermore, testing started with hatching egg *A. salina* using a small aquarium. Then, put in sea water as much as 500 mL and artemia eggs as much as two teaspoons for 48 hours. Then equipped with light incandescent 25 watts that keep sea water still warm, speeding up the hatching and diarrhea process by using an aerator to give sufficient oxygen for the continuous life of *Artemia*. In this way, the amount of oxygen still available and eggs of Artemia will find it challenging to hatch if the amount of oxygen in the sea water is reduced. This toxicity test was investigated in as many as 3 repetitions/replications (triple) to ensure data accuracy and obtain good data. If done only once, an error may occur, and no other data may be used. In every extract concentration, 10 shrimp larvae (*A. salina), 48 hours old, were used* as test animals. The mortality rate of Artemia salina Leach larvae at each tube reaction in various concentration treatments of gotu kola herb extract and control (-) is shown in Table 3.

Table 3. The Effect of Variation in Concentration of Ethanol Extract of Gotu Kola Leaves on Artemia Salina Leach

Sample Group	Concentration	Concentration Log	Probit	% Death	Dead	Total	LC_{50}
Extract Ethanol	50	1.698970004	4.48	30%	9	30	110.55

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100	2	4.92	47%	14	30
500	2.698970004	5.61	73%	22	30
1000	3	6.28	90%	30	30

Based on the table, it can be known that different influences related to various concentrations of extract lead to the death of *A. salina* larvae. Extract is materials containing the mixture component chemistry from dissolved plants in the solvent used. The type of extract shows the amount of compound chemicals dissolved in it and is related to the material's active dissolved biologicals. Based on the results in Table 4, it is visible that shrimp larvae death A. salina is the most common in the extract at concentrations of 1000 ppm and 500 ppm. In the extract, there is a % death as high as 90% at a concentration of 1000 ppm and 73% at a concentration of 500 ppm. This means that the taller concentration extract causes a higher larval death, indicating that the taller characteristic is toxic [26]. The average mortality of larvae was obtained by dividing the total mortality of larvae in each concentration by the number of replications performed, which is three. Then, the percentage larval mortality was calculated from the average mortality in each concentration multiplied by 100%. From the data in Table 3, we then analyzed the probit using Excel from the observation with the percent deaths

%Larvae = Number of Larvae that are 100% Matrix Test Larvae Count

With a known number of deaths of larvae, they can search for probit numbers through the Table and make

an equality line: Y = BX +A

Where: Y = Log concentration

X = Log concentration

From this equation, LC_{50} can then be calculated by entering the probit value.

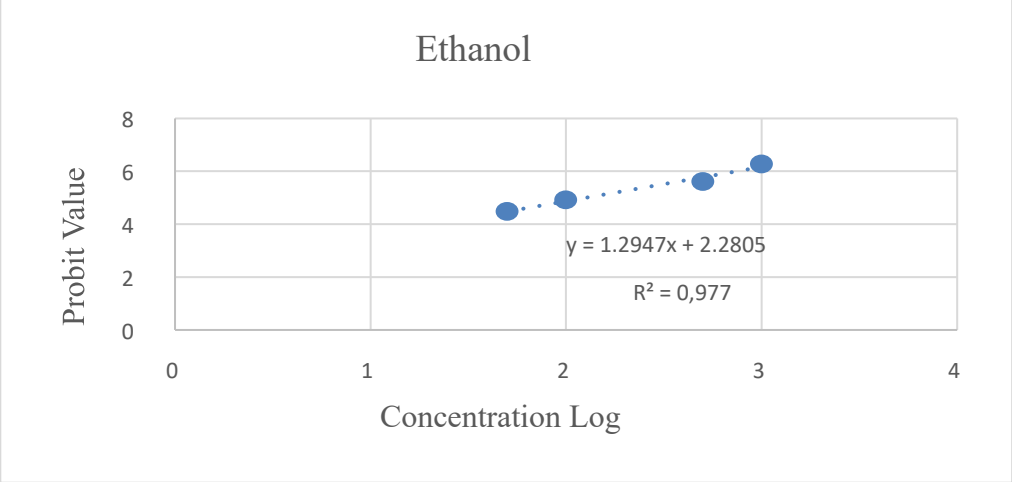

Figure 7. Log Relationship Curve of Extract Concentration Against Probit Value

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Based on the curve, it can be seen that the mark concentration is compared to straight with the percent mortality. Increasingly tall concentration extract, so characteristic, is toxic to test animals [27]. The mortality curve shows the connection between the concentration of the test solution (x-axis) and the percentage mortality (y-axis). Figure 7. The LC50 value of etof ethanol extract from the leaf of gotu kola is 110.55 ppm. This is proven from the extract ethanol's toxicity and can be estimated as a potential anticancer against *A. salina* larvae. The LC_{50} value is value indicating highly toxic properties. A toxicity test with the BSLT method can determine the toxicity of a compound in a short time, namely, the range time for 24 hours after giving the extract, which is called the acute toxicity test. Toxic effects are known to determine the LC50 value from the activity component of the active plant against A. salina larvae. An extract is toxic based on the BSLT method if the LC50 value <1000 ppm shows a correlation between this toxicity test and the cytotoxic test [28]. This method connects the number of shrimp larvae deaths with the test concentration. With this extract, ethanol leaf gotu kola shows highly toxic properties. This is related to metabolites secondary on leaves of Gotu Kola, namely flavonoids, saponins, tannins, and steroids. These compounds, the Work with method, act as stomach poisoning or poison stomach, so the digestive system will be disturbed if these compounds enter the body. This compound will hinder receptor flavors in the area of the larva's mouth. This causes the larvae to fail to get a taste stimulus, so the larvae are not capable of recognizing food. As a result, the larvae die because of hunger [29]. The mechanism of death of A. salina larvae relates to the function of flavonoid compounds that inhibit Power. In the research that has been done, the extract of leaf gotu kola has toxicity against Artemia Salina larvae with the BSLT method, according to the level of its toxicity, namely 0-250 ppm. Therefore, the utilization of leaf gotu kola for public consumption should do in a safe dose.

Antidiabetic Test

Centella asiatica (L.) Urban extract of ethanol activity antidiabetic test in vitro with inhibition activity of α-amylase enzyme method measures reducing sugars formed due to starch hydrolysis by the α-amylase enzyme. The reagent used in this test is dinitro salicylate (DNS), a reagent that can react with the reducing sugar formed and produce a color complex that can be quantified by measuring the absorbance using a spectrophotometer. The presence of inhibition of α-amylase enzyme activity can be observed based on the difference in the absorbance value produced [30].

Using phosphate buffer in the procedure for testing enzymes aims to create optimal conditions for enzyme activity so that the results are more reliable and can be interpreted well [31].

Many enzymes involved in digestion, including alpha-amylase, work optimally at a pH close to neutral (around pH 6.5–7.0). Selecting a pH 7 phosphate buffer ensures the enzyme is in optimal condition to break down carbohydrates. At this pH, the enzyme is more active and able to give relevant results in a moment's test for potential inhibition of antidiabetic compounds [32].

Before testing, a solution of α-amylase enzyme was made, where 20 mg of α-amylase enzyme was dissolved in 10 ml of phosphate buffer at pH 7. So, produce solution enzymes that are already dissolved and produce a little white color. It is cloudy. To make a solution, 0.5% starch is dissolved

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by dissolving 0.05 grams of starch in 10 ml of pH 7 phosphate buffer. The solution has been mixed and heated for 10 minutes until dissolved. So that produces a solution of 0.5% starch, which is clear and white clear. Making DNS reagent is made by making two solutions, solution A, where 30 g of K-Ntartrate is dissolved with 20 ml of 2M NaOH, then heated until dissolved. Then, for solution B, where 1.095 grams of DNS dissolved with 50 ml of distilled water, solution A and solution B were mixed, and 100 ml of distilled water was added. The results of mixing solution A and B range from yellow to orange. To make an acarbose solution equal to the solution extract, 5 mg of acarbose was dissolved in 10 mL of DMSO. The solution that has been produced is solution parent 500 ppm, solution parent diluted to 300 ppm, 250 ppm, 200 ppm, 150 ppm, and 100 ppm. The acarbose solution was made as a control positive for the comparator obstacle α-amylase enzyme. Production solution extract is the same as it says, making solution extract the same as an acarbose solution. A thick 5 mg extract sample was dissolved with 10 ml of DMSO and diluted to several concentrations, namely 500 ppm, 400 ppm, 300 ppm, 200 ppm, and 100 ppm. Dilution becomes several concentrations to compare absorption and absorbance. Preincubation time of 5 minutes in testing was chosen based on consideration for reaching the equilibrium temperature, allowing interaction between the enzymes and starch substrates, and avoiding variation in reaction time.

Decreasing the amount of sugar results in a decrease in the hydrolysis reaction of starch, because of the existence of a compound activity inhibitor, α-amylase enzyme. Heating can stop the reaction of hydrolysis because it changes the configuration of α-amylase, thereby reducing its activity. With the use of reagent dye 3,5-dinitrosalicylic acid (DNS), the concentration of the product of the reaction hydrolysis can be determined after the reaction is stopped [33]. Inhibitory power extract can be determined using IC50, where the coefficient y of the linear regression $y = ax + b$, where the coefficient of x is the concentration of extract that will search for the degree, which can inhibit 50% of the activity α the α-amylase enzyme. Absorption was measured using UV-Vis spectrophotometry when the activity α the α-amylase enzyme was obstructed. Testing UV-Vis spectrophotometry on ethanol leaf gotu kola extracts, aiming to measure active compounds such as flavonoids and glucose, which contribute to antidiabetic activity. This method allows the determination of compound levels accurately and efficiently, providing important insights about the potential of the extract of gotu kola as an agent antidiabetic [34]. Where is the solution substrate color to produce the product measured color, its absorbance at the wavelengths that have been determined. When testing concentration, we can see the influence of adding concentration to the sample to improve the activity α the α-amylase enzyme. Before doing testing, determine the long wave maximum to see the absorption maximum from the results of the reaction test solution. Measurement of long wave maximum needs to be done because it has high sensitivity at this stage, so the change in absorbance for every concentration is the largest, and the absorbance is read at a wavelength of 498 nm. Alpha-amylase hydrolyzes starch into simple sugars, which react with reagents like DNS. This reaction produces a product that is colored and can be detected at a certain wavelength, usually between 490–500 nm, depending on the intensity of the color. Measurement

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at 498 nm was used to measure how much sugar lots of products produced and, in the context of an antidiabetic test, to determine how far the extract of Gouto Kola can hinder α-amylase activity.

Table 4. Results of the α-amylase enzyme inhibition test by the acarbose comparator

Sample	With Enzyme α- amylase (S_1)	Without Enzyme (S_0)	$S_1 - S_0$	% Inhibition
Control	0.065			
Blank		0.003		
100 ppm	0.050	0.024	0.026	58.06451612
150 ppm	0.028	0.015	0.013	79.03225806
200 ppm	0.020	0.009	0.011	82.25806451
250 ppm	0.012	0.007	0.005	91.93548387
300 ppm	0.007	0.004	0.003	95.16129032

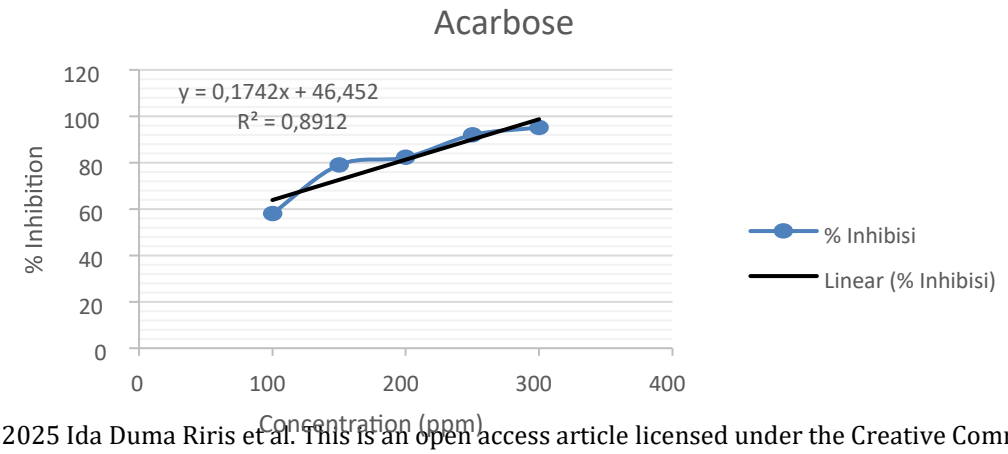

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Figure 8. acarbose concentration and the % inhibition**.**

From the graphic data in Figure 8, a linear regression equation is obtained, namely y = 0.1742 x + 46.452, which gives the calculation result of IC50 = 20.26739380 ppm.

Table 5. *α* -amylase enzyme inhibition test by ethanol extract of pegagan leaves (*Centella asiatica (L.) Urban)*

Sample	With Enzyme α-amylase (S_1)	Without Enzyme (S_0)	$S_1 - S_0$	% Inhibition
Control	0.065			
Blank		0.003		
100 ppm	0.060	0.024	0.036	41.93548387
200 ppm	0.039	0.016	0.023	62.90322580
300 ppm	0.025	0.013	0.012	80.64516129
400 ppm	0.018	0.007	0.011	82.25806451
500 ppm	0.011	0.003	0.008	87.09677419

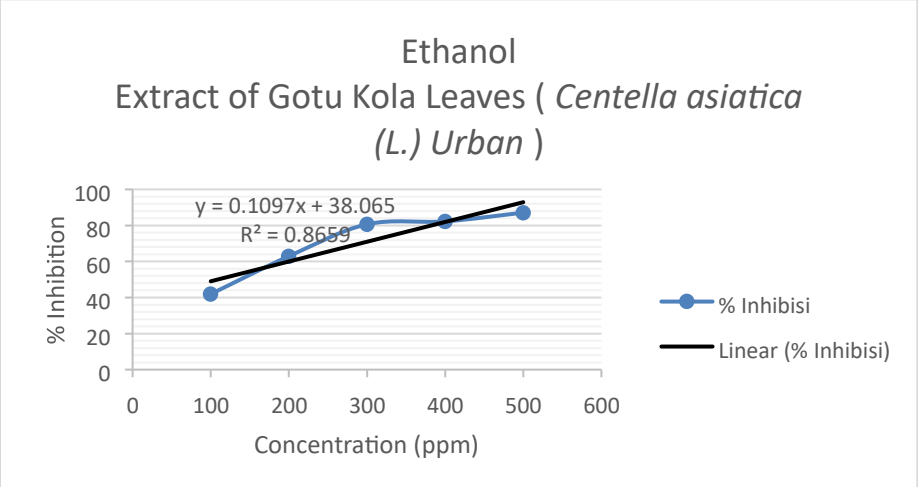

Figure 9. Graph of the relationship between the increase in ethanol extract concentration and % inhibition.

The data in graph 7, in Figure 9, shows that the linear regression equation obtained is y = 0.1097x + 38.065 so that the calculation result is IC_{50} = 108.79671832 ppm. Inhibition % value to activity α- α-amylase enzyme from extract ethanol leaf pegagan (Centella asiatica (L.) Urban) or acarbose can be seen to increase along the rise concentration, which means that concentration influences the strength of inhibition of the α- α-amylase enzyme produced. From the results of the data study on

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the obtained % inhibition extract from leaf pegagan (Centella asiatica (L.) Urban), as the ppm concentration of extract increases, the % inhibition obtained increases. Principle testing sample say that the more active the extract used, the more A little hydrolyzed starch. This occurs Because extract can stop activity α- amylase enzyme for interact with substrate amylase, so that intensity the resulting color will decrease by [35]. Inhibition % value lowest found in concentration sample extract 100 ppm ethanol is 22.58%, while percent inhibition highest contained in the sample extract ethanol 500 ppm is 90.32%. Therefore, it can concluded that faction ethanol with concentration of 500 ppm has ability hinder enzyme α - the best amylase than concentration others. This is in accordance with principle activity inhibition enzymes, namely the bigger concentration extract so the more great value obstacles encountered [36]. From the results of the study above, it was found that the % inhibition of the ethanol extract of pegagan leaves was smaller compared to acarbose, so that the IC_{50} value of the extract would be greater than acarbose. Test compounds that have a small IC_{50} value indicate that the inhibitory activity against the α-amylase enzyme is high 9. IC 50 values < 50 ppm often used as threshold for state that compound it is very potential as inhibitor enzymes and viable for development more carry on as agent antidiabetic. So, if compound or extract plant own IC_{50} value is close to or below 100 ppm, then can considered potential as antidiabetic agent [37,38]. Acarbose with IC_{50} 20.267 ppm has Power more inhibition strong compared to with extract ethanol leaf pegagan which has an IC_{50} of 108.797 ppm. This means that acarbose is more effective in hinder activity α - amylase enzyme at higher concentrations low compared to with extract leaf pegagan, which is appropriate with fact that acarbose has used as drug antidiabetic.

Based on level strength of inhibition % enzyme α - amylase said, sample extract ethanol including in category currently whereas control positive acarbose including very strong category. Criteria percent inhibition enzyme usually categorized based on standard certain that group potential inhibition a substance or extract in category like weak, moderate, strong, and very strong. However, these categories often vary depending on the type compounds and applications scientifically, such as testing antidiabetic or antimicrobial. Percent Inhibition Criteria α- Amylase Enzyme: Very Strong: ≥ 90%, Strong: 50–89%, Moderate: 31–49%, Weak: ≤ 30%. Acarbose has percent inhibition between 58-95%. With thus, acarbose is considered to be very potent. Because in a number of case over 70%. Extract ethanol leaf gotu kola own percent inhibition between 4187%. This means that in a number of concentration, extract ethanol can is at in category currently until strong, depending on concentration specific used. Acarbose is used as control positive for comparator with extract in inhibition α- amylase enzyme. From the data above can be seen that the % inhibition of acarbose is greater tall from sample extract leaf pegagan, because acarbose is medicine that is indeed Already used as drug antidiabetic.

Activity Test Results Antibacterial Diffusion Method Disc.

Bacteria used in study This is *Staphylococcus aureus, Propionibacterium acnes (P. acnes),* and *Streptococcus pyogenes*, where all the bacteria is Gram positive bacteria. Bacteria This obtained from Laboratory Pharmacology of Pharmacy, University of North Sumatra (USU). The method

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used for test activity antibacterial is method diffusion disc. This method show ability extract leaf gotu kola *(Centella asiatica (L.) Urban)* in hinder growth *Staphylococcus aureus, Propionibacterium acnes (P. acnes), and Streptococcus pyogenes* are characterized with the formation of a clear zone around paper disc.

Procedure testing antibacterial started with sterilization equipment use autoclave. Mueller Hinton Agar (MHA) media is then weighed and dissolved in distilled water, then autoclaved and heated return using a hot plate until formed solution colored yellow (Figure 10). And before done testing, the bacteria that will be used moreover formerly dissolved in MHA medium for 24 hours until obtained layer bacteria colored white (Figure 11).

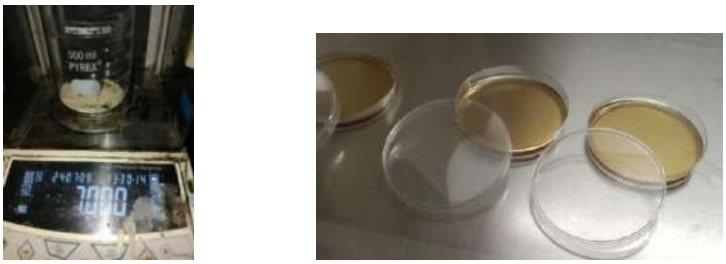
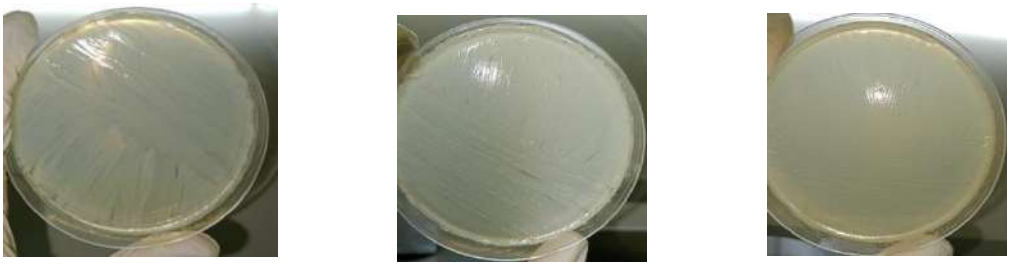


Figure 10. Making MHA Media



(a) (b) (c)

Figure 11. Breeding Bacteria (a) *Streptococcus pyogenes*, (b) *Propionibacterium acnes*, (c) *Staphylococcus aureus*

Furthermore, that is make 1%, 2.5%, 5% and 10% ethanol extract leaf gotu kola with method: for 1% weigh 0.05 g of extract ethanol leaf gotu kola to in beaker glass using scales analytics and spatula then 5 ml of ethanol was added with use glass measure 10 ml and put it in to in the beaker and then stirred with using a spatula. Do the same thing for extract 2.5%, 5% and 10%. For 2.5% weigh 0.125 grams, for 5% weigh 0.25 grams and 10% were weighed as 0.5 grams (Figure 4.2) and each was placed in a vial (Figure 13)

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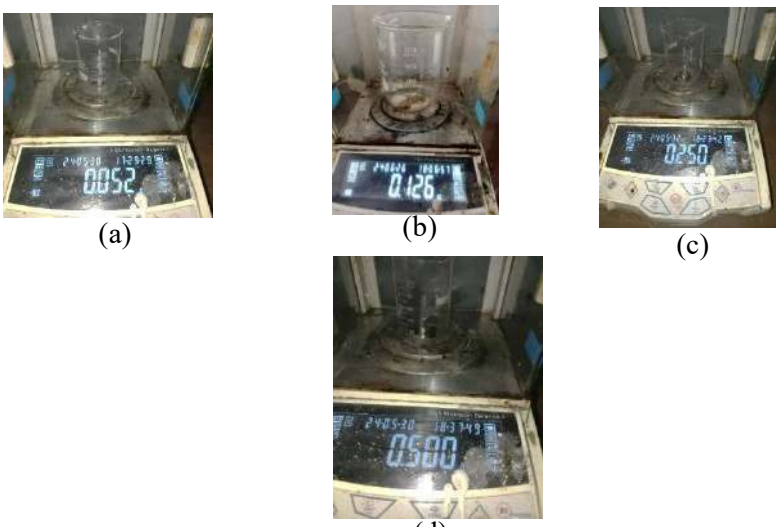

(a) (b) (c) (d)

Figure 12. Making Extract Ethanol For (a) 1%, (b) 2.5%, (c) 5% and (d) 10%

Figure 13. Result of Making Extract Ethanol For (a) 1%, (b) 2.5%, (c) 5% and (d) 10%.

After it's for suspension every bacteria that is with method Enter Physiological NaCl to in vial bottle then enter 3x scratches bacteria with use needle ose then equalize every suspension with mc farland 0.9 (Figure 14)

(a) (b) (c)

Figure 14. Making Suspensi Bacteria (a) *Streptococcus pyogenes*, (b) *Propionibacterium acnes*, (c) *Staphylococcus aureus*

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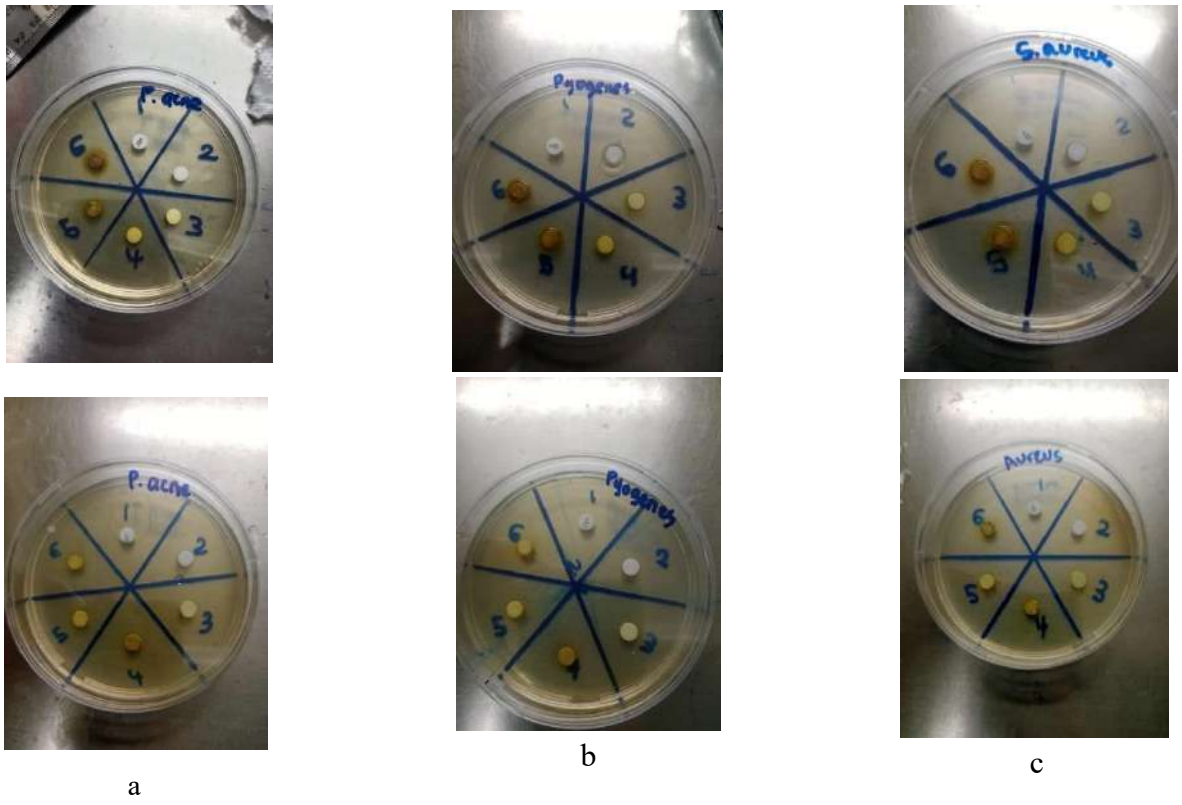
After done breeding bacteria for 1 x 24 hours, making extract and make new suspension done testing diffusion disc, where chloramphenicol as control positive used as antibiotics, because chloramphenicol is antibiotics bacteriostatic spectrum active area to gram- positive and gram-negative bacteria. Chloramphenicol Work with hinder microbial protein synthesis, and DMSO as control negative used as comparator that solvent used as thinner No influence antibacterial test results from the compound that will tested. Testing inhibition zone diffusion repeat 3 times to get it compare or selecting the inhibition zone which produces the best clear zone (Figure 15)



a b c

Figure 15. Bacteria (a) *Propionibacterium acne*, (b) *Streptococcus pyogenes*, (c) *Staphylococcus aureus*

Then results inhibition zone measurement leaf gotu kola *(Centella asiatica (L.) Urban)* measured use term push with precision millimeters (mm) to bacteria.

Table 6. Extract ethanol leaf gotu kola to *Propionibacterium acnes*, *Streptococcus pyogenes,* and *Staphylococcus aureus* bacteria from control with variation concentration extract 1%, 2.5%, 5% and 10%

Bacteria	Chloramphenicol (mm)	1% (mm)	2.5% (mm)	5% (mm)	10% (mm)
	21.2	3.6	3.7	3.9	4.6

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Propionibacterium acnes	23.3	3.5	3.6	3.7	4.2
Streptococcus pyogenes	5.4	3.8	4.2	4.6	5.1
	5.4	3.8	4.3	4.6	4.9
Staphylococcus aureus	21.4	5.2	6.4	8.3	9.2
	23.3	5.0	6.0	8.1	9.0

Based on the table on activity test results, antibacterial from leaf gotu kola *(Centella asiatica (L.) Urban)* against *Propionibacterium acnes (P. acnes), Streptococcus pyogenes,* and *Staphylococcus aureus, we* can conclude that:

Propionibacterium acnes (P. acnes)

Extract of leaf gotu kola shows slight antibacterial activity, increasing along with improved concentration, but overall, its activities are relatively low. At a concentration of 1%, the average inhibition zone diameter was about 3.55 mm.At a concentration of 2.5%, the average inhibition zone diameter is about 3.65 mm. At a concentration of 5%, the average inhibition zone diameter was about 3.8 mm. At a concentration of 10%, the average inhibition zone diameter was about 4.4 mm. Activity is highest achieved at a concentration of 10% with an average inhibition zone diameter of 4.4 mm, which is still far lower compared to the control positive chloramphenicol, which reached 22.25 mm.

Streptococcus pyogenes

Extract of leaf gotu kola shows increased activity against bacteria along with improved concentration. At a concentration of 1%, the average inhibition zone diameter is about 3.8 mm. At a concentration of 2.5%, the average inhibition zone diameter was about 4.25 mm. At a concentration of 5%, the average inhibition zone diameter was about 4.6 mm. At a concentration of 10%, the average inhibition zone diameter was about 5 mm. Activity highest achieved at a concentration of 10% with an average inhibition zone diameter of 5 mm, which is still more low compared to with control positive chloramphenicol reaching 5.4 mm.

Staphylococcus aureus

Extract leaf gotu kola show activity increasingly antibacterial increase along with improvement concentration. At a concentration of 1%, the average inhibition zone diameter is about 5.1 mm. At a concentration of 2.5%, the average inhibition zone diameter was about 6.2 mm. At a concentration of 5%, the average inhibition zone diameter was about 8.2 mm. At a concentration of 10%, the average inhibition zone diameter was about 9.1 mm. Activity highest achieved at a concentration of 10% with an average inhibition zone diameter of 9.1 mm, but Still more low compared to with control positive chloramphenicol which reached 22.35 mm. Conclusion: The

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extract leaf gotu kola own activity antibacterial against Staphylococcus aureus, Propionibacterium acnes (P. acnes), and Streptococcus pyogenes, but his activities tend more low compared to with chloramphenicol as control positive . Activity antibacterial extract leaf gotu kola increase along with improvement concentration, with the most significant effect seen in Staphylococcus aureus. For all tested bacteria, chloramphenicol shows a larger inhibition zone big compared to extract leaf pagan on all the concentrations tested.

Streptococcus pyogenes

Good turbidity at concentration: 1 %: Column A, 2.5%: Column D, 5%: Column F, 10%: Column H. This turbidity indicates that bacteria can grow with good concentration, and the extract used still supports the growth of bacteria at the concentrations.

Staphylococcus aureus

Good turbidity at concentration: 1%: Column B, 2.5%: Column C, 5%: Column F, 10%: Column G. Same as *Streptococcus pyogenes*, these results indicate that *Staphylococcus aureus* can also grow in the concentration of the extract tested.

Propionibacterium acnes

In this testing, Propionibacterium acnes showed no growth in all concentrations of the tested extract. This shows that the extract used has a strong antibacterial effect on Propionibacterium acnes, hindering the growth of bacteria.

Experimental results show that the extract had different effects on type-tested bacteria. *Streptococcus pyogenes* and Staphylococcus *aureus* can grow on various concentrations of extract, showing that the extract has no significant antibacterial effect on the second bacteria, at this concentration

On the other hand, *Propionibacterium acnes* does not show growth, indicating hindered growth bacteria.

Conclusion

The compounds produced from screening phytochemicals extract ethanol leaf gotu kola (*Centella Asian (L.) Urban*), which originates from Village Mountain Nagodang, Subdistrict Uluan, Regency Toba, Province Sumatra North, contain flavonoids, saponins, tannins, and steroids.

Toxicity test results use the Brine Shrimp Lethality Test (BSLT) method with test animals of Artemia salina larvae against the extract of ethanol leaf pegagan. LC_{50} value from the extract ethanol of 110.55 µg/ mL. Based on the level of toxicity, the LC50 value of the extract ethanol is determined as cytotoxic.

Bioactivity test results extract ethanol leaf Centella *Asian (L.) Urban*) which is seen from its toxicity test, shows activity toxicity against Artemia salina larvae with an LC_{50} value of 110.55 µg/ mL. This LC_{50} value is categorized as toxic and can be potentially used as a plant drug.

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Difference extract ethanol leaf pegagan (*Centella asiatica (L.) Urban*) with acarbose is ppm concentration used. The concentration used in the extract ethanol leaf pegagan (*Centella asiatica (L.) Urban*) namely 500 ppm, 400 ppm, 300 ppm, 200 ppm, and 100 ppm while for acarbose use concentrations of 300 ppm, 250 ppm, 200 ppm, 150 ppm, and 100 ppm. Acarbose has a % inhibition taller than extract ethanol leaf pegagan, because acarbose is drug antidiabetic responsible answer For digest carbohydrates in body used as control positive. Extract ethanol leaf pegagan (*Centella asiatica (L.) Urban)* own potential currently as activity antidiabetic which can hinder α- amylase enzyme. Activity inhibition can varies depending on various factor like concentration.

Antidiabetic activity of ethanol extract of pegagan leaves (*Centella asiatica (L.) Urban*) showed that the higher the extract concentration, the greater the % inhibition of α-amylase enzyme activity. The results of linear regression calculations of pegagan leaf extract (*Centella asiatica (L.) Urban*) obtained ethanol extract with an IC_{50} value of 1.989 ppm while the acarbose comparator obtained an IC_{50} value of 1.774 ppm means Ethanol extract of pegagan leaves (*Centella asiatica (L.)Urban*) has activity antidiabetic with smaller resistance than acarbose.

Extract of leaf gotu kola has antibacterial activity against Staphylococcus aureus, Propionibacterium acnes (P. acnes), and Streptococcus pyogenes, but its activities tend to be lower compared to that of chloramphenicol as a control.

Activity antibacterial extract leaf gotu kola increases along with improvement concentration, with the most significant effect seen in *Staphylococcus aureus.* For all tested bacteria, chloramphenicol shows a larger inhibition zone than leaf pegagan extract at all concentrations tested.

The microdilution method is used to determine the minimum concentration of an antibacterial substance capable of hindering bacterial growth. This process involves mixing the antibacterial substance with the media, which suspends the bacteria and is then inserted into every microplate hole. After that, the microplate is incubated to see the result.

Acknowledgements

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Identification of mineral content in corn cob ash using x-ray fluorescence (XRF)

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Abstract. *The increase in corn productivity in Indonesia will lead to a rise in the amount of corn cob waste generated. Corn cob ash is known to have a high mineral content, with potassium being one of the primary minerals present. This study aims to determine the mineral content in corn cob ash using X-ray fluorescence (XRF) analysis. The results indicate that corn cob ash contains various minerals. The mineral with the highest concentration in corn cob ash is potassium, accounting for 77.931% as an element and 78.019% as an oxide.*

Keywords: corn cob, ash, potassium, X-ray Fluorescence, mineral

Introduction

Corn is one of the staple food commodities commonly found in various regions of North Sumatra. According to the Central Statistics Agency, it is estimated that the national corn harvest area in 2023 recorded a production yield of 1,314,467.47 tons in North Sumatra Province, with a harvest area of 14,460,601.32 hectares and a productivity rate of 63.05 quintals per hectare. Alongside the increasing corn production, it is inevitable that the amount of waste from corn processing will also rise.

A part of the corn plant often neglected and discarded as waste, which can potentially pollute the environment if not properly managed, is the corn cob. Corn cob, also known as "jangel," refers

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to the core of the corn after the kernels are removed [1]. Corn cobs are considered useless waste by many communities. The increase in corn productivity in Indonesia will lead to a rise in the amount of corn cob waste generated [2].

The utilization of corn cob waste is currently gaining traction, as corn cobs have various uses, including livestock feed, raw material for handicrafts, and alternative fuel sources [3]. According to [4], approximately 18% of corn cob waste from average corn production remains unutilized.

Corn cobs contain 15% lignin, 45% cellulose, and 35% hemicellulose [1]. Corn cob ash is known to have a high mineral content, with potassium being one of the primary minerals present. The potassium content in corn cobs is reported to be 38.76% in the form of K_2CO_3 [5].

X-Ray Fluorescence (XRF) is a non-destructive analytical technique used for identifying and determining the concentration of elements present in solids, powders, or liquid samples. XRF can measure elements ranging from beryllium (Be) to uranium (U) at trace levels, even below ppm. Generally, an XRF spectrometer measures the wavelength of individual material components based on the fluorescent emissions generated when the sample is irradiated with X-rays [6]. Depending on its application, XRF excitation can be produced not only by X-rays but also by other primary excitation sources such as alpha particles, protons, or high-energy electron sources [7].

Tools and Materials

Tools

X-Ray Fluorescence (XRF) Spectrometer (PANanalytical), Oven, Furnace, Crucible, Desicator, Analytical Balance

Materials

Corn Cobs, Aquadest

Methods

Preparation of Corn Cob Ash

Fresh corn cobs are weighed to determine their initial weight. They are then sun-dried for three days to reduce their moisture content. Once dried, the corn cobs are cut into smaller pieces and placed into crucibles. The crucibles containing the dried corn cobs are placed in a muffle furnace for ashing at a temperature of 550°C for 5 hours. The resulting corn cob ash is allowed to cool in a desiccator to prevent moisture absorption. After cooling, the ash is weighed to determine its final weight.

Examination of Mineral Content in Corn Cob Ash

The examination of the mineral content in corn cob ash is conducted using X-Ray Fluorescence (XRF). XRF analysis is performed based on the identification and quantification of X-rays generated through the photoelectric effect.

Results and Discussion

The research utilized 25 kg of corn cobs, which yielded 78 grams of corn cob ash. Consequently, the yield of corn cob ash was determined to be 0.312%.

The resulting corn cob ash was then analyzed using X-Ray Fluorescence (XRF). Figure 1 presents the spectrum obtained from the analysis of the mineral content in corn cob ash using XRF.

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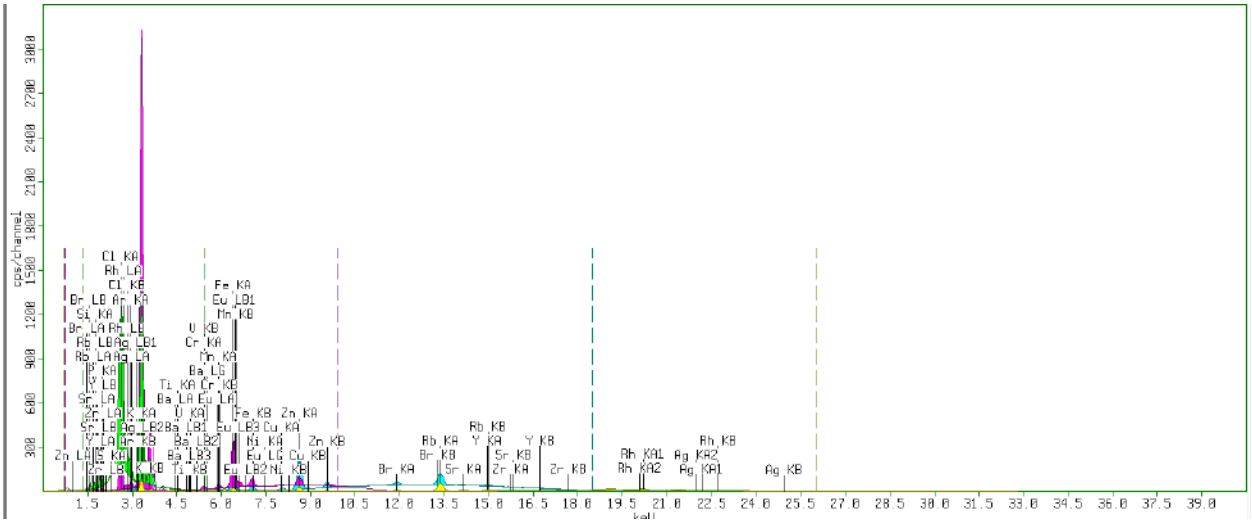

Figure 1. The spectrum obtained from the analysis of corn cob ash using XRF

Table 1 shows the mineral content in corn cob ash

Element		Geology		Oxides	
Compound	Concentration (%)	Compound	Concentration (%)	Compound	Concentration (%)
Si	0	SiO2	0	SiO2	0
P	0	P2O5	0	P2O5	0
S	1,262	SO3	2,835	SO3	2,822
Cl	12,192	Cl	10,727	K2O	78,019
K	77,931	K2O	78,595	TiO2	0,063
Ti	0,048	Ti	0,038	V2O5	0
V	0	V	0	Cr2O3	0,323
Cr	0,279	Cr	0,223	MnO	0,165
Mn	0,161	Mn	0,129	Fe2O3	2,711
Fe	2,398	Fe2O3	2,737	NiO	0,022
Ni	0,022	Ni	0,017	CuO	0,096
Cu	0,098	Cu	0,078	ZnO	1,225
Zn	1,248	Zn	0,994	Rb2O	0,693
Br	0,148	Br	0,118	SrO	0,065
Rb	0,808	Rb	0,64	Y2O3	0
Sr	0,07	Sr	0,056	ZrO2	0,004
Y	0	Y	0	Ag2O	2,879
Zr	0,004	Zr	0,003	BaO	0,113
Ag	3,191	Ag	2,699	Eu2O3	0,011
Ba	0,128	Ba	0,102	Cl	10,671
Eu	0,012	Eu	0,01	Br	0,116

From Table 1, it can be observed that corn cob ash contains various minerals. The most abundant mineral in corn cob ash is potassium, accounting for 77.931% as an element and 78.595% as a compound (K_2O). The next most prevalent component is chlorine (Cl), at 12.192% as an

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element, followed by iron (Fe) at 2.398% as an element, 2.737% in its natural state, and 2.7115% in the form of iron oxide (Fe_2O_3).

The potassium content in corn cob ash can be influenced by several factors, including heating duration. As the pyrolysis time increases, the K_2O content initially decreases and subsequently rises again [8]. This phenomenon is not due to the loss or evaporation of potassium but rather occurs because the levels of other alkali components increase with rising temperatures over extended durations, particularly during pyrolysis [9].

In addition to these three minerals, corn cob ash also contains various other minerals. The abundance of minerals in corn cob ash highlights its significant potential for further utilization. The high potassium content in corn cob ash indicates its potential use as a natural potassium source for various applications.

Conclusion

Corn cob ash contains various beneficial elements and minerals. Potassium is the most abundant component in corn cob ash, accounting for 77.931% as an element and 78.019% as an oxide. The high potassium content in corn cob ash highlights its potential as a natural potassium source that can be utilized for various applications.

Acknowledgments

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Automatic vehicle number plates and driver's face recognition using YOLO and EasyOCR

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Abstract. The increase in population in Indonesia has also resulted in an increase in the number of vehicles and the number of parking spaces. This density makes it difficult for security officers to check vehicles when entering and exiting the parking lot. Checking identity when leaving the parking area is a mandatory activity for security officers, to increase security and ensure that vehicles entering and exiting are driven by the same person. Conventional identity checks often cause traffic jams. Based on these problems, an AI-assisted security system is needed that can help the security system. One system that can be used in the field of computer vision and object detection is You Only Look Once (YOLO). The results obtained in this research using YOLO-v8 to detect the driver's face and plate, where the accuracy model for the Face class has an accuracy of 97%, and the Plate class has an accuracy of 99%. Then the cropping results on the plate label are extracted using EasyOCR to find the vehicle plate number.

Keywords: EasyOCR, Face, Object Detection, Plate, You Only Look Once.

Introduction

Indonesia's population is increasing and vehicles are increasingly congested, causing the need for more and more parking space [1]. Parking density also causes parking officers to have difficulty ensuring the safety of their vehicles [2]. Parking attendants must check each vehicle's ownership identity. Identity checks are carried out when leaving the parking area to increase security and ensure that vehicles entering and exiting are driven by the same person [3]. Conventional identity checking often causes many problems such as traffic jams [3] which results in waste of time and fuel [4].

One solution that can solve this problem is by using a system that is integrated with artificial intelligence (AI). This has been proven by the increasing use of Artificial Intelligence (AI) encouraging researchers to explore its capabilities in solving real-world problems, such as prediction, classification, identification and analysis [5]. The use of computer vision has become a promising solution in the last few decades [5]. Object detection has long been the main research focus in the field of computer vision, the goal is to accurately locate image targets and determine target categories [6]. The use of computer vision for facial and vehicle plate recognition in checking identity can increase user efficiency and comfort, as well as reduce queues when exiting.

General, in the field of computer vision and object detection, there is one model that continues to follow the latest developments, namely You Only Look Once (YOLO) [7]. YOLO is one approach in the world of detecting images of an object [8] in real-time [7], [9]. Previous research has used YOLO in detecting traffic jams on highways [10]. The results show that YOLO can be used to detect vehicles with sufficient distance between one vehicle and another, as well as in adequate lighting conditions [10]. Due to the absence of copyright and patent restrictions, research based on the YOLO architecture, promising lightweight and accurate real-time detection, can be carried out by any individual or research organization [11]. When YOLO detects an object, it will return the coordinates of the object's bounding box in the format (x, y, w, h, conf), with x and y as object coordinates, w as object width, h as object height, and conf as confidence value scores [10], [11], [12]. Intersection over Union (IOU) functions as a box that measures the overlap of the output to detect objects perfectly [13].

Recognition of plate numbers on motorbikes uses Optical Character Recognition (OCR). OCR allows converting characters in printed documents, digital images, and check recordings into word format [13]. One of the OCR systems used is EasyOCR which provides strong performance in various character recognition scenarios and supports various OCR languages. [14]. EasyOCR

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is also used to recognize and extract characters from number plates where the accuracy results are 95% [15]. Based on this, the development of an AI model for automatic detection of number plates and faces of motorbike riders with the help of YOLO and EasyOCR, provides great hope in validating conventional results and making it easier to check identity.

Research Methodology

2.1 Data Collection

The dataset consists of a collection of images and videos from motorbike riders that have been collected at the data collection stage. The data that has been collected is then cleaned to speed up the detection process. The clean data will then be tested again using the YOLO system.

2.2 YOLO

YOLO is a real time object detection algorithm [16]. The clean data is then trained and tested using YOLO, so that detection is obtained in the form of face classes and plates in the image. The aim of object detection is to determine the presence of the desired object in the image or video, then the detector will provide information in the form of the object class and its location (Hussain, 2023). The core principle provided by YOLO is to divide the image into grid cells with dimensions s × s [11], [17]. Each grid cell will predict B bounding box along with dimensions and confidence score. Confidence score shows whether or not an object is in the bounding box. Each bounding box consists of five components (x, y, w, h, conf), with the center coordinates (x, y, width, height) of each bounding box as in Figure 1.

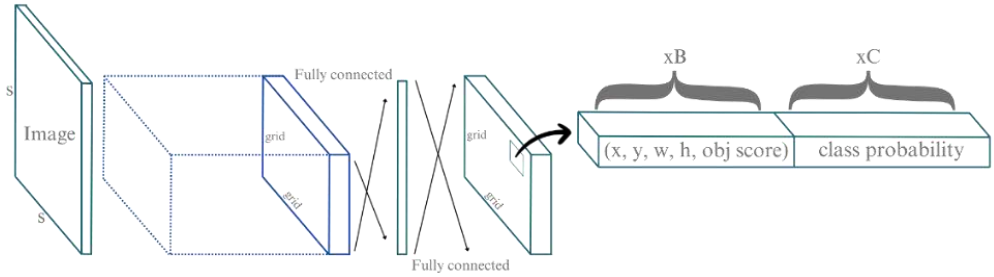

Figure. 1. Architecture of general YOLO.

As stated previously, the image is divided into s × s grid cells. Each grid predicts a bounding box B, each grid contains five components and shares a class prediction probability (C).

$$s \times s \times (5 \times B + C). \quad (1)$$

The initial goal of YOLO is object and location detection via bounding boxes. Therefore, two sets of bounding box vectors (truth and prediction) are needed. YOLO has NMS to handle multiple bounding boxes that contain the same or empty objects.

2.3 EasyOCR

Extracting the number on the vehicle number plate uses a Python module called EasyOCR. EasyOCR is a Python module for text extraction from images that supports more than 80 languages and continues to grow [18]. In general, the EasyOCR framework consists of several processing stages.

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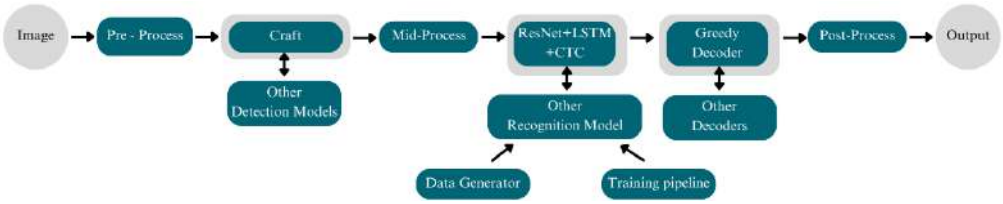

Figure 2. Framework EasyOCR.

OCR prediction results are not only influenced by the model, but also by various other factors such as image clarity, gray scale, hyperparameters, weights, and others [19].

2.4 Interface System

The interface system stage, research allows users to enter image and video files through the interface system. The results include face cropping, plate cropping, and plate number extraction results. Figure 3 show that the system workflow on this research.

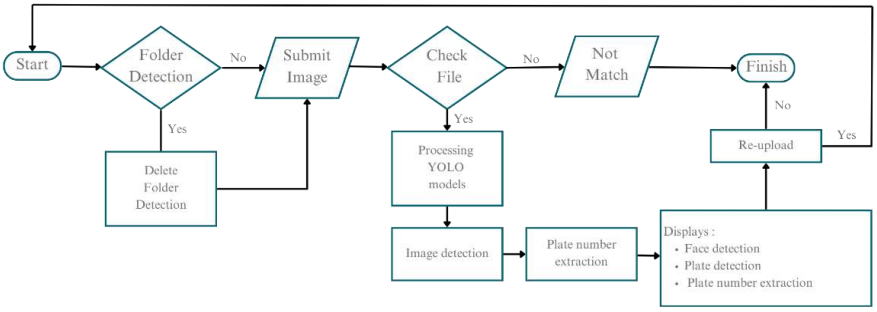

Fig. 3. System Workflow.

Results and Discussion

3.1 Model

The first stage of this research began with data collection, in the form of images and videos of drivers in the parking area. The data is divided into 2 labels, namely face and plate, 50 training images are used for the model training process, while 12 images are used for validation and testing of model data.

Table 1. Dataset.

Class	Train	Validasi	Test
Face	50	12	12
Plate	50	12	12

The data that has been obtained goes through a cleaning stage before being trained to speed up the process. After the model was trained in 300 epochs, Figure 4 shows that the model did not experience overfitting. So the accuracy of the model is obtained with the Face class having an accuracy of 97%, and the Plate class having an accuracy of 99%.

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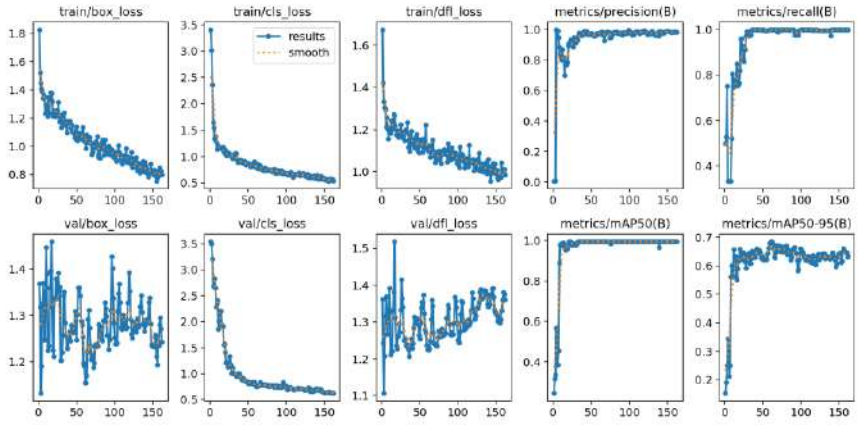

Figure 4. Curva model.

3.2 YOLO-v8 Detection

At the facial and motor vehicle number plate detection stage, this research used the latest version of YOLO which was launched on January 10 2023, namely YOLOv8, which was developed by Ultralytics. YOLOv8 helps improve object detection performance by eliminating overlapping and irrelevant bounding boxes. In COCO dataset detection, YOLO-v8 has a validation mAP performance of 37.3, and AP 53.9%.

YOLOv8 the model does not require calculating the offset of the anchor box to get the object position. This reduces the number of prediction bounding box sets and speeds up the NMS process. Detection uses a 3 × 3 convolution screen, with the size of the first convolution kernel 3 × 3. At the neck, the features are directly combined.

Then labeling is carried out to label each vehicle image according to its type. Labeling for the face class is marked with the "face" label and a pink bounding box, while labeling for the plate class is marked with the "plate" label and an orange bounding box.

Figure 5. Detection and labeling results.

After detection, the image will be cropped and inserted according to the correct label and class.

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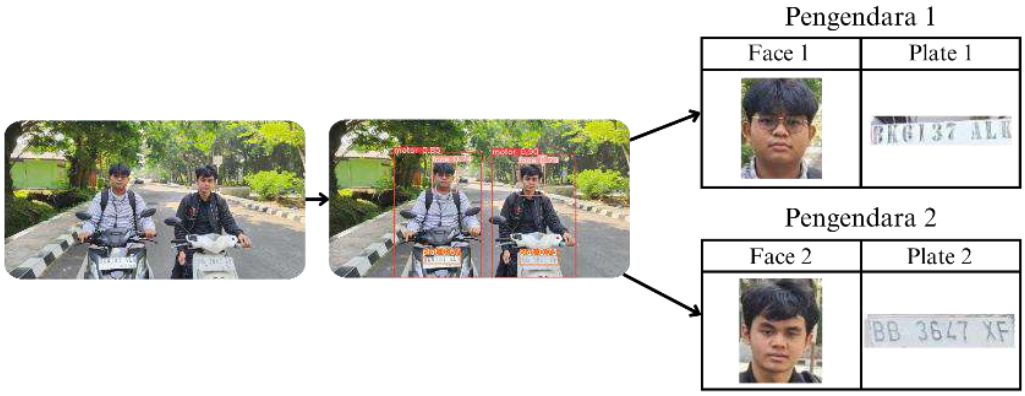

Figure 6. Detection with YOLO-v8.

3.3 EasyOCR

The resulting plate image from the previous stage will then be extracted using EasyOCR to identify the plate number.

Table 2. Detection result.

No	Image	Detection	Issues	Condition
1		BB 5835 JJ	-	Good
2		BK2172 AFV	-	Good
3		BK68 38 AFC	-	Good
4		BK3573 ALB	-	Good
5		BKe) 37 4iA	Some number faded	Not good
6		BK 32 58 AKU	-	Good
7		BB 36L7 XF	4 faded	Good
8		BK2886 AJS	-	Good
9		BK6 137 MBHI	-	Good
10		BK4671 RBn	Blurred text	Good
11		BK305 6 AKY	-	Good
12		Gk6290 PBJ	B faded	Good

Samples 5, 7, 12 showed an extraction error, where the letters or numbers on the plate were faded. Sample 10 shows an extraction error, where the letter K looks like the letter n. Based on the results obtained, vehicle plate number extraction can be affected by various factors. The main factor in this research was the fading of the letters or numbers on the number plates which resulted in the system making errors in extraction.

3.4 System

The system consists of 2 pages, namely the "Home" page which contains the application guide and the "Detect" page which functions as a vehicle number plate detection system.

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Figure 7. Home page.

On the "Home" page, users can read the guidelines provided by researchers, this serves so that users do not experience confusion in using the system.

Figure 8. Upload file page.

On the "Detect" page, users can enter image or video data in the "Browse files" menu. File types that can be used include JPG, JPEG, PNG, BMP, WEBP, MP4, AVI, and MPEG4 with a file size limit of 200 MB.

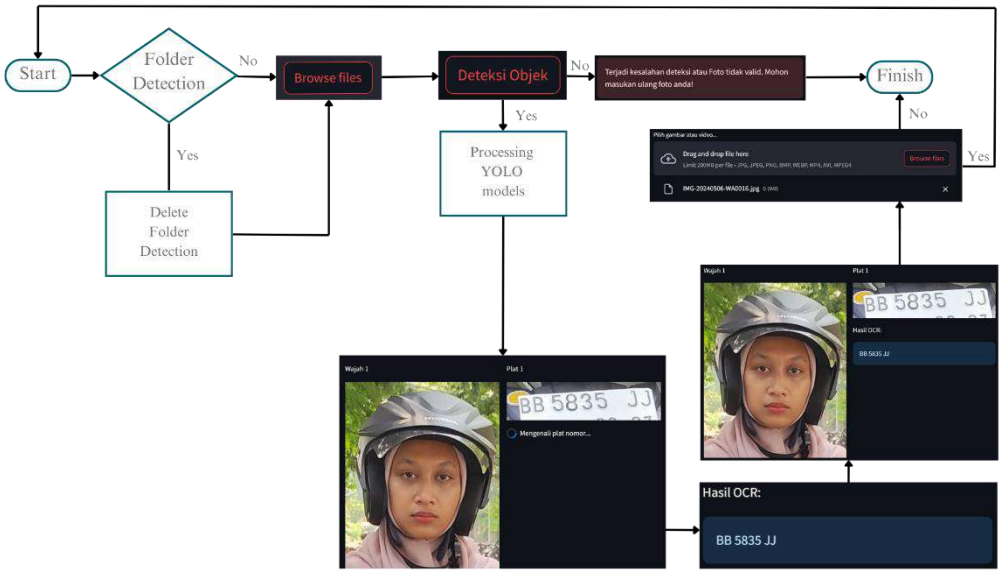

Figure 9. System flow.

Using the system begins with selecting the file to be detected. If the user enters an inappropriate photo, the system will display a message in the form of "A detection error has

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occurred or the photo is invalid. Please re-enter your photo!", and if the user enters an inappropriate video, the system will display a message in the form of "A detection error or video has occurred." invalid. Please re-enter your video!". If the photo and video match, the system will detect the face and plate using YOLO-v8. Next, the detection results will be cut by YOLO-v8, the plate pieces will be processed for extraction using EasyOCR. As previously explained, the results of the system are face cropping, plate cropping, and plate number extraction results.

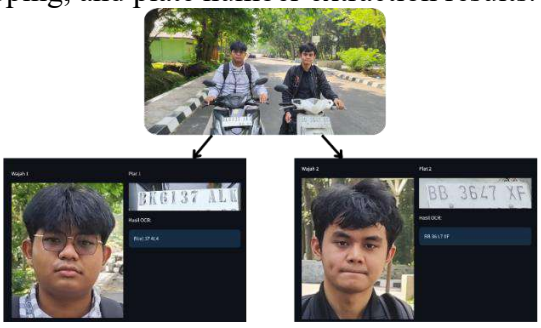

Figure 10. The system results using 2 objects.

Conclusion

Based on the data model, the Face class has an accuracy of 97%, and the Plate class has an accuracy of 99%. YOLO-v8 is used to detect faces, and driver plates based on a pre-trained model. Results that have been detected will be cut and stored according to the label. Image fragments that have been saved on the plate label will be extracted using EasyOCR. This system can work on images and videos with a maximum file size of 200 MB.

The aim of creating the system is to make it easier to check identity when leaving or entering the parking area. The system can detect more than 1 driver in the same frame, but the system cannot detect the passenger's face. If there are 2 faces and 1 plate in the same frame, the system will only detect the face closest to the motor bounding box and motor plate.

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E-reporting application system development for agent of change integrity zone (ZI) in universitas negeri medan

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Abstract. *An Integrity Zone is an activity related to government policies and efforts to create an environment free from corruption, collusion, and nepotism (KKN). The Integrity Zone aims to encourage transparency, accountability, and clean practices in the management of a bureaucracy. The main objective of an integrity zone is to create an environment in an agency where public services, policies, and resource management are carried out honestly, fairly, cleanly, and efficiently without any KKN practices. Efforts to create a good integrity zone must involve various parties. At the Faculty of Mathematics and Natural Sciences, Medan State University, the implementation of the Integrity Zone towards a Corruption-Free Area and a Clean and Serving Bureaucratic Area has been carried out in a massive and structured manner. All parties including leaders, lecturers, employees, students, and the entire academic community apply and implement the integrity zone. To further succeed this Integrity Zone, a Change Agent was formed who acts as a Role Model for all parties. As a role model, agents of change must be able to provide examples in attitude, behavior, and thinking. In addition, they must be able to provide creative solutions in dealing with problems in their agencies. And must be able to provide creative ideas to improve the performance of all parties. Sometimes, their ideas are not well documented. So a digital-based system is needed that can facilitate the work of these agents of change. For this reason, it is necessary to create a Web-based E-Reporting application for recording, reporting, and implementing change agent performance so that it is more optimal, efficient, and effective.*

Keywords: Integrity Zone; Agent of Change; Corruption Free Zone; Clean and Serving Bureaucratic Zone; E-Reporting Application

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Introduction

Integrity Zones must be established in every government instant, following MenPANRB Regulation Number 10 of 2019 and Republic of Indonesia's Decree Number 1176/P/2020. These zones focus on change management, restructuring, HR management systems, performance accountability, supervision, and quality improvement, with two result components [1], [2]. The Leverage Agent implements six leveraging components, including change management, restructuring, HR systems, performance accountability, supervision, and public service quality improvement, with two result components focusing on a clean, KKN-free government and higher-quality public services [3].

The Integrity Zone Towards a Region Free from Corruption (WBK) and a Clean and Serving Bureaucratic Region (WBBM) in Government Agencies requires each component's assessment, including Medan State University's Faculty of Mathematics and Natural Sciences, with all relevant parties involved including an Agent of Change. An Agent of Change is essential for establishing an Integrity Zone, clean government, optimal public services, accountable bureaucracy, and HR professionalism by proposing and implementing improvements in their work settings [4].

There are several tasks that must be carried out by a change agent such as being able to provide alternative solutions and creative ideas in improving quality and good change in their work unit. In addition, a change agent must be able to launch the change process in the implementation of solutions or creative ideas generated or given. And a change agent must be able to provide a good example as a form of commitment in the implementation towards the Integrity Zone in his work unit [4], [5].

The implementation of alternative solutions and creative ideas by agents of change is not optimal due to lack of well-documented evidence. An online-based E-Reporting System is needed to facilitate workers in recording solutions, reporting on progress, collecting evidence, and writing final reports. This can help accelerate the Integrity Zone within the FMIPA Unimed Work Unit. The problem formulation in this research based on the background above is whether the web-based Integrity Zone Change Agent E-Reporting application is able to improve the efficiency and effectiveness of implementing the performance of Change Agents in the Integrity Zone at FMIPA Medan State University. And whether the development of this E-Reporting application can increase the accountability and transparency of Agent of Change performance reporting.

Literature Review

Integrity Zone

The Integrity Zone Towards a Region Free from Corruption (WBK) and a Clean and Serving Bureaucratic Region (WBBM) is a strategy in preventing corruption and free from KKN. The main objective of Integrity Zone development is to build a bureaucratic reform program that is able to develop a bureaucratic work culture that is anti-corruption, collusion and nepotism, high-performance, and able to provide quality public services. In addition, the integrity zone within the government must be able to improve improvements in the bureaucracy that can reduce the number of cases of KKN, abuse of authority and weak aspects of supervision. There are 6 leveraging indicators, namely Change Management, Structuring Management Systems, Strengthening Performance Accountability, Strengthening Supervision, and Strengthening the Quality of Public Services [1], [3], [4].

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Agent of Change

Agents of change are individuals or groups consisting of officials and/or employees who are good role models in integrity and high performance. The main task of agents of change is to create institutions of society and government that can be used as a channel for new ideas and social renewal activities. In addition, change agents act as catalysts, drivers of change, solution providers, mediators, and liaisons between employees and organizational policy makers [6].

E-Reporting

E-Reporting or E-Report System is an electronic-based system that is tasked with digitally reporting information [7]. E-Reporting is a system that is able to provide effective and efficient solutions in managing reporting [8]. The E-Reporting mechanism itself makes it easy for users to manage, present, and distribute reports quickly and these reports can also be quickly processed by related parties [9].

The characteristics of the E-Reporting System include Electronic Access, Interactive and Dynamic, Process Automation, Information Security, Convenience and Integration, Real-time Monitoring, Reporting flexibility, Auditability, Performance tracking.

The E-Reporting System model includes the structure and key components designed to manage the electronic reporting process in an organization. Here are some common components that are often found in the E-Reporting System model [10], [11], [12], [13], [14]:

1. User Interface: use of interactive Dashboard and Navigation
2. User Management and Access Rights: easy management of user accounts and authorization system
3. Data Management: providing good data sources, data cleansing and transformation, and data quality monitoring.
4. Reporting Process: report generation, validation and verification, reporting process automation
5. Document Management: easy storage, search and retrieval of documents
6. Integration: able to integrate with external systems
7. Maintenance and Support: system updates and online documentation/assistance.

Method

The method used in this research is the SDLC (Software Development Life Cycle) system development method. The following is an overview of the system development method used:

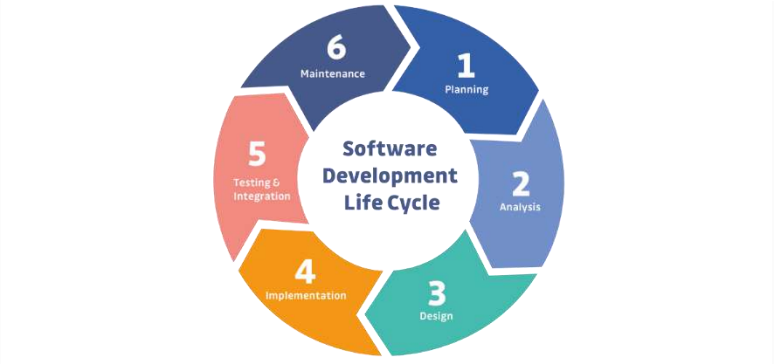

Figure 1. Overview of the SDLC System Development Method
(Source: https://it.telkomuniversity.ac.id/wp-content/uploads/2022/12/Mengenal-Software-Development-Life-Cycle.png)

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Overview of The System

An overview of the application is made based on entity information and application input/output using a context diagram, as follows:

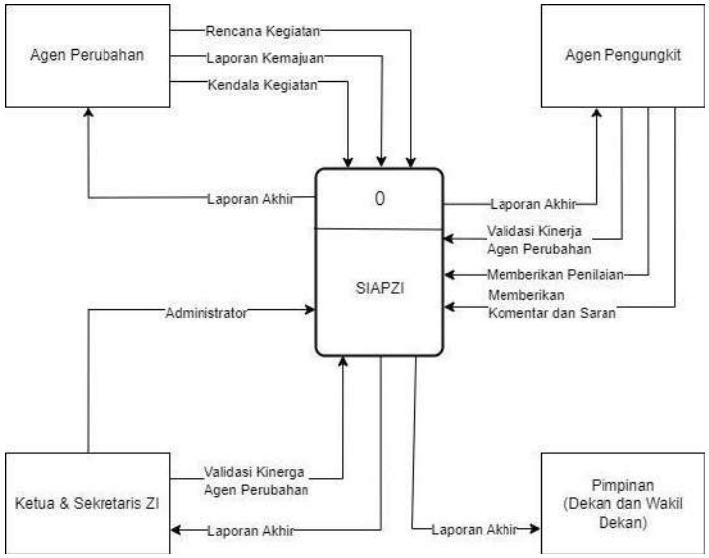

Figure 2. The Application Context Diagram

Design Database

Database design is the initial step in creating a web-based system. The Integrity Zone Agent of Change Information System database design is shown below. This system is essentially designed as an electronic reporting application for the Chage Agent. Siapzi is the name of the database.

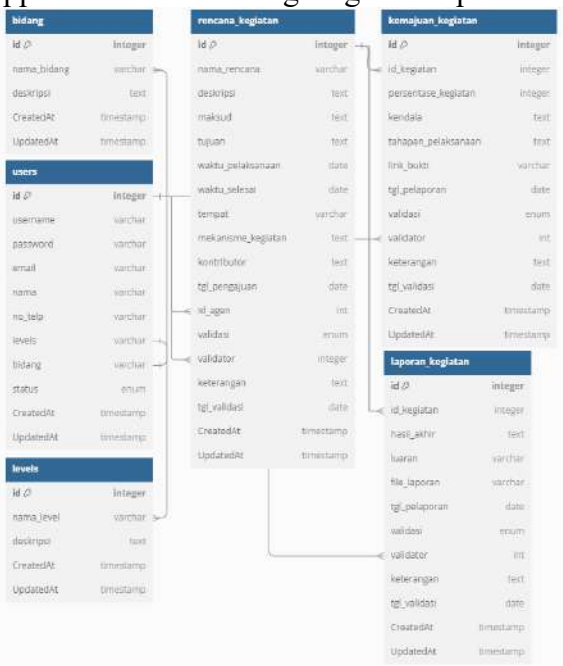

Figure 3. Design Databases and Relational

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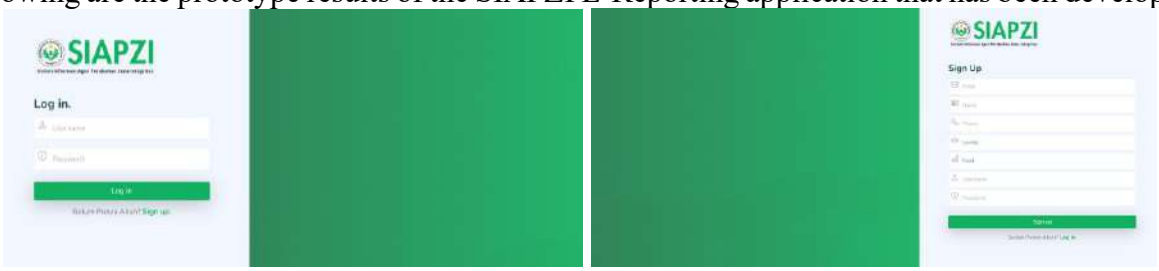
Result

In this paper, the SIAPZI E-Reporting application development process uses cloud technology, with document data from Change Agents stored and processed into a performance report. Through the SIAPZI E-reporting application that has been developed, FMIPA UNIMED can report and store change agent performance documents quickly and in accordance with the classification of document types by simply typing keywords in the search field available in the application. The following are the prototype results of the SIAPZI E-Reporting application that has been developed.



(a) (b)

Figure 4. Login Page (a) and Register Page (b)

In Figure 4, login page and register page is shown, login page aims to connect users with the dashboard page through the sign in process using a username and password. While the register page serves to create a new account for the user.

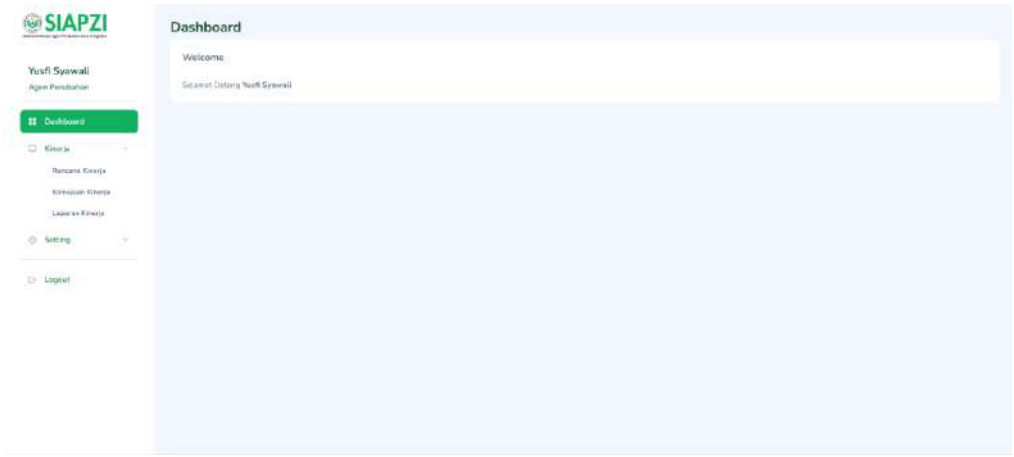


Figure 5. Dashboard Page for Agent of Change

On the Dashboard menu (Figure 5), the interface of the website will look like this, displaying the welcome message 'Welcome'. On the “Kinerja” Menu, there are submenus consisting of “Rencana Kinerja”, “Kemajuan Kinerja”, and “Laporan Kinerja”.

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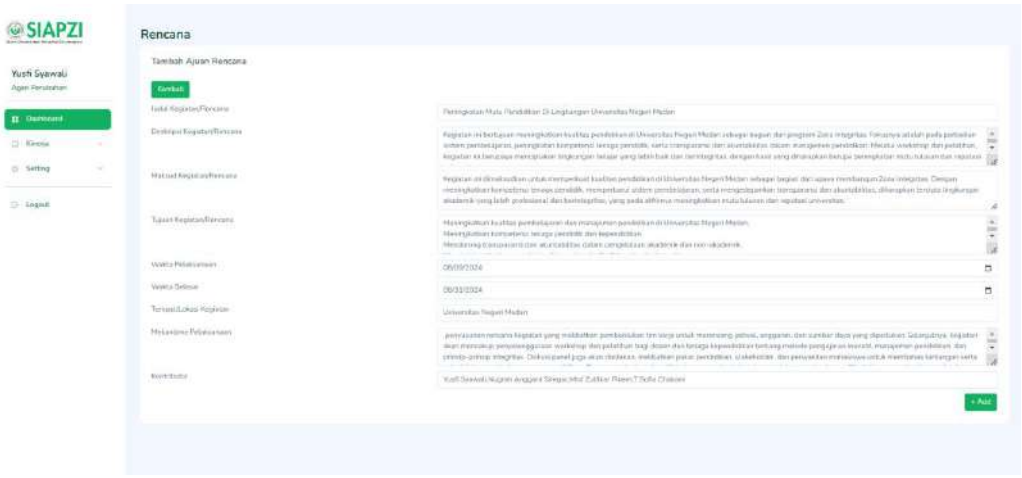

Figure 6. Rencana Kinerja Page

On the Performance menu, Change Agents can submit ideas, work programs, or performance plans by filling out a form that includes some important information. This information includes the name of the idea, work program, performance plan, or activity plan; a brief description; purpose and objectives; implementation and completion time plan; place or location; implementation mechanism; and contributors involved. and if you have finished filling in the performance plan data then click add then the data will automatically be successfully saved.

After the Change Agent submits the Work Program Plan, the Leveraging Agent will check and validate it to determine whether the activity can be carried out. In addition, the Leveraging Agent will also provide relevant information and if the performance plan has been validated, the website will display as shown in Figure 7.

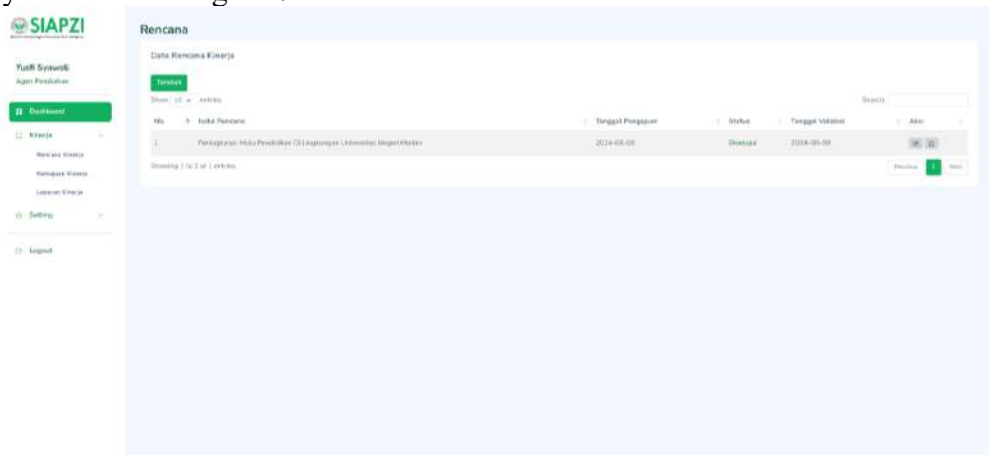

Figure 7. Rencana Kinerja Page for Agent of Leverage

After the Work Program Plan is validated, the Agent of Change will carry out the activity. After the activity is carried out, the Agent of Change is required to report work progress through the system on the Performance Progress menu by filling in several information, including: Percentage of Work Progress (in the form of numbers or score sliders), Obstacles faced, Stages of Implementation Activities in the field, Uploading partial (if not completed) or complete (if completed) evidence, such as photos, videos, and documents, in the form of Google Drive links (all evidence must be entered into Google Drive and the link taken).

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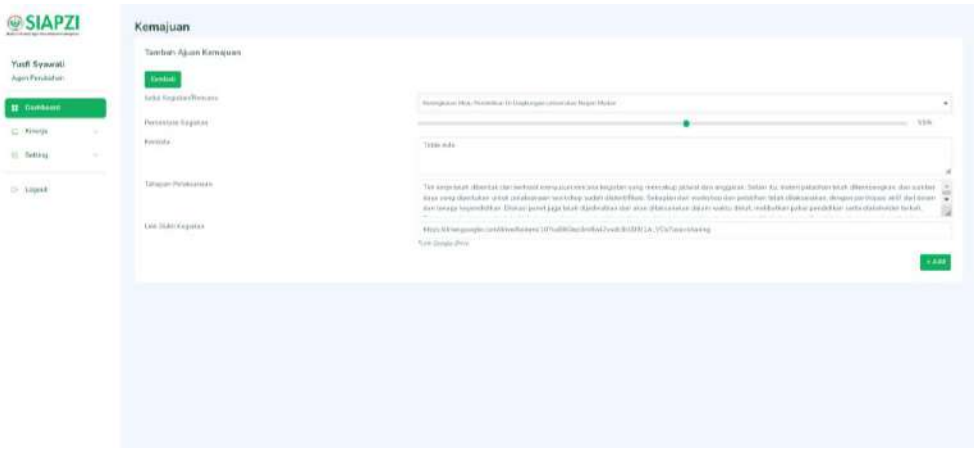

Figure 8. Progress Page

In the final stage, the Agent of Change prepares a Final Report of the activities that have been carried out by filling in some information, including: Final Results of Activities, Outputs (if any, can be anything) (optional), Final Report in PDF format.

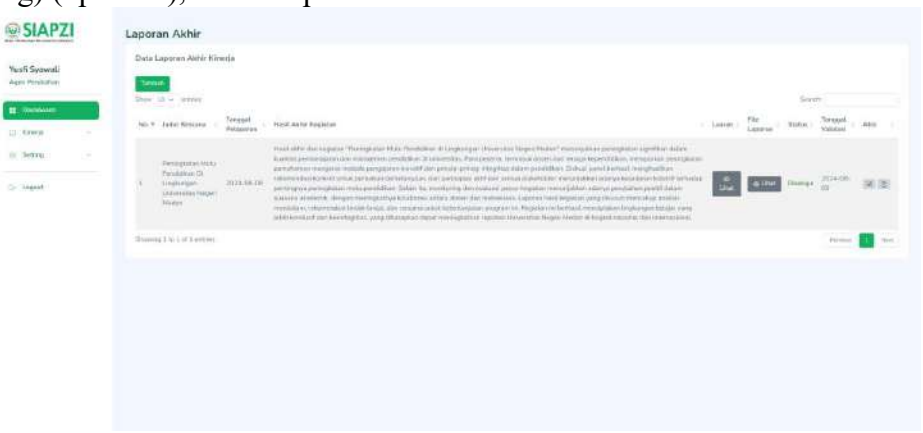

Figure 9. Final Report Page

Conclusion

Based on the results and outcomes achieved in the development of the E-Reporting application SIAPZI for Agent of Change in FMIPA UNIMED, the following conclusions have been drawn:

1. The application of design using the SDLC (Software Development Life Cycle) method is able to provide the desired results starting from planning, analysis, design, implementation, testing and integration, and maintenance runs well and in accordance with the design.
2. The design and development of the integrity zone change agent information system at FMIPA Unimed is to build a web-based application that can accommodate the performance of change agents, as well as create access pages for change agents, leverage agents, secretariats, ZI secretaries, ZI Chairmen, and Leaders who have data filtering features as needed.

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Smart document storage for PT cipto sarana nusantara

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Abstract. PT Cipto Sarana Nusantara is an industry engaged in construction in collaboration with PT PGN which also has duties and functions in managing information and data related to State Gas construction. PT Cipto Sarana Nusantara has an important task in managing documents, so that, they need to implement effective and efficient document management methods to maintain the confidentiality of documents and ensure the security of stored documents. Smart document storage and management is a system that uses advanced technologies such as machine learning and encryption to manage and store documents in a secure and accessible way. The examples of documents that have been allowed as research data sources will be classified into one or more predefined classes. Word2vec algorithm is used to convert words into numeric vectors that can be analyzed by machine learning algorithms. Continuous Bag-of-Words (CBOW) is one of the artificial neural network architecture models from Word2vec. The CBOW model uses several words around the target word to predict the target word itself and then Support Vector Machine (SVM) is used to classify vector representations of words in a document into predefined classes. As an additional layer of security to documents on storage, Advanced Encryption Standard (AES) is used. The result is a digital document storage service that is integrated with automatic category management and security implementation using cryptographic methods for managing documents in PT Cipto Sarana Nusantara.

Keywords: AES, CBOW, Storage, SVM, Word2vec

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Introduction

The effective and efficient document storage and management are essential for any organization. Digital documents generated by an organization can be diverse, including emails, internal documents, contracts, reports, and many more. It is critical to have a storage and management system that is secure, easily accessible, and capable of retrieving the necessary information quickly and accurately.

The concept of smart document storage and management offers a promising solution for managing and storing documents digitally. Smart document storage leverages advanced technologies such as machine learning and encryption to manage documents securely and make them easily accessible. PT Cipto Sarana Nusantara, a construction industry player collaborating with PT PGN, handles significant volumes of construction-related information and data, including sensitive documents. The company needs to implement an effective and efficient document management system to ensure confidentiality and security of stored documents. Based on the background, the research questions addressed in this study are:

1. How can the smart document storage system be implemented in PT Cipto Sarana Nusantara?
2. How can document encryption ensure the confidentiality of documents?
3. How can the word2vec method be used to retrieve the necessary information from stored documents?

The primary objective of this research is to develop an application that provides a digital document storage service equipped with automatic document management based on the classification of the document types. Additionally, this application aims to enhance document security by applying encryption techniques to safeguard the stored digital documents. Through this, the system ensures that sensitive information remains confidential and secure while maintaining ease of access and management.

Literature Review

Digital Documents

Digital documents refer to the concept of collecting, storing, and managing information in printed or electronic image form that can be used as evidence or information. The use of digital documents is considered more efficient in terms of document transmission, with faster delivery times, complete data, and easier access, making digital documents a preferred alternative for administrative processes [1].

Word2Vec

The Word2Vec method was proposed by Mikolov in 2013, considering the corpus as input and generating vectors as output. Word2Vec transforms each unique word into a vector, allowing for the representation of contextual similarity between two words based on the resulting vectors [2]. This algorithm is widely used in Natural Language Processing (NLP) because of its ability to cluster similar words into similar vectors. Word2Vec computes word representations into vectors using neural networks. The resulting word vectors exist in a dimensional space that captures the semantic meaning of the words. Word2Vec has three main parameters that affect model training: architecture, evaluation method, and vector dimensions. Each type of these three parameters influences the accuracy performance in deep learning [3].

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Advanced Encryption Standard (AES)

The Advanced Encryption Standard (AES) is a cipher algorithm used to protect confidential data or information. Since 2001, AES has replaced the Data Encryption Standard (DES) algorithm, which was considered outdated and easily breached. AES supports key sizes of 128 bits, 192 bits, and 256 bits, with the key size affecting the number of rounds used during the encryption and decryption processes [4]. AES is widely adopted in information security due to its high level of security and difficulty in cracking. The following table shows the differences in key sizes in the AES algorithm.

Table 1. The Difference of AES Key Size

Type	Key Length	Block Length	Rounds
AES-128	4	4	10
AES-192	6	4	12
AES-256	8	4	14

Method

The focuses of this paper are on developing a digital document storage service model integrated with automatic category management and the implementation of security using cryptographic methods.

This system aims to enhance document management by:

1. Automating Document Categorization: Leveraging machine learning or predefined rules to automatically classify and organize documents, reducing manual effort.
2. Enhancing Security: Implementing encryption techniques, such as AES (Advanced Encryption Standard), to protect sensitive documents from unauthorized access and ensure data confidentiality.

By addressing these two key areas, the proposed model seeks to improve the efficiency of digital document storage and retrieval, while simultaneously ensuring data security, especially for sensitive or confidential information. This can be particularly beneficial for organizations that handle a large volume of digital files requiring secure, efficient management, such as PT Cipto Sarana Nusantara.

Population and Data Sample

The data population is the examples of documents that have been allowed to be used as research data sources by partner agencies. The sample data will later be divided into two types of data, training and testing data with a division proportion of 70% training data and 30% testing data. The training data will be used to train artificial neural networks and form embedding vectors that can be used in the process of testing the classification of test data before the document classification model is finalized.

Document Classification with Word2Vec

The Word2vec algorithm is an embedding algorithm that maps each word in a text into vectors that provide semantic meaning information for those words [5]. Word2vec is a neural network-based algorithm that has become popular in the field of Natural Language Processing (NLP). This algorithm is used to transform words into vectors that can be analyzed by machine learning algorithms. Word2vec is a powerful tool that can capture semantic relationships between words, with various applications, including document classification.

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The main goal of document classification is to categorize documents into one or more predefined classes. This task is challenging as it requires an understanding of the document content and the identification of the most relevant features. Word2vec can assist by transforming words within documents into numerical vectors, making it easier for machine learning algorithms to analyze the documents.

The artificial neural network architecture of Word2vec consists of two types of models: the Continuous Bag-of-Words (CBOW) model and the Skip-Gram model. These two models have similar architectures but differ in the input and output used. The CBOW model uses several surrounding words to predict the target word itself. The CBOW network architecture consists of an input layer, one or more hidden layers, and an output layer. The input layer consists of binary vectors indicating the presence of words in a particular context. The hidden layer can have multiple layers, each with several neuron units. Each neuron unit is connected to all neuron units in the input and output layers.

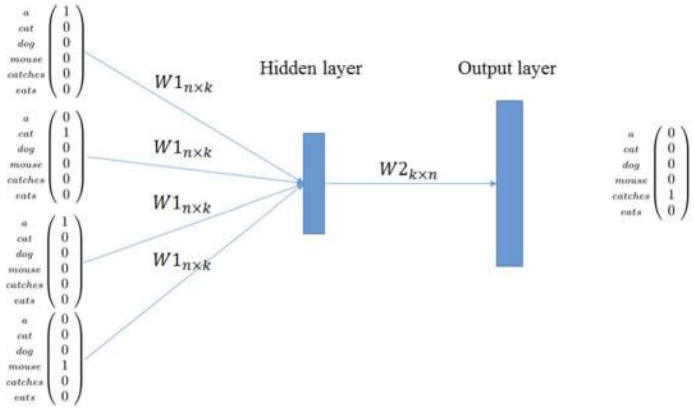

Figure 1. CBOW Model [6]

Document Security with AES

The Advanced Encryption Standard (AES) is a widely applied symmetric cryptographic method still in use today. This study employs the AES method to provide an additional layer of security for documents stored in storage media.

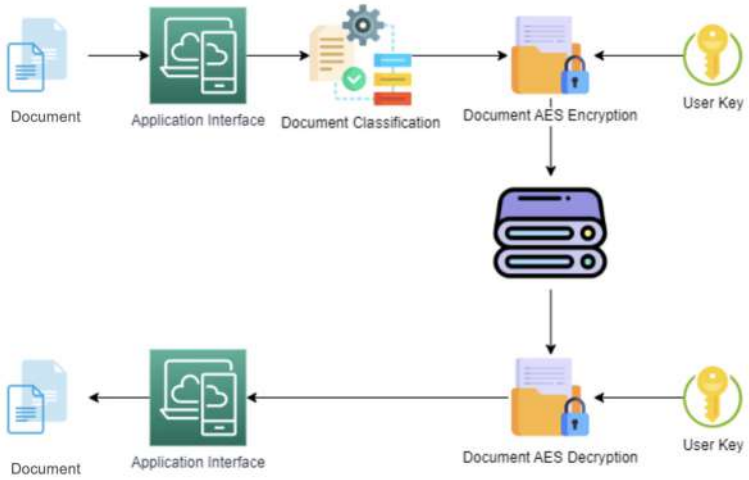

Figure 2. Document Security with AES

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The implementation of AES in securing digital documents used in this study adopts methods and techniques from several previous studies [7][8] and simulates some of these methods and techniques to obtain efficient implementation techniques considering the limited computing time and cost of cloud applications.

Result

In this research, the process of developing the Smart Document application uses cloud technology, with 70% of the document data from PT Cipto Sarana Nusantara serving as training data. Meanwhile, the testing process uses 30% of the document data from PT Cipto Sarana Nusantara, which has been authorized for access. Through the Smart Document application that has been developed, PT Cipto Sarana Nusantara can search for and store documents quickly and in accordance with the classification of the document type by simply typing keywords into the search field available in the application.

The development of the Smart-Doc application uses the SVM (Support Vector Machine) method with the Word2Vec algorithms for document classification. The Word2Vec algorithm is integrated into the Smart-Document application using the Gensim library in Python software. The following shows the prototype results of the Smart Document application that has been developed.

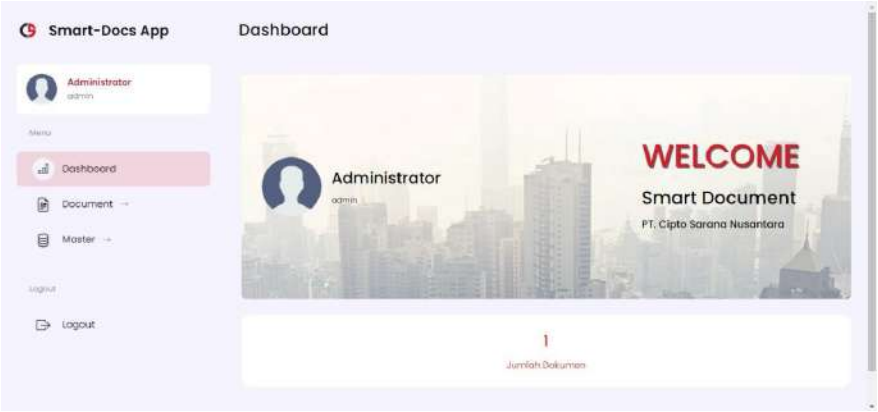

Figure 3. Smart-Document Main Dashboard

In Figure 1, the main dashboard display of the Smart-Docs App is shown, with the Administrator logged in as the admin user. The left side of the dashboard contains a tab menu consisting of Dashboard, Document, and Master Data, along with a Log Out option for users to exit the system.

In the main section of the dashboard, there is information indicating the total number of documents stored in the Smart-Doc app system. The Document menu lists all the documents stored in the system, organized by type, which have been classified.

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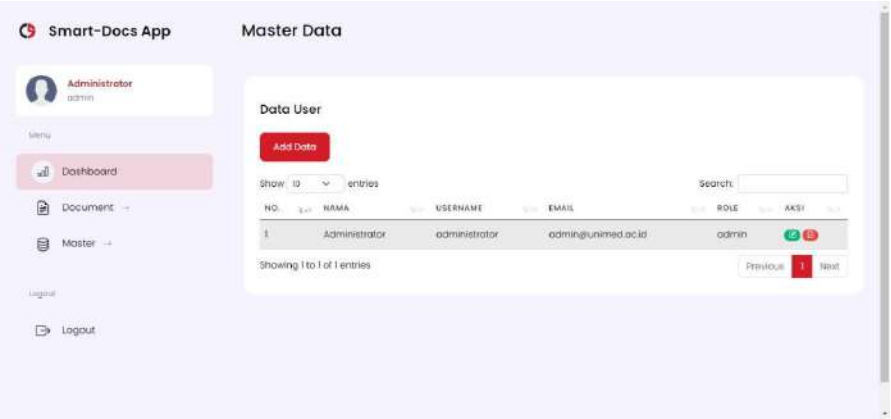

Figure 4. Master Data

The Master Data menu**,** as shown in Figure 2, displays the application users of the Smart-Docs App under the User Data submenu. The first user listed is Administrator, with their email address and role as an admin. This user can modify their details by selecting the green edit icon or remove their account by selecting the red delete icon.

Additionally, users can add new user data by clicking the "Add Data" button located at the top left of the user list. This action will bring up a page similar to Figure 3, allowing for the addition of new user information into the system.

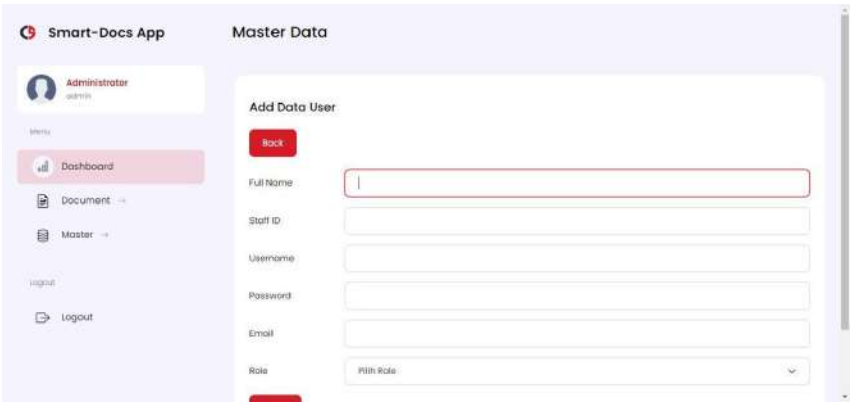

Figure 5. The "Add Data User" feature in the Smart-Doc App system

The user addition feature on the Smart-Doc App system is useful for adding users or Smart-Docs App users. To add users, you can do this by filling out a form with appropriate data such as full name, staff ID, username, password, email, and selecting roles consisting of admin, user, and guest. The purpose of differentiating roles in these users is so that other users such as guests or guests can only access documents that have been published. In addition, it is also so that internal documents or confidential documents are maintained. The Advanced Encryption Standard (AES) model is implemented to provide an additional layer of security to documents stored on storage media.

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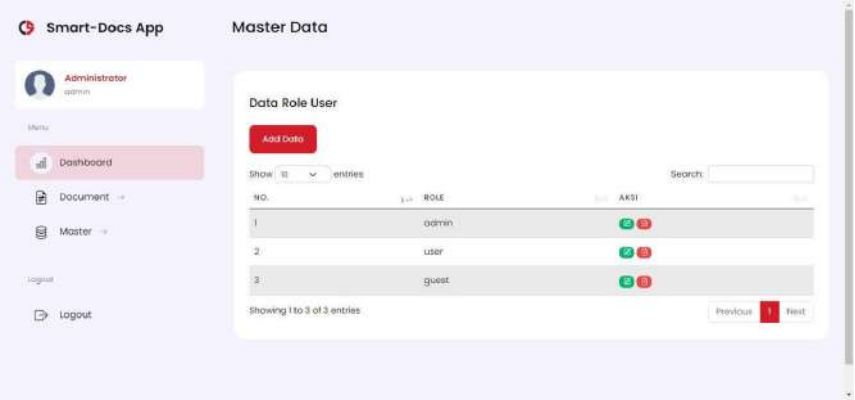

Figure 6. "Role" in the Smart-Doc App system

Admin users can add, edit, or even delete user role data if needed as shown in Figure 4. The feature of adding a role is found at the top left of the role list. Adding a role can be done by filling in the name of the new role you want to add as seen in Figure 5. The new role will appear in the list of roles on the "User Role Data" page.

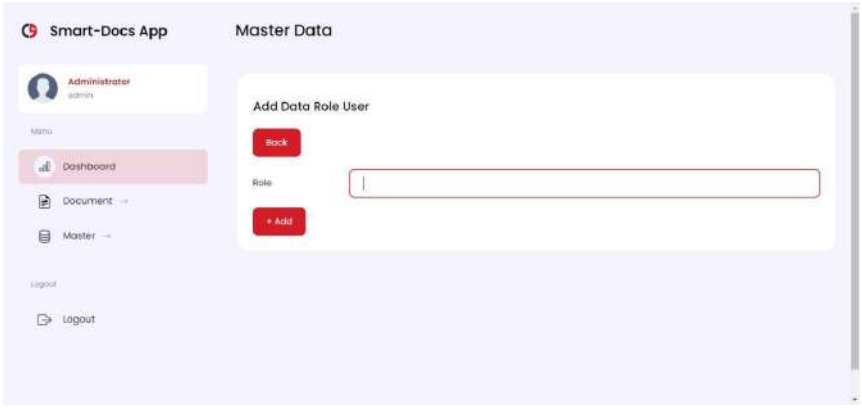

Figure 7. Addition of new roles to the Smart-Doc App system

When the application is ready to use, the number of documents on the Smart-Docs App will increase to thousands or even more. With automatic grouping, search, and archiving features, PT Cipto Sarana Nusantara can manage large amounts of documents more efficiently. A file search can be easily found using the Smart-Docs application by entering the document identity which can be in the form of file name, document type, document tag, year, or document status in the search field at the top right of the document list. Here's what the app looks like for the "Document" menu.

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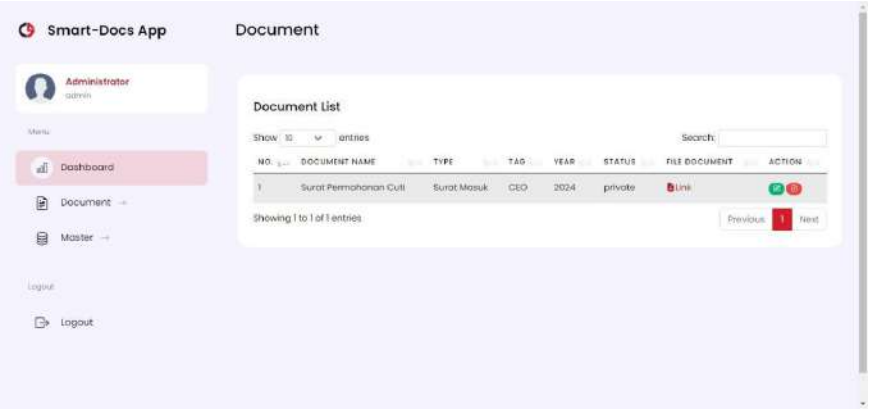

Figure 8. Document Menu

Documents or files in the Smart-Docs App system are in the form of links that are directly connected to the storage cloud. Users of the Smart-Docs application can directly download the desired document or file by clicking on the available document file link. Admins can also edit and delete the document or file if needed by selecting the green "edit" action and will be redirected to the document edit page.

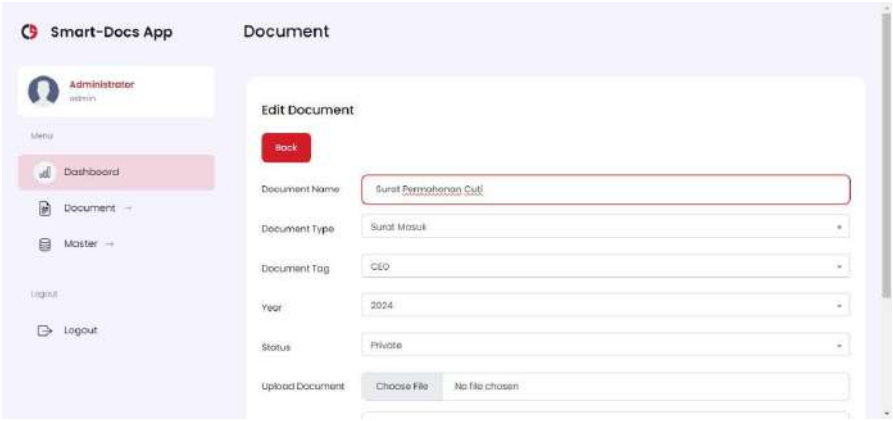

Figure 9. Edit Document

The document data that can be edited is document name, document type, document tag, year, status, and document file. In addition, new documents can also be added by the admin by selecting the "Add Document" sub-menu as follows.

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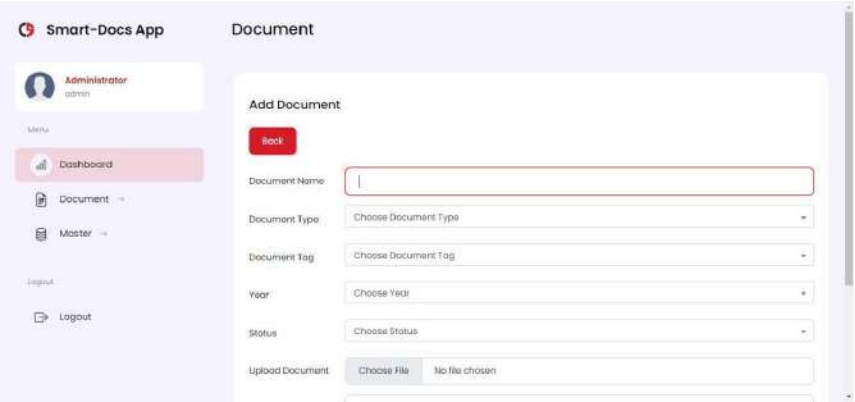

Figure 10. Add Document

Adding files or documents to the Smart-Docs application can be done by filling out the form that has been provided such as the name of the document, selecting the type of document (incoming letter, outgoing letter, or guide), selecting the document tag (CEO, CTO, Finance, Field), selecting the year, selecting the document status, and uploading the document file. Files that have been uploaded and added to the system will be entered into the document list or document list and users can access the file depending on the user's role. The status of a private file indicates that the document is confidential and that only authorized users can access the file.

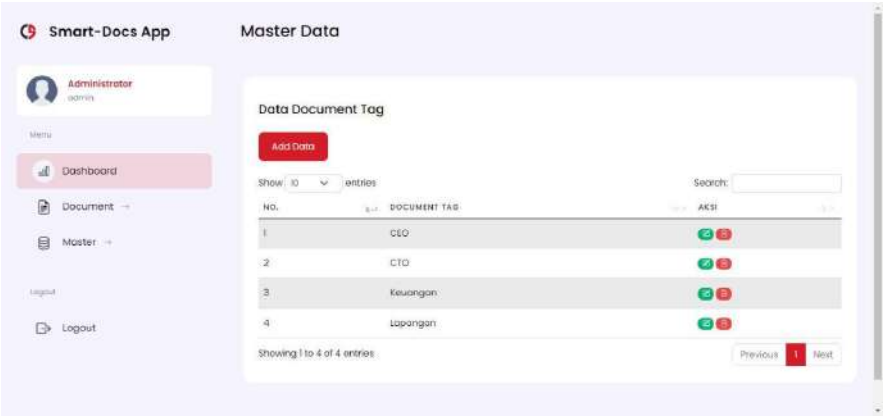

Figure 11. Document Tag

Document tags and document types can also be added, edited, and deleted as needed. Document tags contain divisions or positions within the company. This is to find out that the file or document is related to a division or position in the Company. Like a leave request letter, it is related to the CEO for his approval. Document Type contains document types such as incoming letters, outgoing letters, or guides. With this kind of classification, the search for a document or file can be easily accessed.

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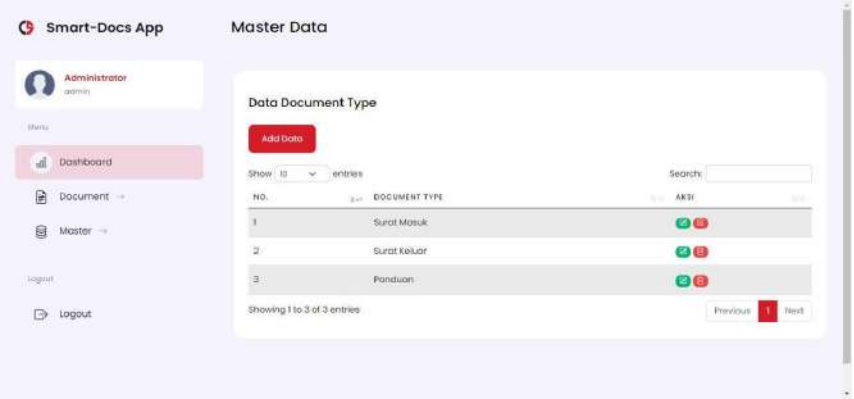

Figure 12. Document Type

Overall, the creation of the Smart-Docs App provides significant benefits for PT Cipto Sarana Nusantara, helping to create a more efficient, safe, and productive work environment. The Smart-Docs App that has been created can help improve work efficiency because it allows the automation of routine tasks such as form filling, data collection, and report generation, and reduces manual workload and saves time. The cloud-based Smart-Docs App allows multiple users to access and edit documents simultaneously, so companies know the latest versions of documents and can improve team collaboration. Additionally, with the digitization of documents, companies can reduce the use of paper, which not only saves costs but also supports eco-friendly life. By the implementation of Smart-Docs application, PT Cipto Sarana Nusantara can continue to improve operational efficiency and security in document management, which will ultimately support better business growth.

Conclusion

Based on the results and outcomes achieved in the development of the Smart-Docs application for PT Cipto Sarana Nusantara, the following conclusions have been drawn:

1. The Smart-Docs application developed has successfully improved efficiency in document management at PT Cipto Sarana Nusantara. With features such as automatic classification using the SVM method and Word2Vec algorithm, the document search and archiving processes have become faster and more accurate.
2. The implementation of the Advanced Encryption Standard (AES) model adds an extra layer of security to stored documents, ensuring that only authorized users can access sensitive or private documents. This is crucial for maintaining the confidentiality of company information.
3. The cloud-based application enables more effective collaboration among users, where multiple users can access and edit documents simultaneously. This also ensures that the company always has the most up-to-date versions of documents.
4. The digitalization of documents through this application helps the company reduce paper usage, not only saving operational costs but also supporting environmentally friendly initiatives.
5. Features such as user role management, document tagging, and document type management allow the application to be tailored to the specific needs of the company, making it more effective in meeting various document management requirements.

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Combination of expert system and emotion recognition system based on facial expression to detect stress level of gen Z students

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Abstract. *Mental health among adolescents is quite high in Indonesia. According to research in 2021, it was stated that 35% of students in North Sumatra experienced stress due to accumulated tasks or pressure from their surroundings. The public's desire to detect mental health to a psychologist or psychiatrist is very low. This is due to lack of health knowledge, financial constraints, distant locations, or laborious administrative procedures. Current stress detection methods have limitations such as subjectivity, and invasiveness, so a reliable and unobtrusive stress detection system is needed. The purpose of this research to develop an expert system and emotion recognition system based on detecting mental health. The expert system algorithm used is certainty factor The expert system algorithm used is certainty factor and the emotion recognition system uses CNN model. From the tests conducted on 30 students of Computer Science in Medan, the results of the expert system showed that 100% of students were in the category of severe stress with an average weight value of 0.98. Meanwhile, the results of emotion recognition based on facial expressions obtained 80% of students in the category of severe stress and 20% of students in the category of moderate stress. It can be concluded that most computer science students are in the severe stress category. Based on the results of interviews, the stress experienced by students is not only influenced by lecture assignments, but also influenced by other factors such as activities outside of lectures, the environment, economic conditions, family problems and others.*

Keywords**:** *Mental Health, Stress detection, expert system, emotion recognition, facial expression*

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Introduction

Student mental health has become an increasingly crucial topic as the academic, social and financial pressures faced by students around the world increase. Various studies show a significant increase in mental health disorders among students, with cases of anxiety, depression and stress continuing to increase every year [1][2]. The COVID-19 pandemic also has an additional impact, where social isolation and the shift to online learning models trigger mental health symptoms in most students [3]. This condition calls for the development of a system that can provide quick and accurate assessments regarding student mental health as a first step for early detection and appropriate intervention.

An expert system based on artificial intelligence (AI) is a potential solution in this case, especially in providing a fast and efficient initial diagnosis tool. Certainty Factor (CF), as a method in expert systems, allows the system to provide a level of confidence or certainty for a hypothesis based on user input. The CF method has been proven to be effective in dealing with uncertainty, which is one of the main challenges in mental health diagnosis due to its varied symptoms and subjective nature [4][5]. By applying CF, the expert system can provide initial diagnosis results based on symptoms reported by students, which can then be used to determine the need for further intervention. Meanwhile facial Emotion Recognition is a field of study that uses technology to identify and interpret human emotions based on facial expressions. This technology has been used in various applications such as healthcare, human-computer interaction, and security. Stress detection is one of the most important applications of Facial Emotion Recognition; it helps in early diagnosis and treatment of stress disorders. The system uses machine learning and computer vision algorithms to analyse facial features and identify emotions such as happiness, sadness, anger, and fear. The system is designed for mental stress detection, which means it can detect mental stress in individuals through analysing their facial expressions [6][7].

The importance of early detection is reinforced by several studies showing that rapid intervention can reduce further mental health risks and improve students' quality of life. For example, research from [7] shows that early treatment of anxiety and depression in students can reduce the risk of decreased academic achievement and involvement in high-risk behavior. This research aims to develop a system that combines an expert system based on the Certainty Factor method and an emotion recognition system on facial expressions to detect student mental health by focusing on symptoms of anxiety, stress, and depression. With expected accurate and fast results, this system is expected to be an early diagnosis tool that can reduce the burden on mental health professionals on campus while providing support to students who need it.

Research Method

This research uses a system development model called the Software Development Life Cycle (SDLC) or often called the waterfall model to build and test a mobile-based expert system for detecting student anxiety using the Certainty Factor method. The Waterfall SDLC approach was chosen to ensure development takes place in a structured manner, through a linear flow from requirements analysis to final evaluation. The following are the stages carried out in this research:

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Figure 1. SDLC Waterfall

Analysis

At this stage, an analysis is carried out to identify the system's functional and non-functional requirements, including:

- Functional Requirements: The system must detect student anxiety levels based on symptoms input by the user, process the data using the Certainty Factor method, and provide initial recommendations to the user.
- Non-Functional Requirements: The system must be easy to use (user-friendly), have a fast response, and be accessible on Android-based mobile devices.

Data for this needs analysis is obtained through:

1. Literature Study: Review previous research relevant to expert systems for anxiety detection and the use of the Certainty Factor method

2. Expert Interview: Conduct an interview with a psychologist to determine the main factors of anxiety, common symptoms, as well as the appropriate Certainty Factor weight for each symptom.

System Design

At this stage, the system architecture and main components of the expert system are designed, including method design and database design for the system to be developed [8]

Implementation

The implementation stage is the system development process based on the design that has been created. Implementation stages include:

- Knowledge Base Module Development: Developing a knowledge base with pre-designed CF rules and values, which will be the basis for diagnosis in the expert system. If there is more than one symptom in a rule or diagnosis, then the CF of these symptoms is combined using the following formula:

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$$\text{CF Combine} = \text{CF}_1 + \text{CF}_2 \times (1 - |\text{CF}_1|) \quad (1)$$

The process is carried out iteratively until all CFs of relevant symptoms are combined [8].

- Implementation of the Certainty Factor Algorithm: The Certainty Factor Algorithm is used to process symptom input provided by the user and calculate anxiety levels.
- Front-End and Back-End Integration: Connects user interfaces with expert system processing logic to provide a smooth and responsive user experience.

Testing

The implementation stage is the system development process based on the design that has been created. Implementation stages include:

- Knowledge Base Module Development: Developing a knowledge base with pre-designed CF rules and values, which will be the basis for diagnosis in the expert system.
- Implementation of the Certainty Factor Algorithm: The Certainty Factor Algorithm is used to process symptom input provided by the user and calculate anxiety levels.
- Front-End and Back-End Integration: Connects user interfaces with expert system processing logic to provide a smooth and responsive user experience.

Evaluate

Based on the results of the testing that has been carried out, a comprehensive evaluation is carried out on the system that has been developed with the aim of making the system built more perfect.

The development of the facial expression-based emotion recognition system will go through several stages of the process which can be seen in the Figure 2.

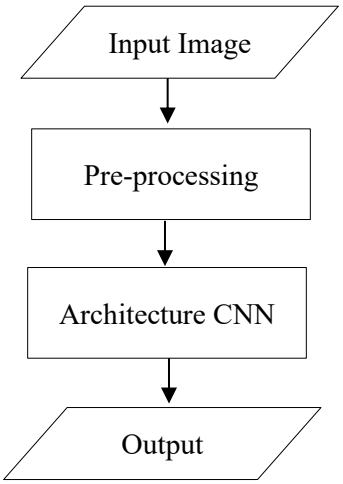

Figure 2. Design of Emotional Recognition System

Before the image is processed by the CNN algorithm, there are 3 stages of image *preprocessing*, namely cropping, grayscale image and image augmentation. After going through the preprocessing stage, the next stage is to build a CNN architecture which is a model that functions for emotion

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recognition systems through facial expression images. The CNN architecture can be shown as in Figure 3.

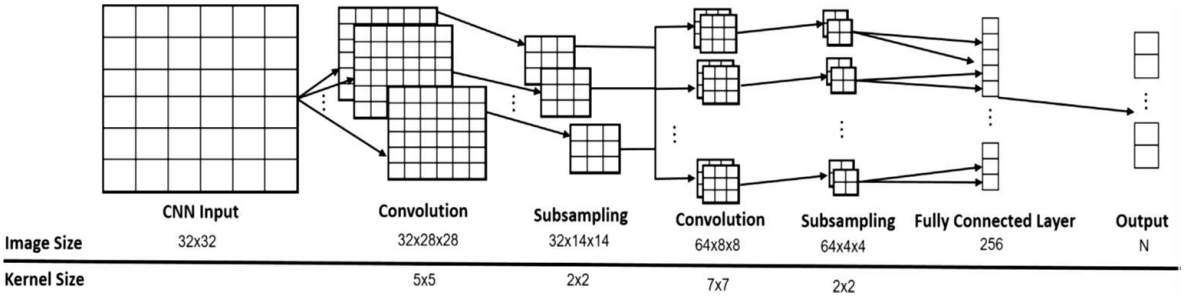

Figure 3. Architecture CNN

For the proposed model, the data set includes six facial emotions: angry, happy, neutral, sad, fearful, and surprised. Then the five data are categorised into two categories: the stressful one, consisting of angry, sad, and fearful; the non-stressful one, consisting of happy, neutral, and surprised. The data was collected manually using a web camera. Each expression has 100 images, making the dataset a total of 700 facial expression images. The data consisting of the set of images was divided into two parts, namely training data and testing data, with a sharing percentage of 80%:20%. Each class has the same number of training samples, so there is no bias.

Result and Discussion

The results at each stage will become input for the next stage. The system built at the analysis stage produces a number of questions with weights that have been verified by psychologists. The number of questions produced is 30 questions with each weight as attached in Table 1.

Tabel 1. Symptoms Anxiety and Probability

Number	Symptoms	Probability
1	Often Forgetting/Forgetful	0.80
2	Difficulty Concentrating/Not Focusing	0.80
3	Feeling Anxious	0.75
4	The mood of the day changes easily	0.75
5	Decreased Appetite	0.65
6	Easily offended	0.75
7	Difficulty Sleeping/Sleeping More	0.80
8	Easy to Cry	0.70
9	Diarrhea	0.80
10	Indigestion	0.75
11	Tension in certain muscles, especially the neck, shoulders and back	0.75
12	Headache	0.70
13	Excessive and Uncontrolled Emotions	0.70
14	Excessive Sweating	0.55
15	Lack of spirit	0.70
16	Loss of Self-Confidence	0.95
17	Itching - Itchy skin/allergies	0.95
18	Severe Digestive Disorders	0.55
19	Heart palpitations are increasing	0.80
20	Out of breath	0.50
21	Tremor (Uncontrollable Shaking)	0.70
22	Feelings of Anxiety and Fear Increase	0.70

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23	Distracted mind	0.85
24	Sensitive / Easily Offended	0.80
25	Loss of Sense of Humor	0.80
26	Decreased Achievement	0.75
27	Tired Easily	0.75
28	Feeling that there is no hope/hopeless	0.70
29	Back pain	0.55
30	Too Sensitive	0.70

By using the Certanty factor algorithm the results of the predictions will be grouped into 3 anxiety classes, namely anxiety: Low, Medium and High/Severe as attached in Table 2.

Table 2. Class of Stress

Number	Class	Value Certanty Factor
1	Low	0.0 – 03
2	Middle	0.31 – 0.6
3	High	0.61 – 1.0

After the model is prepared according to the design, the next step is to create a system interface on the mobile platform, where the interface to be developed will have input, process and output features.

Meanwhile, Emotion recognition system based on facial expressions using CNN for mental health detection can be done by capturing the user's face using a camera. After the face is captured by the camera, the user can press the confirmation button to get the result of the user's facial expression as shown in Figure 4.

Figure 4. Result of Emotional Face Recognition

It can be seen that the model has been able to automatically detect facial expressions with a smile rate prediction of 91%, meaning that the user is happy and not stressed.

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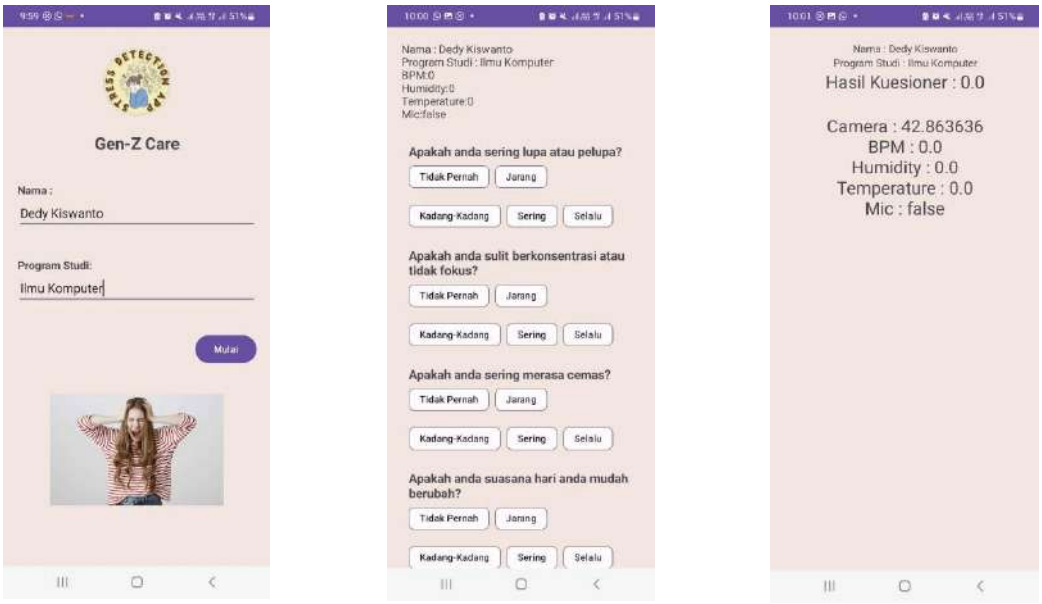
The display results of the mental health detection system based on the expert system and the emotion recognition system based on facial expressions can be seen in Figure 5.



(a) (b) (c)

Figure 5. Dasboard System (a) User Biodata, (b) Data Capture (c) Predictive Value Of Anxiety

The next stage after developing the mobile application for the Gen Z mental health detection expert system was to carry out a trial. The trial was carried out involving 30 students from the Computer Science Study Program at Medan State University. The results of the trial showed that the average certification factor value produced after going through the data collection process was 0.98. If you refer to table 2 on the division of anxiety classes, it can be concluded that 100% of Computer Science Students are Severely or high Stressed. Meanwhile, the results of emotion recognition based on facial expressions obtained 80% of students in the category of severe stress and 20% of students in the category of moderate stress. To validate these results, a direct check was then carried out with validation via confirmation from students and it was found that all samples stated that when they were testing the system they were indeed in a condition of severe stress. To ascertain this situation, in-depth questions were then asked as to what caused the respondents' severe stress and data was obtained on student stress due to the high learning load, including weekly assignments and final projects for each ongoing course.

Conclusion

From the results of this research, it was concluded that the mobile-based Gen Z anxiety detection expert system had been successfully developed using the Certanty Factor method. The test results showed that 100% of respondents were in a condition of severe or high stress due to the ongoing courseload. Meanwhile, the results of emotion recognition based on facial expressions obtained 80% of students in the category of severe stress and 20% of students in the category of moderate stress. This could certainly be a concern for Medan State University for future policy making.

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Implementation of decision support system (DSS) for assessment of tracer study results

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Abstract. Tracer Study is an important method in higher education used to track alumni and gather feedback. Through tracer studies, universities can assess graduates' adaptation to the workforce and the relevance of the education provided, yielding insights to improve educational quality and align the curriculum with market needs. Unfortunately, many universities often use tracer studies merely to fulfill accreditation requirements. This process typically involves simple questionnaire distribution, lacking adequate data processing, leading to the waste of valuable information. This research aims to develop a comprehensive database of tracer study results that is easily accessible and regularly updated. The data will be analyzed using a Decision Support System (DSS) to provide strong guidance for ongoing improvements. The ultimate goal of the research is to create a web-based DSS application that facilitates the assessment of tracer study results and helps universities adapt to industry changes. This application is expected to serve as a strategic tool for producing competent graduates ready to compete globally.

Keywords: decision support system, assessment, tracer study

Introduction

The quality of higher education graduates is a critical concern not only for governments and educational institutions but also for society at large, both locally and nationally. One effective method for assessing the quality of graduates from higher education institutions is through tracer studies. A tracer study is a research method used to track and gather feedback from alumni, aiming to evaluate the relevance of the education they received in relation to the demands of the workforce. The results of tracer studies serve as an effective tool for measuring graduate performance, particularly in assessing the alignment between the competencies of graduates and the needs of the job market [1].

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The findings of a tracer study are generally utilized by higher education institutions to evaluate and improve the quality of their educational systems. Continuous evaluation of educational quality is necessary, as the performance of an educational institution must be constantly monitored to ensure compliance with accreditation standards set by the government [2]. Furthermore, the feedback obtained from tracer studies provides valuable insights into the needs of the business and industrial sectors, helping universities adjust their curricula to meet the skills required by the labor market. In this way, tracer studies can help ensure that graduates possess the relevant competencies needed to effectively compete in the professional world.

The achievement of graduate quality cannot solely be measured by high academic achievement but also by several other key indicators, such as timely completion of studies, alignment between the field of study and the obtained employment, and the graduates' ability to compete in the labor market[3]. According to Regulation of the Minister of Education and Culture No. 49 of 2014 concerning National Standards for Higher Education, the quality of graduates is influenced by factors such as on-time graduation rates and the relevance between the field of study and the graduates' employment. Therefore, tracer studies play a crucial role in evaluating the effectiveness of education, particularly in determining whether graduate competencies meet the expectations of employers. Moreover, tracer studies contribute to formulating policies, designing more relevant curricula, and improving the quality of teaching and learning processes.

However, a significant issue with the implementation of tracer studies in many higher education institutions is that these studies are often treated as mere administrative requirements for accreditation purposes. Typically, tracer studies are conducted only in preparation for program accreditation, with data collection methods such as distributing questionnaires via Google Forms to alumni. Once the accreditation process is completed, the results of these studies are often neglected. This is problematic, as the data gathered through tracer studies hold immense value and can serve as a critical benchmark for assessing the quality of graduates, as well as for evaluating and improving educational processes to enhance graduate quality.

Therefore, research that examines the outcomes of tracer studies is essential. One of the primary objectives of this research is to create a structured database of tracer study results, which can be accessed at any time and periodically updated with new data from subsequent years. This ensures that the valuable data collected through tracer studies are not wasted but instead can be continuously utilized for ongoing educational improvement.

Furthermore, the data obtained from tracer studies can be processed and analyzed using a Decision Support System (DSS). DSS allows for comprehensive data analysis, providing insightful recommendations for improving graduate quality. One method that can be implemented within a DSS framework to analyze tracer study data is Simple Additive Weighting (SAW). SAW is one of the simplest yet most widely used methods within Multi-Attribute Decision Making (MADM). This method enables decision-making by calculating the total weight of each alternative based on various attributes, allowing for objective and data-driven decisions[4][5][6].

By applying the SAW method within a DSS, higher education institutions can determine the most suitable graduate profiles to meet industry needs and design curricula that are more adaptable

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to the evolving business and industrial sectors. Consequently, the use of DSS combined with the SAW method for analyzing tracer study data will provide a robust foundation for strategic decision-making, ultimately leading to improved graduate quality and enhanced competitiveness in the global job market.

Research Method

The stages in this research as shown in Figure 1.

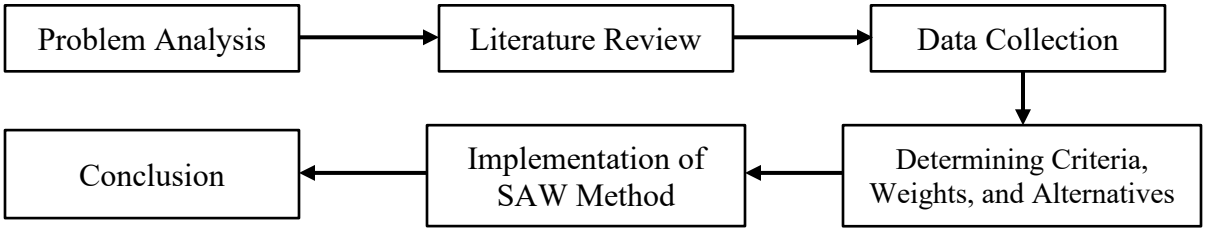

Figure 1. Research Stages

Problem Analysis

The problem analysis phase is a crucial initial step in this research, as it serves to identify the research object and its related environment in order to explore the underlying situations and conditions surrounding the issues at hand. During this phase, the researcher will conduct an in-depth exploration of various factors that may influence the implementation of tracer studies at higher education institutions, including policies in place, procedures followed, as well as the challenges and obstacles faced by institutions in managing and utilizing the data obtained. This problem analysis is not limited to understanding the technical aspects of the tracer study process but also encompasses a broader mapping of issues related to the relationship between higher education institutions and alumni, as well as with the industry or job market.

Additionally, this phase of problem analysis aims to gather detailed information about the tracer study process conducted by higher education institutions. This involves examining various procedures used in the implementation of tracer studies, such as data collection methods, the instruments utilized (e.g., questionnaires or interviews), and how the data is processed and analyzed. By obtaining comprehensive information about the steps involved in conducting a tracer study, the researcher can better understand its effectiveness and efficiency in providing a clear picture of the graduates' competencies and the relevance of the education provided by the institution.

Furthermore, this problem analysis phase also focuses on how the results of the tracer study are used by higher education institutions to improve the quality of their educational systems. Higher education institutions should not simply collect data to fulfill administrative requirements, as is often the case, but should also leverage the results to perform a thorough evaluation of their teaching and learning processes. In this context, it is important to investigate how feedback from alumni regarding the skills they acquired and their work experiences can be used as a reference for

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improving curricula, teaching methods, and the content delivered to students. Moreover, the results of tracer studies can also serve as a foundation for formulating strategic policies in program development to ensure that academic offerings are more aligned with the evolving demands of the labor market.

Thus, this problem analysis phase aims not only to identify existing issues but also to create a comprehensive understanding of the tracer study process, and how the results obtained can be optimally utilized by higher education institutions to enhance educational quality and the relevance of graduates in the workforce.

Literature Review

A literature review is an essential technique in research that integrates findings and perspectives from a range of empirical studies. This approach allows researchers to answer research questions with a level of depth and rigor that a single study alone cannot provide[7]. By drawing on diverse sources, a literature review synthesizes existing knowledge, identifies gaps, and provides a broader context for understanding the topic at hand. In its broader scope, the literature review summarizes and critically evaluates a body of work on a specific subject, offering a comprehensive overview of current theories, methodologies, and findings related to the research area[8].

In the context of this study, the literature review plays a critical role as a written synthesis of key scholarly articles, books, reports, and other relevant documents. These sources are carefully selected and analyzed to inform the development of the tracer study system. By examining existing literature on tracer studies, educational systems, and relevant technological advancements, the review provides a foundation for understanding the best practices, challenges, and opportunities in the design and implementation of an effective tracer study system. This review not only guides the development of the system but also ensures that the research is rooted in a comprehensive understanding of the current academic and practical discourse surrounding the topic.

Data Collection

The next stage of this research involves the systematic collection of data related to the Tracer Study of alumni from the Computer Science program at the Faculty of Mathematics and Natural Sciences, Medan State University. This data collection is crucial for evaluating the effectiveness and impact of the program on its graduates' careers. The specific data to be gathered includes several key indicators:

1. GPA of Graduates, which will provide insights into the academic performance and its potential correlation with job market outcomes.
2. Length of study period, which will help assess the efficiency of the program in terms of graduation time and whether graduates are completing their studies within the expected timeframe.
3. Waiting time for graduates to secure employment, an important metric to evaluate the effectiveness of the program in preparing students for the job market and the overall employability of the graduates.

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4. Job suitability with graduate competencies, which will indicate how well the skills and knowledge gained during the program align with the requirements of the job market and the roles that graduates take on.
5. Graduate user satisfaction, which involves gathering feedback from employers or organizations that hired the graduates to assess their performance, job readiness, and how well they meet the expectations of the industry.

Additionally, other relevant data will be collected, such as the geographical location of employment, the type of industries where graduates are employed, and whether they have pursued further studies or training. By capturing these various aspects, the research aims to provide a comprehensive picture of the career trajectories of alumni and the relevance of the Computer Science program to the current demands of the labor market. This data will not only help evaluate the program's strengths and areas for improvement but also contribute to future curriculum enhancements and the development of strategies that can better align the program with the evolving needs of the workforce.

Determining Criteria, Weights, and Alternatives

The determination of criteria, weights, and alternatives in this research is directly informed by the results of the tracer study, which provides valuable insights into the experiences and outcomes of alumni. These criteria serve as the key metrics for evaluating the effectiveness of the educational program and its alignment with the needs of the labor market.

In determining the weights for each criterion, it is essential to recognize that the level of importance varies across different criteria. For example, the GPA might hold significant weight for academic roles or positions requiring strong theoretical expertise, while the waiting time for employment may carry more importance in assessing the program's ability to prepare graduates for the labor market. The weight assigned to each criterion will be based on its relative importance in evaluating the success of the graduates in the workforce. This weighted approach ensures that the decision-making process accurately reflects the real-world priorities of both employers and educational institutions.

Ultimately, the combination of these criteria, along with the determination of appropriate weights, allows for a comprehensive and balanced assessment of the graduates' success and the effectiveness of the educational program. This methodology will enable the research to provide actionable insights that can guide improvements in the curriculum, teaching practices, and overall program design

Implementation of SAW Method

Decision Support System (DSS) is a computer-based system designed to increase effectiveness in decision making that can solve semi-structured and unstructured problems, so that the decision-making process can be of higher quality [9]. DSS will be effective if it has five characteristics, namely, performance, ease of use, trustworthiness, cost, and conformity to existing habits or relevance [10]. One method that can be used in DSS is Simple Additive Weighting (SAW). Simple Additive Weighting (SAW) is a method in a basic concept that can make a decision on the total

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weight of each alternative on all attributes [11], [12]. The SAW method requires a process of normalizing the decision matrix x to a scale that can be compared with existing alternative ratings [13]. The formula for the SAW method is as follows [9]:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max\ x_{ij}} & If\ j\ is\ the\ benefit\ attribute \\ \frac{Min\ x_{ij}}{x_{ij}} & If\ j\ is\ the\ cost\ attribute \end{cases} \quad (1)$$

r_{ij} = normalized performance branch value
x_{ij} = attribute value that is owned from criterion
$Max\ x_{ij}$ = the highest value of each criteria
$Min\ x_{ij}$ = the lowest value of each criteria

Meanwhile, the level of preference for each alternative (Vi) is as follows:

$$V_i = \sum_{j=1}^{n} W_{ij} r_{ij} \quad (2)$$

V_i = end value alternative
W_{ij} = weight predetermined
r_{ij} = normalization matrix

There are several stages of SAW in this research, namely as follows [9], [10]:

1. Determine the criteria that will be used as a reference in decision making, namely Ci
2. Determine the weight of each criterion
3. Determine the alternative whose tracer study results will be assessed
4. Rate each alternative on each criterion. Then Normalize the matrix based on the type of attribute, so that a normal matrix is obtained
5. Calculate value of the normalized matrix values for each alternative
6. Do ranking. The final result obtained from the ranking process is that the largest value is selected as the best alternative (Ai).

Conclusion

Conclusion is the final stage in this research. Based on the Big Indonesian Dictionary, a conclusion is a decision obtained based on a deductive or inductive way of thinking from a particular discussion or idea. After obtaining the final results at the implementation stage, at this stage the final conclusion is obtained regarding the tracer study.

Result

The results obtained from the application of the developed decision support system are as follows:

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Figure 2. The initial view for visitors of the Tracer Study

To access this application, users will be required to log in using a username and password. If the user does not have an account, they can easily register one before proceeding. Below is the login screen display:

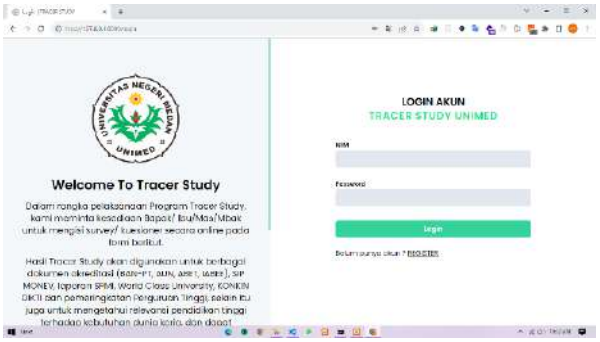

Figure 3. Login page of the Tracer Study

Once logged in successfully, the user can proceed to complete the tracer study data

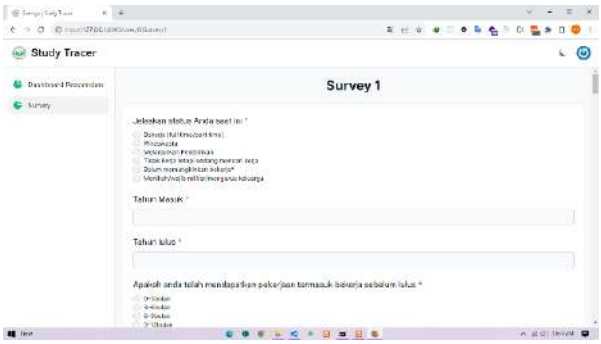

Figure 4. Page for Entering Tracer Study Data

The admin page displays the results of the tracer study conducted by alumni

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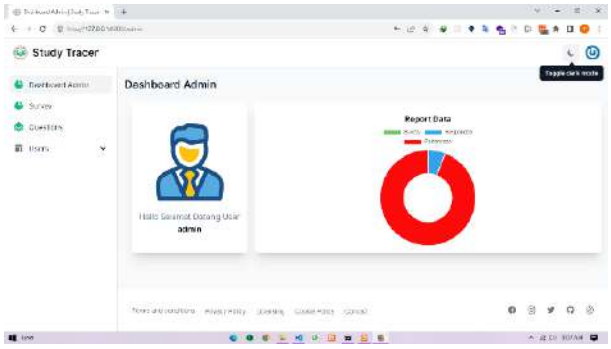

Figure 5. The admin page displays the results of the tracer study

Conclusion

Based on the results of the tests conducted using this decision support system application, it can be concluded that the application is effective in assisting decision-making processes related to the evaluation of tracer study outcomes. The system demonstrated its ability to process and analyze data efficiently, providing valuable insights into various factors such as graduate performance, employability, and the alignment of academic competencies with job market requirements. Additionally, the application offers a user-friendly interface, making it accessible for administrators and decision-makers to easily interpret the data. Overall, the decision support system enhances the accuracy and objectivity of assessments, helping higher education institutions improve their educational strategies and better align their programs with the needs of the labor market. This conclusion underscores the system's potential to contribute to continuous improvements in academic program evaluation and graduate success..

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Text summarization on digital library system application review using TF-IDF and maximum marginal relevance methods

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Abstract. *Text summarization refers to the automatic generation of text summaries using natural language processing (NLP) approaches. Text summarization is needed when the number of documents or reviews to be summarized is large. A summary that is generated can become knowledge, input and suggestions for the improvement / development of various applications. The Digital Library System application is a mobile app for Medan State University (Unimed) library services. The app has many reviews on various platforms. Naturally, the summary of the reviews can be an input for the latest version. This research aims to provide a summary of the mobile Apps reviews with an automatic text summarization approach. The algorithm used in text summarization in this research is Maximum Marginal Relevance (MMR) and Term Frequency-Inverse Document Frequency (TF-IDF) as feature extraction. The evaluation process uses Rouge. Mobile apps reviews are obtained from Play Store and App Store. Reviews will go through the text pre-processing stage with the help of the NLTK library. This research successfully identified 30 reviews with the highest MMR value. Furthermore, the review summary presented is a series of 10 reviews with the highest MMR value. The resulting summary has a positive Rouge rate.*

Keywords: Text summarization, NLP, TF-IDF, MMR, Rouge**.**

Introduction

Text auto-summarization is the automatic creation of text summaries using a computer [1]. It involves using a computer to reduce a text document and create a summary that retains the important points of the original document. A summarization system is given input text, then performs summarization, and produces output text that is shorter than the original text. In text summarization there are two approaches, that is extraction and abstraction.

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Text summarization methods can be divided into two main categories: extractive and abstractive[2]. The extractive approach selects key sentences from the source text, while the abstractive approach generates a new summary by using words and sentence structures that may not be present in the original text. In text summarization, there are two approaches, namely extraction (a more superficial approach) and abstraction (a more in-depth approach). The extraction approach is a summary that selects a crucial paragraph or sentence to interpret the document into a simpler form. In contrast, the abstraction approach produces a summary not just from a collection of important sentences, but captures the essence of the main concepts in the text and represents them as new sentences.

The Digital Library System application is an application-based online platform used by Medan State University to facilitate services to students. The Digital Library System application provides many features including features for borrowing books, returning books, and scanning barcodes to enter rooms in the Unimed Digital Library.

The Maximum Margin of Relevance (MMR) algorithm is one of the summarization methods used to summarize individual documents or multiple documents[3]. MMR summarizes documents by calculating the degree of similarity between sections of text. The proposal with the highest MMR is iteratively selected from the resume until a predetermined value is reached. Previous studies using the maximal marginal relevance method were used to calculate the ranking weight of each proposal[4]. The MMR algorithm performs text summarization by combining the cosine similarity matrix between each sentence. There are two types of similarity evaluated, namely the similarity between documents or sentences, and the similarity between documents or sentences and questions/queries.

This research aims to implement Text Summarization on the review of the Digital Library System Application on the Google Play Store using the Maximum Marginal Relevance (MMR) method. The main objectives involve the development of a Text Summarization system using MMR, evaluation of summary quality with ROUGE metric, and comparison of MMR implementation results with other Text Summarization methods to assess the contribution and superiority of MMR in that context.

Related Work

This section describes some previous related research. Some studies that apply the MMR algorithm to make inferences from various case studies are presented in the form of a brief Table 1.

Table 1. Brief of MMR Algorithm Application.

Research Article	Methods	Result and Discuss
[5]	This research uses the Maximum Marginal Relevance (MMR) algorithm to summarize single or multiple documents.	The results of the study using the MMR algorithm showed a precision value with an average of 40.4% in three experiments, with the highest precision value reaching 60.4% in the experiment using the parameter $\lambda = 0.7$. Although it gives the best results, but in large-scale documents, the smaller the λ value can reduce the possibility of redundant summary results.

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[6].	This research uses the Maximum Marginal Relevance algorithm by finding similarity between each sentence in the document. The sentence used is the title of the document through the query process.	Based on the test results of automatic text summarization using MMR, the average precision is 0.70, the average recall is 0.75, the average f-measure is 0.70 and the average accuracy is 74.17% of the 150 data tested. The summary results succeeded in getting sentences that were relevant to the contents of the document and succeeded in reducing redundant sentences that had been summarized..
[7].	This research uses the MMR algorithm along with the sentence weighting process. The dataset that is summarized is a single document or multi-document.	The results of the automatic text summarization system in this study are in the form of core sentences that are similar to the query and based on the order of weight, so for the development of future research, it is expected that the summary results have a good systematic order.
[8].	The text extraction method applied is MMR (Maximum Marginal Relevance), then using a boolean model with jaccard, dice and cosine coefficient representations. These three methods are used to find out the most relevant documents for a given set of keywords (queries).	The results obtained for all short news articles tested on 30 articles, obtained with an accuracy value of 59.5%, the cosine coefficient method is superior to be applied to the process of summarizing short news articles compared to the jaccard and dice coefficient methods. Thus, it is proven that summarizing short news articles is more appropriate using the cosine coefficient-based MMR method.
[9].	Just MMR with analysing α.	This research was conducted by taking 30 samples of news article data with the theme COVID-19 from the online news provider website kompas.com. Obtained test results with the value, the best value setting coefficient is α = 0.5 with the results of precission = 0.684333, recall = 0.772 and f-measure = 0.7. While based on the number of words, the number of words in 300 produces the best f-measure value with a value of 0.726923.

Research Method

The flowchart (shown in Figure 1) starts with the extraction of reviews from the Unimed library system application, followed by preprocessing of the reviews, including translation into Indonesian and removal of symbols and common words. Next, a reference summary is generated for each review. The MMR method is used to select the sentences that are most relevant to the pre-selected summary and also to the reference summary. Each sentence is selected based on the highest similarity value by considering aspects of internal sentence relatedness and relatedness to the reference. This process is repeated for each review until the desired number of sentences for each summary is reached. Next, an evaluation is performed using ROUGE to measure the quality of the generated summaries by comparing them with the original content. The evaluation results, namely precision, recall, and F1 score, are displayed or printed to provide an understanding of the performance of the MMR method.

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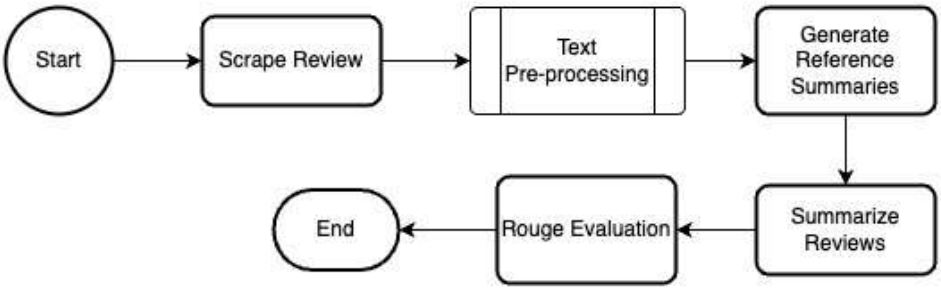

Figure 1. Research flowchart

Dataset

The data that is the focus of this research was obtained through an in-depth review of user reviews and feedback on digital library system applications available on the Google Playstore distribution platform. The information drawn from these reviews summarizes users' views and experiences of the apps, covering aspects such as usability, user interface, performance, and features provided. The data used in this study is substantially text-based, encompassing a variety of language expressions used by users in detailing their experiences with digital library apps.

Algoritma Maximum Marginal Relevance

Maximum Marginal Relevance (MMR) algorithm is an extractive summary method used to summarize a single document or multiple documents by considering the similarity between parts of the text. In the process of summarizing documents using MMR, documents are segmented into sentences, and then grouped based on the relevance of the sentences. MMR applies the cosine similarity matrix to rank sentences in response to queries given by users [10]. Maximum Marginal Relevance (MMR) is one of the text summarization algorithms that can summarize single or multi-document documents. The way the MMR algorithm summarizes documents is by calculating the similarity between parts of the text[11]. MMR is a summarization technique that aims to retrieve relevant information and does not contain redundancies[10]. Figure 2 is a flowchart of the MMR method that will be used in the process of text summarization of data review of the unimed library system application.

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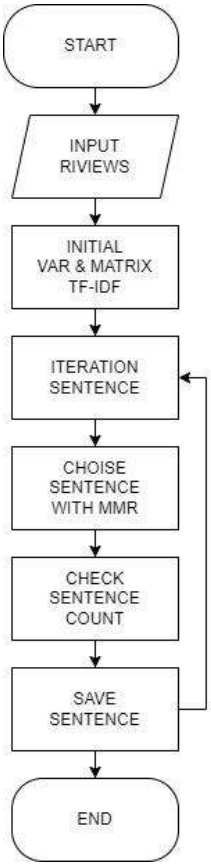

Figure 2. MMR flowchart

Result and Discuss

This study aimed to implement and evaluate Text Summarization techniques on user reviews of a Digital Library System application using TF-IDF (Term Frequency-Inverse Document Frequency) and Maximum Marginal Relevance (MMR) methods. The experiments were conducted on a dataset of user reviews and feedback collected from the application's digital platform. The TF-IDF method was applied to determine the importance of terms within user reviews, and MMR was used to select sentences that maximize relevance while reducing redundancy in the final summary.

Preprocessing result

This section presents the results of text preprocessing. The figure presents the results of two text preprocessing methods.

```
0    Aplikasinya Bagus, namun fitur yg Ada Terlalu ...
1    Bagus Sih, Tapi Sangan Disayangkan Terjadi Pen...
2    Wifinya Sering Lemot Dan Putus Jaringan, Semog...
3    Kenapa Kartu anggota fisik di tarik padahal Pe...
4    Aplikasi Sangat Buruk Masa Sua Sudah Balik Kan...
Name: content_normalized, dtype: object
```

(a)

```
0    aplikasinya bagus fitur yg sedikitsekedar sara...
1    bagus sih sangan disayangkan penarikan kartu f...
2     wifinya lemot putus jaringan semoga ditingkatkan
3    kartu anggota fisik tarik pembuatnya bayar dis...
4    aplikasi buruk sua buku keterangan nya berbali...
Name: preprocessed_content, dtype: object
```

(b)

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Figure 1. Pre-processing result (a) text normalized process, (b) case folding process

MMR Performance

Based on the evaluation data provided, it can be concluded that the text summarization method using Maximal Marginal Relevance (MMR) has a Rouge 1 of 30.51%, Rouge 2 of 56.25%, and Rouge L of 39.56%. Although the recall rate is quite good, the relatively low precision rate indicates that most of the sentences selected as summaries may include some less relevant sentences. With the F1 value reflecting the balance between precision and recall, it is still necessary to pay attention and optimize to improve the quality of the summary produced by the MMR method. This evaluation provides a view of the system's performance in capturing relevant information from reviews, but it should be noted that these results can be affected by a number of factors, including the parameter settings of the MMR method and the quality of the summary references used in the evaluation.

Conclusion

This research successfully implemented and evaluated an automatic text summarization method for user reviews of the Digital Library System application using a combination of Term Frequency-Inverse Document Frequency (TF-IDF) for feature extraction and Maximum Marginal Relevance (MMR) for sentence selection. The study aimed to generate concise and informative summaries that could assist developers and stakeholders in understanding user feedback effectively.

Based on the results, the MMR method demonstrated a ROUGE-1 score of 30.51%, ROUGE-2 score of 56.25%, and ROUGE-L score of 39.56%, indicating that the system is capable of capturing a significant portion of relevant information while reducing redundancy. The approach proved to be effective in selecting diverse and relevant sentences, although there remains room for improvement, particularly in precision and overall coherence.

The findings confirm that combining TF-IDF and MMR can be a practical and efficient approach for extractive summarization in the context of user-generated content like app reviews. However, for future studies, it is recommended to explore advanced embedding techniques such as BERT or other deep learning models to enhance semantic understanding and to consider abstractive summarization methods for more natural and coherent summaries.

In conclusion, this research contributes a valuable method for automatically summarizing user feedback, which can be leveraged to improve the quality and functionality of digital library applications, and can be adapted to other similar applications that require effective analysis of user reviews.

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Development of learning media with artificial intelligence: innovation in phytgoras learning at the junior high school

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Abstract. *One of the technologies that is very useful today is Artificial Intelligence (AI), as well as in the education. AI-based learning tools can improve the quality of learning by providing a personalized and adaptive learning experience, as well as providing effective guidance and feedback. This research aims to develop mathematics learning media based on Artificial Intelligence (AI) technology. This AI-based media was developed using a Curipod application. This media is used by teachers in implementing the learning process on phytagoras material. The specific objectives of this study are 1) to describe the practicality of using AI technology-based learning media to improve the understanding of mathematical concepts and student motivation, 3) to describe the effectiveness of AI technology-based learning media to improve the understanding of mathematical concepts and student motivation. This research is a development research using the ADDIE type which consists of 5 stages of research, namely 1) Analysis 2) Design, 3) Develop, 4) Implementation and 5) Evaluation. The results of the study show that Artificial Intelligence-based learning media is practical and effective in learning Phytagoras.*

Keywords: Artificial Intellegence, Curipod

Introduction

The integration of technology in learning refers to the use of tools and applications in the teaching and learning process [1].With the rapid development of technology, this integration has become increasingly important in ensuring effective learning that is relevant to the times. The importance of technology integration in learning includes enhancing teaching efficiency, enabling access to various information resources, and strengthening students' technological skills[2]. By understanding and addressing these challenges, the integration of technology in learning can provide significant benefits in enhancing the quality of education[3].

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In addition, the integration of technology can also help enhance students' engagement and motivation in the learning process[4]. With the presence of technology, students can learn interactively and enjoyably, making learning more engaging and effective. In addition, technology also allows for collaborative learning, where students can work together and share ideas through digital platforms[5]. This provides students with the opportunity to develop social skills and cooperation, which are essential in today's increasingly global and digitally communicating job market. For example, the use of digital learning platforms like Google Classroom allows students to interact with their classmates in group assignments online. They can share ideas, provide feedback, and collaborate efficiently without the limitations of the classroom.

The use of technology in education also allows students to easily and quickly access a variety of information sources and learning materials[6]. With access to the internet, students can seek additional information, watch educational videos, and take online courses to enrich their learning. This not only broadens students' knowledge but also helps them become more independent in the learning process. With technology, learning is no longer limited to textbooks alone, but encompasses various forms of media that can enrich students' learning experiences. Students can also interact with peers and teachers through online learning platforms, allowing them to exchange opinions and contribute ideas collaboratively. This not only enriches their learning experience but also builds essential communication and collaboration skills in this digital age. With continuously evolving technology, students can also access interactive and fun learning applications, making the learning process more engaging and effective [7].All of this proves that technology has brought positive changes to modern education, preparing students to face the challenges of an increasingly complex and rapidly changing world.

Currently, one of the technologies that is very beneficial for education is artificial intelligence[8]. Artificial Intelligence (AI) in learning media refers to the use of advanced technologies such as machine learning and natural language processing to enhance the educational experience[9]. By incorporating AI into learning platforms, educators can personalize learning content, provide real-time feedback, and adapt instruction to meet the individual needs of students. This innovative approach has the potential to revolutionize the way we teach and learn, making education more engaging, effective, and accessible for all learners. Furthermore, AI in learning media can also help educators identify areas where students may be struggling and provide additional support in those areas. This targeted assistance can lead to improved academic performance and increased student confidence. Additionally, AI can analyze data on student progress and performance to help educators make informed decisions about their teaching methods and curriculum. Overall, the integration of AI in learning media holds great promise for creating a more personalized and effective educational experience for students of all ages.

By utilizing AI in learning media, educators can also save time by automating certain tasks, such as grading assignments and providing immediate feedback to students [10]. This allows teachers to focus more on facilitating discussions, engaging students in hands-on activities, and providing individualized support. Furthermore, AI can help identify patterns in student learning and behavior, enabling teachers to intervene early and provide additional support to those who need it most. Overall, the integration of AI in learning media has the potential to revolutionize the way education is delivered and improve student outcomes across the board [10]. For example, in a mathematics class, AI can track each student's progress on specific concepts and provide personalized practice exercises to reinforce understanding. This targeted approach can help struggling students improve their skills and excel in the subject. Additionally, AI can generate

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detailed reports on student performance, allowing teachers to tailor their instruction to meet the diverse needs of their students effectively.

AI be possible can improve the understanding of concepts, especially in the field of mathematic [11]. However, on the contrary, the researcher found that students' understanding of the concept was still in a low category, especially related to the concept of Phytagoras material. Understanding mathematical concepts, such as the Pythagorean theorem, is crucial as it allows individuals to grasp and apply basic mathematical principles effectively). It involves the ability to comprehend mathematical concepts deeply and relate them to different situations or problems encountered. The results of the researcher's initial observation of concept comprehension ability showed that out of 45 students, only 10 students had moderate concept comprehension ability, while students had low concept comprehension.

In fact, this Pythagorean Theorem is very important in developing the understanding of other mathematical matter to higher dimensions, as in the case of Pythagoreans' theorem in three dimensions, which states that the square of the hypotenuse length of a right triangle in three dimensions is equal to the sum of the squares of the other two sides. This theorem has many practical applications, such as in calculating distances in three-dimensional space or in designing structures with right angles. Overall, the Pythagorean theorem is a fundamental concept in mathematics that is constantly being studied and applied in various areas of life. However, the problem in learning phytagoras is that students cannot understand the concept well, let alone develop it to the higher dimension.

Based on the observations made by researchers, there are still many teachers who do not use media in learning[12] , Some who use media are not in accordance with the material, so that for students the Phytagoras theorem is only a memorization, not to the competence of application, let alone to the development. Therefore, researchers are interested in conducting research and development to produce products in the form of learning media. This media will be tested for its feasibility, then it will be tested for practicality in the learning process, especially phytagoras material and finally its effectiveness will be tested by looking at the increase in students' understanding of the concept in the phytagoras .

Literature Review

Artificial Intelligence (AI)

Artificial Intelligence is a field of computer science that specializes in solving cognitive problems commonly related to human intelligence, such as learning, problem solving, and pattern recognition[13][14]. Applications and instructions related to computer programming to do something that in the eyes of humans is intelligent. Artificial intelligence, often abbreviated as "AI", can evoke robots or futuristic landscapes. Artificial Intelligence is moving beyond science fiction robots to modern and sophisticated non-fiction computing. Recently, advances in statistical computing efficiency have allowed Bayesians to successfully advance this field in a number of areas known as "machine learning". Similarly, advances in network computing have led network activists to expand into a subfield called "deep learning." Machine learning (ML) and deep learning (DL) are fields of computer science that originated from the discipline of artificial intelligence[15][16]. Artificial Intelligence is grouped based on its types, including:

1. Weak Artificial Intelligence (Weak AI), Weak Artificial Intelligence is a system designed to

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perform a specific task using predetermined algorithms and data. Examples of weak Artificial Intelligence are search engines, virtual assistants, voice recognition, and facial recognition. Weak Artificial Intelligence cannot exceed the limits set by programmers.

2. Strong Artificial Intelligence (Strong AI), Strong Artificial Intelligence is a system that is able to understand and simulate human cognitive abilities in general, including reasoning, problem-solving, creativity, and awareness. Powerful Artificial Intelligence does not yet exist, but many researchers are trying to develop it. Powerful Artificial Intelligence can pose a threat or opportunity to humans, depending on how we use it.

Machine Learning (ML) according to the Task Force Application System (SAS) is a data analysis method that automates the creation of analytical models. Machine learning is a branch of artificial intelligence that is based on the idea that systems can learn from data, identify patterns, and make decisions with little manual human intervention. With Machine Learning, computers can handle new situations through self-training, experience, analysis, and observation. The relationship between the two is very close. Come to think of it, Artificial Intelligence is an umbrella that includes machine learning. As already explained, Machine Learning is one of the branches or parts of Artificial Intelligence. The task of Machine Learning is to train machine learning. Machine Learning is used to study historical data to find network trends. This means that if a problem arises and is resolved, the problematic data will be examined by Machine Learning to understand what problem is happening in the network.

This allows Network Performance Monitoring to immediately recognize future malicious data. In this way, Network Performance Monitoring alerts you to potentially harmful information without having to conduct in-depth analysis every time. In addition, in the world of artificial intelligence (Artificial Intelligence), there is the term deep learning which is a subfield of machine learning, deep learning is a field of machine learning whose algorithms are inspired by the structure of the human brain. Currently, deep learning techniques are very popular among data practitioners and attract the attention of many parties. It is true, deep learning technology has been applied to many different high-tech products such as self-driving cars. In addition, deep learning is the source of products and services that we use every day. Examples include digital assistants, Google Translate, and voice-activated devices (smart devices that can be activated by voice). Deep Learning not only has a big impact on the development of artificial intelligence, but also poses challenges that need to be overcome in the Artificial Intelligence security landscape.

Tabel 1. AI tools

NO	Learning Tools	Tools AI
1	Learning Plan	Kopilot Pendidikan
2	Learning Media	Gamma/Curipod
3	Quis	ClassPoint Ai
4	Test	Samartgrads

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Understanding mathematical concept Ability

Comprehension ability is an important aspect that must be possessed by every student in teaching and learning activities, because comprehension ability allows students to be involved in overcoming various problems. Comprehension is also described as the ability to express, explain or draw conclusions that differ from textbooks. Understanding is the ability of a person to understand what he has acquired or learned and to explain from one form to another so that he can develop his knowledge [17]. The term "concept" refers to an individual or group of ideas that have a specific definition that states that the idea is the basis of science, including principles, laws, and theories. A concept is an abstraction that allows a person to group objects or events and describe whether or not the object or event is an example of a given ide[18]. Understanding mathematical concepts is an important factor in improving learning outcomes.

Understanding mathematical concepts refers to the ability of students to understand, explain, apply, and internalize the idea of ideas about mathematical concepts [19]. So that they can express it in their own words through the mathematics teaching and learning activities that they have undergone. Concept understanding is one of the mathematical skills or knowledge achieved during mathematics teaching and learning activities [20]. This shows students' understanding of the concepts they are learning, their ability to explain their relationships, and their ability to apply concepts or algorithms flexibly, accurately, efficiently, and precisely in solving problems. Therefore, understanding mathematical concepts has a very important role**.** The ability to master mathematical concepts will provide students with assistance in learning mathematics and applying it in real life. Understanding concepts is also the basis for the development of other mathematical skills and is a basic achievement for students. Based on some of the definitions presented, it can be concluded that concept understanding is the ability of students to understand, explain, apply and re-implement ideas or ideas related to mathematical concepts. With an understanding of the concept, students can remember and utilize the learning that has been obtained. Here are the indicators of concept understanding based on several experts [21].

Restate learned concepts

1. Classifying objects based on mathematical concepts
2. Providing examples instead of Examples
3. Using and utilizing and having certain procedures or operations
4. Applying concepts or algorithms in problem-solving

Methods

The research method used in this study is the development of the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) model developed by Reiser and Mollenda. In this ADDIE development design model, there are five stages of research implementation, which are as follows at Figure 1 : Analyze Stage, at this stage the activities carried out are to analyze the needs of the learning process. Where later the products developed can meet the needs of the desired targets. The analysis is applied based on learning needs and learning materials. The analysis was carried out by conducting an initial survey and assessment on SMP Negeri 27 Medan students to become

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the basis for differentiated learning treatment, both in the form of processes, assessments and products.The research design of this non-equivalent control group design is:

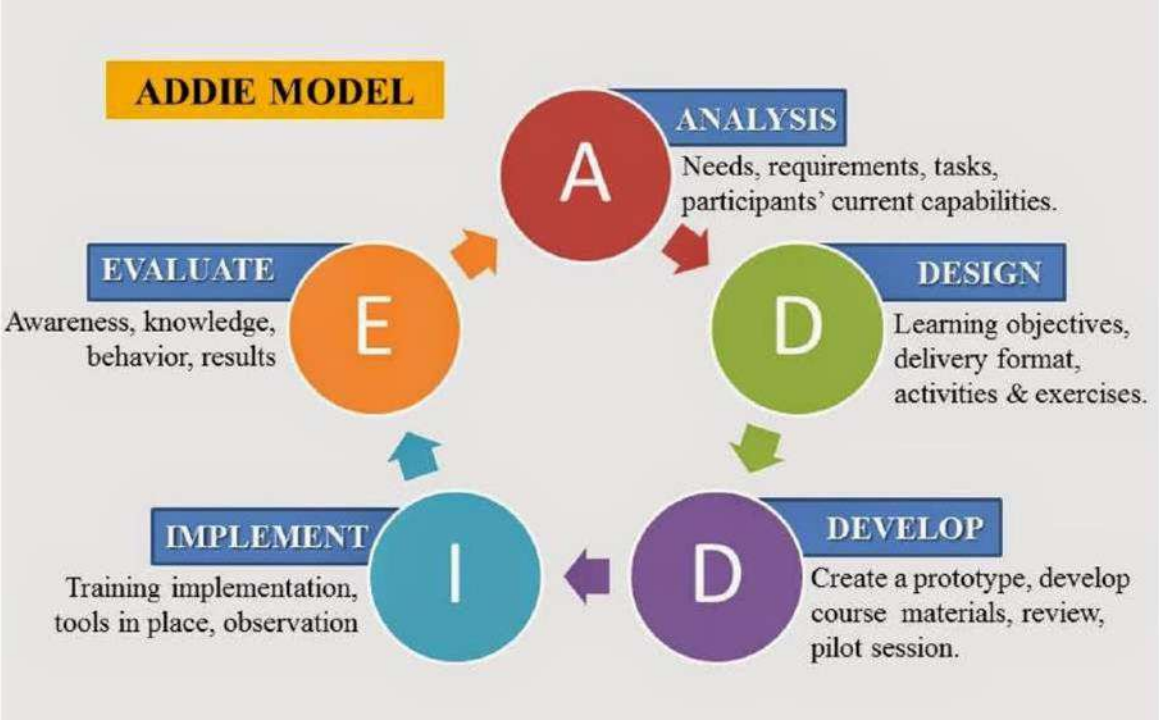

Figure. 1 Stages of the ADDIE Model

Design Stage, This activity is a design activity based on a needs analysis that has been carried out previously. At this stage, the researcher conducts 1) Designing Differentiated Learning, 2) Designing AI-based Teaching Materials (Story Board), 3) Designing AI-Based Student Worksheets (LKPD) (Story Board), 4) Selecting AI tools that are used in development 5) Designing Research Instruments in the form of concept comprehension tests, learning motivation questionnaires, student response questionnaires, rubrics and interview items, practicality questionnaires, effectiveness questionnaire.

Development Stage, then developing a Differentiated Learning Design (Teaching Module), Developing Teaching Materials and LKPD Using AI Tools. Next, export the device in several outputs, namely html5 and offline-based, into an application file that can be extracted in a computer device or mobile device. At this stage, research instruments were also developed in the form of a practicality questionnaire. Then at this stage, a review of the feasibility of the product was carried out by conducting a validity test which was assessed by 5 lecturers and 2 teachers. Furthermore, this feasibility test will be revised according to the input from the lecturers and teachers. To find out the practicality of the product, a small-scale test was carried out on 10 students who were the object of the research. The results of the validity and practicality test are then used as input for improvement and development of products to be of higher quality.

Implementation Stage, after the product is developed, the next stage is to carry out product

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implementation, namely large-scale trials. Where the trial will be carried out on grade VII students of SMPN 27 Medan. This test is to see the effectiveness of the product in the form of AI-based differentiated learning tools.

Evaluation Stage, after the implementation stage, the results of all instrument implementation activities are obtained. The results obtained are the basis for the evaluation stage of the product. The source of evaluation can be obtained from the results of interviews with students, student response questionnaires, or notes while in the field during the implementation. On the basis of all these results, a final revision was made to the assessment instrument. Products that have been revised according to the results of the evaluation are called products that have met the feasibility aspects.

Result and Discussion

This research produces an AI-based learning media by utilizing an AI application, namely Curipod. This learning media is interactive, so there is 2-way communication, this can happen because in this media there are feature features that researchers can use to make the media more interactive, the choice of feature features includes Poll, Word Cloud, drawings, open question, and AI feedback. With this feature, students can use their devices or gadgets to provide answers or responses from the instructions given. This interactive media can foster students' interest so that learning activities increase [22].

Figure 2. Cover display of learning media

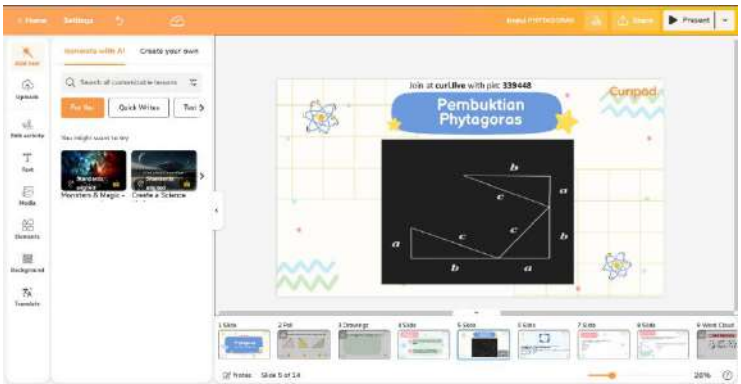

Figure 3. Display of Material Substance on Curipod

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This AI-based learning media received input from media experts and material experts, namely:

1. The lack of color consistency on each slide, should just choose one or 2 of the same color themes for each slide.
2. The background slide does not show the characteristics of the material being taught, it is better to provide illustrations of images related to the mathematics material.

The following is the feasibility score of Curipod's AI-based learning media.

Table 1. Qualification Value

Ahli Materi	Ahli Media	Kategori
3,2	3,01	Layak
3,1	3,05	Layak
3,02	3,1	Layak

After all learning tools get good feasibility scores and good readability tests, these learning tools are used in the learning process. The learning outcomes achieved by using AI-based differentiated learning tools are as follows.

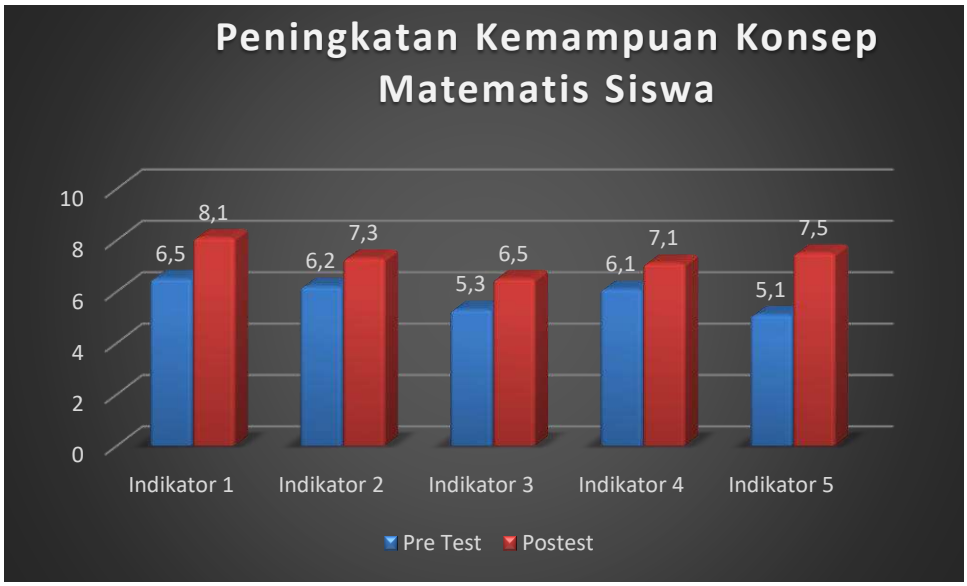

Figure 4. Improving Concept Comprehension Skills

This research is included in the type of development research that follows the ADDIE development model consisting of five stages, namely analysis, design, development, implementation, and evaluation [23] The following is an explanation of the data from media development using the ADDIE model.

The initial stage of this research is to analyze the needs of the learning process. Needs analysis is an effective way to identify problems that arise in a learning organization [24], This analysis

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was carried out on the initial abilities and characteristics of students. This is important to do before developing a learning tool because an initial characteristic analysis result is needed in developing a media [25]. Initial ability was analyzed based on the results of initial observations in grade VIII students of SMP Negeri 27 Medan. There are 100% of students who have facilities that support the digital and network-based learning process. This facility is in the form of gadget ownership. Based on the survey, data was obtained that 25 students had high abilities in utilizing features in gadgets, 8 students had moderate abilities while only 2 students were in the low category in utilizing features in their gadgets. These initial characteristics and abilities greatly support researchers in developing digital-based learning tools.

Then analyze the curriculum that is being implemented in the school. The curriculum that is being implemented at SMP Negeri 27 Medan is an independent curriculum, this curriculum facilitates a differentiated learning process. Students will have the opportunity to learn independently and creatively. This allows every student in Indonesia, who come from various tribes and cultures, to have diverse learning approaches according to their respective characteristics. Learning differentiation is an effort to accommodate the diversity of learners based on their differences in characteristics [26]. When students are in the school environment, they bring various kinds of differences. These differences can be in the form of abilities, experiences, talents, interests, languages, cultures, learning styles, and many more. The diversity of students is a reality in schools. Each student has different abilities, experiences, talents, interests, languages, cultures, and learning styles. Therefore, it is unfair if teachers only deliver the subject matter and assess students in the same way. Teachers need to pay attention to this diversity and provide services that suit the needs of each individual[26]. Based on the needs of the curriculum that is being implemented in schools, researchers develop a teaching medium that will facilitate the learning process. In the media there is a video that will facilitate students who have an audio-visual learning style, for visual students the media facilitates with material infographics, while for kinesthetic students there is a drawing service.

The next stage is Design, At this stage the researcher conducts 1) Designing a teaching mat consisting of 3 sub-subjects about phytagoras, 2) Designing an AI-Based video, 3) Designing a Curipod AI-based storyboard, 5) Designing an assessment instrument in the form of a student questionnaire, a practicality questionnaire, a readability questionnaire, and a feasibility questionnaire, so that at this stage a draft 1 is produced which will be displayed in the form of a flowchart.

The next stage is the development stage, the results of the flowchart in the previous stage were developed into an AI-Based Video product, AI-Based Teaching Media. Then conducted product trials to 3 lecturers who are subject matter experts and 2 media experts. The results of the validation given by the experts as shown in table 1 that the product developed is suitable for use based on the aspect of assessing the material experts in terms of content and construction, as well as media experts stating that the product is feasible in terms of presentation and ease of use of the features in the product. The validity of draft 1 products that have been assessed by these experts also received input from experts as seen in table 1. The result of the revision of draft 1 became a draft 2 product. This validation is to ensure that the product, in this case the learning media, is in accordance with the requirements and meets the expected learning objectives[27]. The next stage is the product implementation stage, this stage is divided into 2 parts, namely small-scale and large-scale implementation. The small-scale test is the implementation of the product on 10 grade IX students.

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Table 2. Question Item Readability Value

Mahasiswa	Kriteria Keterbacaan (BAB)		
	I	II	III
1	Baik	Baik	Baik
2	Baik	Baik	Baik
3	Baik	Baik	Baik
4	Baik	Baik	Baik
5	Baik	Baik	Baik
6	Baik	Baik	Baik
7	Baik	Baik	Baik
8	Baik	Baik	Baik
9	Baik	Baik	Baik
10	Baik	Baik	Baik

This test was carried out to obtain the readability score of the learning device product. Based on table 2, it shows that it is well readable. This adds to the quality of the products developed. The second stage of implementation is large-scale testing. All learning tools are implemented in grade VIII of SMP Negeri 27 on the sub-subject of phytagoras, before the implementation of the implementation, students are given pretest questions, the average score of the student postest is 5.84, after the learning process the posttest data is taken with the average score of the student postest is 7.3, it can be seen that there is an increase in students' ability to understand mathematical concepts, as well as an increase in per indicator of students' ability to understand concepts. The learning media developed facilitates the learning needs of students, so that students with visual learning styles can take advantage of PPTs in curipods, as well as students with audio visual learning, they can see the videos listed in the media. The learning process that facilitates the learning needs of students will have a positive effect, namely increasing student activities and achieving learning goals[28][29]. The media developed meets the needs of students based on the results of the initial analysis, students have plurality in learning styles so that this media is present in facilitating it.

Conclusion

Based on research data, AI-based learning media is feasible to use in the learning process of Phytagoras. This media is used in facilitating the plurality of students' learning styles. This AI media is effective in improving students' abilities, especially in phytagoras metrics.

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Designing computer-based applet to teach mathematics at college: a theoretical review

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Abstract. This article provides a small-scale exploratoral study towards the design of computer-based applet to teach mathematics at university. It attempts to give readers and educators an paradigm about the importance of intgrating technological environment in teaching mathematics at university. In this article, a balance review will be pursued to ensure readers what they should conduct for their future studies. With the increasing needs of technology in mathematics classroom practices, this equal description includes several instances of the best practices to teach mathematics in Calculus course. In addition, it also highlights the disadvantages and the challages faced during designing the applet. The findings of this paper aim to guide reserachers and educators about establishing an interactive atmsphere that can fully support students to learn mathematics at college.

Keywords: (Computer-Based Applet, GeoGebra, Mathematics Education, Higher Education, Calculus, Theoretical Review.)

INTRODUCTION

The rapid integration of technology has increasingly changed the teaching and learning paradigms from traditional teaching style into digital circumstances at higher education [1], including mathematics classrooms. At higher mathematics education classroom, educators often use technology to introduce a making-sense learning circumstances to help the students grasp the mathematical ideas from their learning [2]. An example of technological learning environment that can be observed to teach mathematics at higher education is the use of computer-based applets. Designing applets for teaching mathematics at college level does not only play as a supplementary source of learning, but also as a pivotal element in creating innovative teaching and learning circumstances. This theoretical review proposed to provide an inclusive framework and

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understanding of challenges that educators may face in designing a transformative and engaging computer-based teaching and learning process in teaching mathematics at higher education.

In general, applet is known as a tool to compute or process numerical data and particularly to demonstrate how the process takes place [12]. In this case, applet provides opportunity for its users to create individual proposed materials and even construct modifications or adjustments towards it to reach the objective [3]. However, educators, in fact, still face many challenges in designing an innovative and interactive mathematics applet to provide meaningful learning experiences for students. One possible major challenge that university lecturers may struggle with is the connection of the designed applet to the standard mathematics curriculum and learning purposes [10]. In doing so, educators, in this case, should be able to navigate the learning process by reflecting on the students' learning diversity. Customizing the applets to the students' mathematics learning needs requires immense efforts and expertise in mathematics and education.

Although many educators have increasingly transformed the traditional teaching style to computer-based learning, however, most of study discuss how applet is used in teaching, and it is rarely found that the discussion centers around revealing the challenges and disadvantages that educators may encounter when integrating applet in mathematics classroom at higher education. therefore, the main question "what challenges and disadvantages do educators face when designing and implementing computer-based applets for mathematics instruction?" will be further discussed in this paper.

Theoretical Framework

The tenets of integrating applet in learning

According to findings of some studies, the integration of digital applets in higher-education mathematics classrooms is seen to have potential in enhancing the students' mathematical knowledge and engagement in the teaching and learning process through digital tools creations [8][7]. In the teaching and learning process, applets, in this case, are fundamentally designed to perform specific mathematical tasks, provide learners with opportunities to explore complex concepts through simulations, visualizations, and interactive exercises. These tools can cater to diverse learning styles, making abstract topics more accessible by presenting them in a visual or tactile format [4]. For instance, in mathematics, applets can help students manipulate graphs and equations, fostering a deeper understanding of underlying principles. By incorporating applets, educators create an environment where learners actively participate in their education, promoting critical thinking and problem-solving skills.

The effective integration of applets in learning, however, relies on adherence to key tenets. First, applets should align closely with learning objectives to ensure they enhance, rather than distract from, the educational goals [6]. Second, they must be user-friendly and intuitive to allow seamless interaction without steep learning curves. Third, accessibility is vital applets should be compatible across devices and inclusive for students with varying abilities [9]. Finally, educators must provide guidance and context for using applets, ensuring they complement traditional teaching methods rather than replacing them [13]. When implemented thoughtfully, applets can transform classrooms into interactive spaces that inspire curiosity and foster a deeper understanding of subject matter.

The challenges of applet integration in mathematics teaching and learning process

Integrating applets into the mathematics teaching and learning process can present several challenges. One primary issue is the accessibility and availability of the necessary technology [8].

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Many schools and educators lack the infrastructure, such as reliable internet connections, up-to-date devices, or the budget to purchase or maintain software licenses for applets [5]. Additionally, teachers may face difficulties in learning to use applets effectively, as many do not receive adequate training in technology integration [10]. This can lead to hesitation or a lack of confidence in utilizing applets, ultimately limiting their potential to enhance learning.

Another significant challenge is aligning applets with curriculum objectives and student needs. Mathematics curricula often adhere to strict standards and timelines, leaving little room for exploratory or applet-based activities [9]. Furthermore, applets may not always provide a comprehensive approach to problem-solving or theoretical understanding, potentially creating gaps in learning. Students' diverse learning styles can also pose difficulties, as some may struggle with the abstract or interactive nature of applets, preferring traditional methods instead [7]. To address these challenges, it is essential to provide proper training, support for educators, and thoughtfully designed applets that align with pedagogical goals while considering accessibility and inclusivity.

The disadvantages of applet integration in mathematics classroom practices

The integration of applets in mathematics classroom practices comes with notable disadvantages that can hinder their effectiveness. One major drawback is the potential for over-reliance on technology, which may reduce students' ability to perform calculations or solve problems manually [6]. This reliance can lead to a superficial understanding of mathematical concepts, as students may focus more on manipulating the applet than grasping the underlying principles. Additionally, applets often require a steep learning curve for both students and teachers, and without proper training or guidance, their use can become a source of confusion rather than a tool for clarity [11]. Time constraints in classrooms can further exacerbate this issue, as teachers may find it challenging to balance traditional teaching methods with the integration of technology.

Another disadvantage is the unequal access to the necessary technological resources. Many schools, particularly in underfunded or rural areas, lack the infrastructure to support widespread applet use. This digital divide can exacerbate educational inequalities, leaving some students at a disadvantage [12]. Even in classrooms with adequate resources, technical issues such as software glitches, compatibility problems, or internet disruptions can interfere with the learning process. Moreover, the integration of applets may inadvertently shift focus from critical thinking and collaborative problem-solving to individual screen-based activities, potentially reducing opportunities for meaningful student-teacher and peer interactions [5]. Addressing these drawbacks requires careful planning, equitable resource allocation, and a balanced approach to incorporating technology in the classroom.

Conclusion

In conclusion, while applets hold significant potential for transforming mathematics teaching and learning at higher education levels, their integration comes with substantial challenges and disadvantages. Applets can enhance engagement, foster critical thinking, and provide dynamic visualizations of complex concepts, making abstract mathematical ideas more accessible. However, their effective application requires careful alignment with curriculum goals, adequate technological infrastructure, and comprehensive training for educators to navigate the steep learning curve associated with these tools. Without these considerations, applets risk being underutilized or misapplied, diminishing their educational impact.

The challenges of applet integration are multifaceted, ranging from technical issues such as

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limited access to devices and unreliable internet connections to pedagogical concerns like ensuring alignment with standardized curricula and accommodating diverse learning styles. Additionally, the potential for over-reliance on technology can lead to a superficial understanding of mathematical concepts, reducing students' ability to engage in manual problem-solving. Addressing these challenges demands a concerted effort to equip educators with the skills and resources necessary to implement applets effectively, along with thoughtful design and accessibility enhancements in applet development.

Ultimately, the successful integration of applets in mathematics classrooms requires a balanced approach that leverages their strengths while mitigating their limitations. Educators, curriculum developers, and policymakers must work collaboratively to create a supportive environment for applet use, ensuring equitable access and fostering innovative teaching practices. By addressing the outlined challenges and disadvantages, applets can become a valuable tool in modern mathematics education, enhancing student learning and engagement in meaningful ways.

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A perspective insight towards designing a technological simulator machine in mathematics a discrete classroom

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Abstract. *This current paper attempts to discuss theoretically from several research perspectives to gain insights on how to design an interactive technological learning environment in mathematics classroom discourse at higher education. In this paper, the authors will further explore the essential aspects to embed technology in the learning process. Several instances from current studies will be depicted to provide readers with the importance of technology in learning, such as a learning machine, and the phases within the design process. The authors also include a brief example of the learning machine which had been designed and implemented in the mathematics discrete classroom. The result and information of this paper are expected to give an overview of how to design the technology so that the upcoming researchers can apply these outputs as their research database.*

Keywords: (Technology, Simulator Machine, Higher Education, Mathematics Discrete, Theoretical Review)

Introduction

The embedment of technology in mathematics has widely transformed the traditional way of teaching and learning practices, specifically in higher education. As mathematics classroom in higher education increasingly implement technological environments and digital devices, the manipulatives in technology have stimulated studies in integrating simulator machine learning to introduce mathematical ideas for students [9], this also happens in discrete mathematics course. In teaching discrete mathematics course, this simulator machine offers a nuanced and unique opportunities to sense a cutting-edge learning experience for students which can possibly enhance their mathematical skills and interest to learn more complex concepts [1]. This perspective raises the need to develop simulator machine learning in closing the gap between theorical perceptions

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and our existing understanding.

For mathematics higher education, discrete mathematics though its substantial topics, plays a pivotal role for students' learning success since its concepts are tremendously used in many advanced mathematics and technological scientific learning circumstances, such as data analysis, cryptography, graph theory, and computerization [6]. In this case, students often perceive struggles in understanding the main ideas of these topics that lead them to a misconstrued and unwillingness to learn mathematics [2]. Designing an interactive simulator machine is the solution to these problems that enable students to create constructive visualization and imagination to better understand mathematical ideas. This engaging mathematics learning environment will not only strengthen the students' theoretical insights, but also foster their critical thinking and problem-solving skills in the digital classroom experiences.

In designing and matching the simulator machine to the students' learning needs, we considered several core elements to pursue the effectiveness and user employment [4]. Firstly, the learning machine should integrate dynamic visualizations and simulations that can support students to conduct investigations towards different discrete objects [10]. This possibly includes interactive graphs, combinatorial representations, and algorithmic exhibitions that students can do some manipulations in observing and creating an object. In addition, the learning machine must be useful in accommodating the wide range of students' learning styles, needs, and competencies.

Secondly, the simulator should support collaborative learning among the students, enabling them to have group discussions where they can share their thinking with peers to hone their analytical thinking. The enhancement of such technological devices intricates beyond its digital function, it necessitates as a vehicle to align with educational objectives and standard [11]. Therefore, educators must engage in a cycle of ongoing feedback, iterating the students' performance and classroom-based experience. Therefore, the main research question "*What are the essential design elements that need to be considered when integrating simulator machine into mathematics discrete classroom at the higher education level?*" will be further discussed in this study.

Theoretical Framework

The Intertwinement of Constructivist Learning and Simulators

In educational settings, constructivist learning theory highlights the ideas of conducting transformative learning where students attractively construct knowledge with experiences rather than being passive knowledge attainers [8]. In discrete mathematics, simulators can be platforms that provide opportunities for students to explore mathematical ideas and concepts where they can construct, test, and observe with mathematical models. For example, a mathematical simulator which displays solutions towards graphical problems will possibly enable them to communicate with algorithmic processes and foster a deeper mathematical insight in learning discrete object through trial and error [7].

TPACK Framework and Simulator Integration

In shaping the ideas of TPACK (Technological, Pedagogical, and Content Knowledge), the central discussion is on how machine learning and pedagogical contents are connected [5]. In designing a simulator in teaching mathematics discrete at higher education, [3] argued that educators should consider the following criteria, such as:

1. **Technological knowledge:** this means that it is mandatory for educators to gain understanding towards the designed digital devices how they operate to teach mathematics

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for students.

2. **Pedagogical Knowledge:** the idea of pedagogical-knowledge integration in teaching discrete mathematics is the embedment of lesson structure in machine learning to achieve mathematics learning outputs and outcomes. In this case, educators should consider what pedagogical knowledge is integrated in machine learning in enhancing students' mathematical competencies in learning discrete mathematics.
3. **Content Knowledge:** this refers to the integration of mathematical ideas in the simulator. In this case, educators must have prior vision towards what mathematical knowledge that the students need to learn in mathematics discrete classroom, such as graph theory, combinatorics, and or logics.

Based on the mentioned arguments, it is crystal clear that simulator, in discrete mathematics classroom, can bring nuanced learning to students and then transforming the learning into an interactive environment where they can engage themselves in the discussion.

The Benefits of Integrating Simulator in Teaching Discrete Mathematics

According to [6], there are several advantages in integrating simulator machine to teach discrete mathematics in classroom, such as:

1. Enhancing students' framework of understanding,
2. Increasing classroom engagement ang motivation,
3. Proving immediate horizon of knowledge, and
4. Supporting students' diverged learning needs and styles.

At the same time, simulators are also perceived as tools to resonate active learning for students aimed to enhance their mathematics academic performance, particularly in discrete courses. Therefore, integrating simulators in teaching discrete mathematics at higher education will not only support students in gaining mathematical knowledge, but also help mathematics educators design transformative learning environments at higher education.

Challenges of Simulator Engagement in Teaching Discrete Mathematics

In integration of simulators in discrete mathematics classroom has its dual roles. Previously, we have discussed the benefit aspect of this simulator engagement; this part will further discuss the challenges that mathematics educators may face in integrating this learning machine in discrete mathematics courses. In this case, [11] reported that there are four components that educators face in integrating machine learning to teach discrete mathematics in classrooms, such as:

1. Technical barriers

In integrating simulators in mathematics classrooms, technical barriers are the most common challenge that educators struggle with. This challenge means the readiness of an institution to carry out such learning environment. In technical barriers, educators often struggle to integrate simulators since not all institutions can afford high-quality digital laboratory or the infrastructures to support the learning. Then, not all students can access the learning due to their limitations in providing devices or internet connections.

2. Educator readiness

Another challenge possibly encountered by educators is their preparation towards the digital learning tools. In this case, some educators do not have sufficient knowledge to operate the simulator as they include IT support in designing the simulator. In addition, several educators may be unwilling and hesitant to adopt new teaching instruments in mathematics teaching and learning process, they prefer to integrate the traditional methods.

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3. Overreliance on technology

When integrating technological devices in teaching mathematics to students, a possible consequence of this is the students tend to overuse the technology in their learning. In this case, students may disregard the conceptual understanding and prefer to focus on manipulating objects through the simulator. By doing this, the students will not get the essential knowledge of mathematics learning.

4. Cognitive overload

In teaching mathematics with simulator-based learning, this can be a minor aspect but a necessarily to be considered. In designing a simulator in mathematics teaching, educators and designers may sometimes embed high-complex features which may contribute to a confused and overwhelmed situation rather than providing the students with educational acquaintances. Therefore, educators and designers should have mutual collaboration in designing such learning machines that contain simplicity, clarity and understandable for students to learn.

Conclusion

The authors perceived that it would take a long time to design learning machines in teaching discrete mathematics for higher education students because there are several aspects to be considered in doing so and it, indeed, is not an easy task to undergo. Although it seems challenging to design simulators in mathematics teaching and learning process, however, a small step must be construed to support the students in the learning process that can enhance their academic profile and success. Therefore, this paper provides a theoretical perspective to educators towards what benefits they will have and what challenges they will face in integrating simulators in teaching mathematics, particularly in discrete mathematics classrooms.

Based on our findings, there are several benefits that educators have in integrating simulators in mathematics classrooms, such as the simulator can (1) enhance the students conceptual understanding; (2) increase students' engagement and motivations in classroom discourses; (3) provide immediate horizon of knowledge; and (4) support students' diverged learning needs and styles. When educators gain benefits in integrating simulators to teach mathematics, the students will be aware of the importance of learning using the simulators for learning success.

Besides the advantages that educators can have, they will possibly face challenges in integrating the simulator. In this case, educators may often find challenges during the process of integration, such as technical barriers, educator readiness, overreliance on technology, and cognitive overloads. These types of challenges need to be taken care of since educators will engage in the process much.

Overall, the integration of simulators will bring benefits and challenges at the same time. This paper has exposed these two important views to higher-education lecturers in providing a perspective on what they will get and what they will consider. Therefore, educators can have a thoughtful insight in designing simulators in mathematics learning.

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Case-based learning in basic statistics course: consideration on backward design to reveals students' self-directed learning

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Abstract. *Digital teaching materials to improve students' self-directed learning in basic statistics lectures have been developed in previous studies. This study developed a case-based learning using backward design techniques in basic statistics lectures. The development used the ADDIE model with the stages of Analysis, Design, Development, Implementation, and Evaluation. The backward design technique resulted in case-based learning activities for basic statistics topics. Cases were designed contextually and stimulated students' critical thinking skills with indicators; analysis, evaluation, inference, synthesis, problem solving, and reflection. The results obtained a series of case-based lecture activities and cases used for each basic statistics topic in the study. At the implementation stage, a quasi-experiment was conducted between students who were taught using case-based learning through backward design (experimental group) and students who were taught using problem-solving learning as learning that is usually done in the Mathematics Department in Universitas Negeri Medan (control group). A t-test was conducted to see the difference in critical thinking skills and students' self-directed learning between the experimental group and the control group. The results obtained were; the critical thinking skills of students who were taught using case-based learning through backward design were higher than students who were taught using problem solving learning; and there is no difference in self-directed learning between students who are taught using case-based learning through backward design and students who are taught using problem solving learning. The evaluation obtained that students' self-directed learning of Mathematics Department students in*

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Universitas Negeri Medan is not influenced by the learning approach used but by the media and teaching materials used.

Keywords: *case-based learning, backward design, and self-directed learning*

Introduction

One of the 21st-century keys that are very important for students in facing real-world challenges when they work in the future is critical thinking skills [1], [2]. Critical thinking skills are a mandatory learning achievement for school students, especially in mathematics lessons. Through critical thinking skills, students will have the ability to think logically, systematically, and objectively in understanding various mathematical ideas and concepts [3]. Training students to have critical thinking skills means preparing students to compete in today's era of disruption.

The importance of critical thinking skills for students in mathematics lessons in schools makes critical thinking skills also a mandatory skill for prospective mathematics teacher students. A prospective mathematics teacher must be able to train students' critical thinking skills in the future and also need critical thinking skills to deal with policies and changes in the world of education [4].

The Ministry of Education, Culture, Research and Technology recommends using a case-based approach to improve students' critical thinking skills. (Permendikbud, 2022). The case method effectively develops students' critical and creative thinking skills through a structured problem-solving process [5].

Lectures at State University of Medan are conducted with various learning strategies and models. The author wants to ensure that not all innovative learning models that are currently very suitable for achieving student competencies in schools can also be applied to lecture models for students at Unimed. Students and students have significant differences in terms of mindset, attitude, and responsibility [6]. Learning models in higher education are also often more complex and require a deeper understanding of various theories and concepts. They are also expected to be more independent in learning and able to shoulder heavier responsibilities than students. Therefore, there are many new and specific terminologies if the study focuses on learning models or strategies in higher education. Instead of developing a learning model for students, this time the author proposes a framework for compiling student learning activities in lectures that support the improvement of critical thinking skills and support students' self-directed learning.

One relevant method to support curriculum development in responding to future challenges is backward design [7]. Backward design in education consists of three main stages: (1) identifying learning outcomes or objectives (goals); (2) determining evidence and assessment (assessment); and (3) designing learning experiences and teaching materials [8]. In the first stage, learning objectives are identified through in-depth reflection on the competencies and understanding expected of students. In the context of this study, the goal is to improve students' critical thinking skills and their understanding of the Basic Statistics course. The second stage is to determine evidence that shows the achievement of these objectives, which in this study were measured through critical thinking skills test instruments and observation sheets. These instruments need to go through an in-depth validation process to ensure accuracy in measuring student achievement. The third stage involves designing learning experiences to help students achieve their learning goals. At this stage, it is important to consider the learning resources to be used, the form of scaffolding provided, and the duration of the intervention required [8]. The application of the case study method approach is interesting in this context because it can help answer the question of how designing the right

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case study method can improve students' critical thinking skills and students' self-directed learning.

Students' self-directed learning means the ability of students to carry out learning activities with confidence and self-confidence without help from friends or others. Students are responsible for making decisions related to the learning process and have the ability to carry out these decisions. Self-directed learning is one form of expected student learning behavior. Self-directed learning is the behavior of students in their will and desires in a real way and not depending on others. Self-directed learning operationally can be interpreted as students being able to learn on their own, determine sources and teaching materials, are able to determine their own learning methods and styles, and divide their own time [9].

This study answers whether the application of case-based learning using backward design as a supporter of critical thinking skills has an impact on students' self-directed learning. In this study, the author used a self-directed learning questionnaire that had been modified from the online self-directed learning questionnaire in previous studies. The validated online self-directed learning questionnaire was designed based on the instruments of Murray Fisher and colleagues, namely; having learning initiatives; diagnosing learning needs; setting learning targets; organizing the learning process; finding and utilizing relevant learning resources; choosing and determining learning strategies; independently evaluating the learning process and results; and appropriate self-efficacy [10].

Methodology

This research and development study employed the ADDIE model, which consists of five phases: analysis, design, development, implementation, and evaluation. The study was conducted in the mathematics department, involving students enrolled in the Basic Statistics course. These students were divided into four classes: two classes in the first teaching block and two classes in the second teaching block.

In the analysis phase, the authors established the learning objectives and designed cases aligned with the Basic Statistics course content. The authors developed learning activities during the design phase using a case-based problem-solving approach framed within the backward design model. Additionally, teaching materials and instruments to assess students' self-directed learning were also developed in this phase.

During the development phase, the authors conducted a series of focus group discussions (FGDs) with experts to review and validate the teaching materials and online self-directed learning assessment instruments. In the implementation phase, the authors tested the case-based teaching activities and instructional materials designed using the backward design framework.

Results

Analysis

The learning outcomes formulated for the Basic Statistics course in the Mathematics Department at State University of Medan are as follows; (1) Understanding the fundamental concepts of statistics; (2) Understanding the definition of statistical data; (3) Understanding various forms of data presentation; (4) Understanding measures of central tendency; (5) Understanding measures of data dispersion; (6) Understanding the concept of population and sampling; (7) Understanding probability distributions; (8) Understanding parameter estimation; and (9) Understanding research hypotheses.

Design

The design phase comprises the following sub-stages: formulating learning outcomes, designing learning strategies, designing assessments, and designing learning media. The first

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three sub-stages were developed using the backward design technique, resulting in a distinctive format that includes; (1) Established goal; (2) Understanding; (3) Question (essential questions); (4) Know (concepts/skills students are expected to acquire); (5) Permofmance tasks; (6) Other evidence; and (7) Learning Activities. This format is presented in Table 1, as illustrated in the corresponding table, which also serves as an example of how learning activities are structured using the backward design framework for the topic of statistical data dispersion.

Tabel 4.1. Backward design in topic measures of central tendency

<table>
<tr><th colspan="2">Stage 1 – Desired results</th></tr>
<tr><td colspan="2">Established goal
Students possess critical thinking skills in determining the range, standard deviation, and variance of a dataset and are able to analyze the relationships among these measures within a data group.</td></tr>
<tr><td>Understanding
a. Students understand the concept of range and the procedures for calculating it for both ungrouped and grouped data.
b. Students understand the concept of standard deviation and the procedures for calculating it for both ungrouped and grouped data.
c. Students comprehend the concepts of range and standard deviation as well as the relationship between the two within a dataset.</td><td>Essential Question
There are two data groups with the same standard deviation, but the range of the second group is twice that of the first group. Analyze the data distribution for both groups.</td></tr>
<tr><td colspan="2">Students will be able to:
a. Students possess the skills to analyze the distribution of two data groups with the same mean but different standard deviations and ranges.
b. Students possess the skills to evaluate differences in the standard deviation of data groups calculated from ungrouped and grouped data.
c. Students possess the inferential skills to interpret the meaning of standard deviation and range after being presented with two data groups that have the same mean but different standard deviations and ranges.
d. Students are capable of synthesizing two ungrouped data sets with the same standard deviation and range but different means.
e. Students are able to solve problems related to the validation of a research instrument involving outlier data.
f. f. Students are able to reflect on their experience conducting a mini-research project aligned with the concepts of data dispersion they have studied.</td></tr>
<tr><th colspan="2">Stage 2: Assessment evidence</th></tr>
<tr><td>Performance Task
Reports and presentations on case-solving related to the interpretation of the mean and standard deviation across multiple data groups.</td><td>Other Evidence
A test instrument to assess critical thinking skills in analyzing the mean and standard deviation of two different data groups. The critical thinking skill indicators include: analysis, evaluation, inference, synthesis, problem-solving, and reflection.</td></tr>
<tr><th colspan="2">Stage 3: Learning plan</th></tr>
<tr><td colspan="2">Learning activities
1. Students are divided into groups, and each group is assigned a case related to the interpretation of the mean and standard deviation of two different data groups.
2. Students engage in group discussions, utilizing various learning resources, both printed and digital.
3. Each group submits their case-solving report to another group.
4. Each group reviews the case-solving report submitted by another group.
5. Selected groups are given the opportunity to participate in an open discussion to evaluate other groups' reports.
6. Students hold group discussions to reflect on their case-solving reports that have been prepared and evaluated by other groups.</td></tr>
</table>

Develop

The development of instructional materials was carried out through the preparation of teaching materials and student worksheets, which were compiled into a learning module. The teaching materials include an introduction to theory, explanations of basic statistical concepts, and exercises for solving cases. Each module is designed in a format that is easily accessible

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and understandable for students. The initial module was provided to students in digital form and made accessible via Google Sites at https://sites.google.com/view/pak-badzlan-official.

Validation of the student self-directed learning questionnaire was also conducted. The validation test for the self-directed learning questionnaire instrument was carried out with 31 students from PSPM 23A in the first teaching block. From the 38 statement items, 30 were found to be valid.

Implementation

The implementation phase involved testing the effectiveness of the case-based learning model designed using the backward design technique in the Basic Statistics course to assess students' self-directed learning. The evaluation was conducted using a mean difference test with the t-test technique. Two student groups participated: the experimental group consisting of 61 students and the control group consisting of 54 students.

The average self-directed learning questionnaire score for the experimental group was 3.26, while the control group scored 3.17. Normality and homogeneity tests were conducted, confirming that both datasets were normal and homogeneous. Subsequently, a t-test was performed with a 95% confidence interval using SPSS 21. The results showed a significance value (Sig.) = 0.079, which is greater than 0.05. This indicates that there was no significant difference in self-directed learning between students taught using the case-based learning model designed through backward design and those taught using conventional methods.

Discussion

Based on the results of the implementation phase, it was found that the case-based learning model developed using the backward design approach effectively supports students' critical thinking skills in the Basic Statistics course. However, in terms of students' self-directed learning, no significant differences were observed between the two groups. In other words, the case-based learning model developed through backward design does not specifically enhance students' self-directed learning in the Basic Statistics course.

This outcome can be attributed to the fact that both groups of students were taught using the same digital teaching modules. The use of digital teaching modules has been shown to foster greater independence in learning among students.

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Preliminary insights on integrating problem-based learning and mathematical discourse in virtual collaborative environments for mathematics teacher education

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Abstract. *This research examines the integration of Problem-Based Learning and mathematical discourse within a virtual collaborative environment tailored for mathematics teacher education. Employing a mixed-methods approach, data were gathered from 60 third-year mathematics education students through surveys, observations, task evaluations, and interviews. The results demonstrate that incorporating PBL and mathematical discourse significantly improves student engagement across emotional, behavioral, and cognitive dimensions, as well as enhances conceptual understanding and the effectiveness of team collaboration. Nonetheless, cognitive engagement demands further support, including structured guidance to foster critical questioning and the validation of mathematical arguments. The study highlights practical implications, emphasizing the necessity of asynchronous virtual platforms designed to promote meaningful interaction and strategies to optimize collaborative efforts. Acknowledging limitations such as sample diversity, dependence on a single platform, and the short duration of the study, the research suggests future investigations to assess long-term effects and examine factors shaping student interactions and learning achievements.*

Keywords: Problem-Based Learning, Mathematical Discourse, Virtual Collaboration, Student Engagement, Mathematics Teacher Education.

Introduction

Problem-Based Learning (PBL) and mathematical discourse have become central to mathematics education because they cultivate conceptual understanding, critical thinking, and problem-solving skills essential for success in contemporary society [1-2]. PBL situates learning in authentic contexts that require students to investigate and resolve real-world problems, while mathematical discourse encourages learners to articulate, defend, and refine their reasoning through dialogic interaction [3-5]. When these complementary approaches are enacted effectively, learners deepen their grasp of mathematical ideas and develop the capacity to apply those ideas flexibly in novel situations. Yet teachers often report that fostering sustained discourse, especially

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the critical questioning and validation of arguments demanded by PBL, requires targeted preparation and support, particularly in heterogeneous classrooms [6].

Recent advances in educational technology offer new opportunities to embed PBL and discourse within virtual collaborative environments. Learning-management platforms such as Moodle and Google Classroom can extend interaction across time and space, supporting asynchronous discussion, shared artefacts, and multimodal feedback [7]. Nevertheless, technical constraints, inequitable access, and limited digital fluency may hinder the social presence and reciprocity that both PBL and mathematical discourse depend upon [8]. Ensuring that virtual spaces function not merely as content repositories but as arenas for meaningful mathematical argumentation therefore remains a pressing design challenge.

Although extensive research has examined PBL and mathematical discourse individually, studies exploring their combined implementation in virtual settings, especially within mathematics teacher education, are comparatively scarce. Existing work often overlooks the rich social exchanges that underpin effective discourse, as well as the distinctive mentoring demands placed on pre-service teachers who must orchestrate such exchanges for their future pupils [9]. Addressing this gap, the present mixed-methods study investigates strategies for integrating PBL with mathematical discourse in an asynchronous virtual collaborative environment tailored to mathematics teacher education. By analyzing the experiences of 60 third-year mathematics education students, the study aims to illuminate how virtual platforms can be configured to sustain emotionally, behaviorally, and cognitively engaging collaboration, identify supports required for rigorous argumentation, and offer design principles that enhance the quality and effectiveness of mathematics instruction in digitally mediated contexts.

Method

This study employs an evaluation framework designed to identify and analyze effective strategies for integrating PBL and mathematical discourse within a virtual collaborative environment. The framework is adapted from the approach proposed by Dyson and Campello [10], which incorporates both process-oriented and outcome-based measurements to assess the effectiveness of Virtual Learning Environments (VLEs). This comprehensive approach facilitates a thorough examination of student engagement, social interactions, conceptual understanding, and collaboration effectiveness.

The primary aim of the study is to evaluate the extent to which the integration of PBL and mathematical discourse enhances student engagement, optimizes social interactions, and deepens mathematical conceptual understanding within virtual collaborative learning contexts. The evaluation process involves examining both procedural elements, such as patterns of student contributions during discussions, and outcome-based factors, including task performance and the quality of mathematical discourse.

Research Design

This study adopts a descriptive evaluation design utilizing both qualitative and quantitative approaches. The design is structured to assess the effectiveness of integrating PBL and mathematical discourse from two key perspectives: the collaborative process and learning outcomes. Data were collected from a purposively selected sample of 60 third-year students enrolled in a mathematics education program.

The sample selection criteria included students who had successfully completed courses in Differential and Integral Calculus and had stable access to a Moodle-based virtual learning

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platform provided through SiPDa (https://sipda.unimed.ac.id/). This platform was chosen for its features that support asynchronous discussions, group collaboration, and task submission, which are essential for facilitating effective virtual learning and interaction.

Data Collection

Data collection in this study employed multiple methods to ensure the comprehensiveness and validity of the gathered information. Firstly, collaborative process observations were conducted to record student interactions and participation during virtual discussions using the log feature on the SiPDa platform. These observations focused on the frequency of contributions, the quality of discussions, and collaborative patterns exhibited by students during PBL sessions, providing detailed insights into their engagement in the collaborative process.

Secondly, surveys and Likert scale-based questionnaires (1–5) were utilized to measure student engagement across three dimensions: emotional, behavioral, and cognitive. The indicators assessed included students' confidence levels, collaborative experiences, and their perceptions of the effectiveness of virtual learning. Thirdly, task and discussion analyses were carried out by evaluating group assignments using rubrics that assessed conceptual understanding, solution application, and collaborative skills. The discussions were further analyzed based on criteria proposed by Sfard [4], which evaluate the quality of mathematical interactions, such as argument construction and solution analysis.

Lastly, in-depth interviews were conducted with 10 purposively selected participants. These semi-structured interviews were designed to explore students' perceptions of the benefits and challenges associated with integrating PBL and mathematical discourse in a virtual environment. The qualitative data obtained from these interviews complemented findings from the observations and surveys, thereby offering a more comprehensive perspective on the research findings.

Data Analysis

Data analysis in this study employed both quantitative and qualitative approaches to provide a comprehensive understanding of the integration of PBL and mathematical discourse in a virtual environment. Quantitative analysis involved the use of descriptive statistics to evaluate the distribution of student engagement across emotional, behavioral, and cognitive dimensions. Furthermore, inferential statistics, particularly ANOVA, were applied to compare the frequency of student contributions during discussions and task achievements across groups, enabling the identification of significant differences related to learning effectiveness.

Qualitative analysis was conducted using thematic methods to examine data from interviews and group discussions. This approach facilitated the identification of interaction patterns that emerged during the collaborative process and highlighted factors influencing the success or challenges in implementing PBL and mathematical discourse. The qualitative analysis provided detailed insights into how students participated in mathematical discussions, including their strategies for constructing arguments, formulating critical questions, and resolving conflicts within teams.

To ensure the validity of the findings, data triangulation was performed by comparing and verifying results from various data sources, such as surveys, observations, and interviews. This triangulation approach aimed to enhance the accuracy and credibility of the research outcomes while ensuring that the conclusions drawn represented a holistic understanding of students' experiences in a virtual collaborative environment.

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Success Indicators

The success of integrating PBL and mathematical discourse in a virtual collaborative environment was assessed using three primary indicators. The first indicator, student engagement, was evaluated based on the quantity and quality of contributions made by students in virtual discussions. The quality of these contributions reflected their relevance and informativeness, particularly in constructing arguments, responding to questions, and interacting with peers throughout the learning process.

The second indicator was conceptual understanding, measured through group task scores and rubric-based evaluations of conceptual comprehension. These rubrics assessed aspects such as the clarity of solutions, innovation, and the application of mathematical concepts. The results of these evaluations provided insights into the extent to which students internalized and applied mathematical concepts in problem-solving contexts.

The final indicator was collaboration effectiveness, gauged through students' perceptions of their group work experiences. These perceptions included aspects such as task division, communication quality, and the flexibility of scheduling within the collaborative process. Collectively, these three indicators offered a holistic perspective on the efficacy of the PBL and mathematical discourse approach in fostering meaningful and interactive learning experiences.

Findings

This study assessed the effectiveness of integrating PBL and mathematical discourse within a virtual collaborative environment tailored for the education of prospective mathematics teachers. The findings are presented through the application of three data analysis methods—quantitative, qualitative, and data triangulation—which collectively provide a comprehensive understanding of student engagement, conceptual achievement, and the effectiveness of collaboration.

Student Engagement

Student engagement in virtual PBL discussions was examined across three primary dimensions: emotional, behavioral, and cognitive. Survey results revealed that 86.7% of students (52 out of 60) felt motivated to actively participate in discussions. Students reported that collaborative interactions significantly enhanced their emotional engagement in the learning process. This finding was corroborated by interviews, where most students highlighted the convenience of asynchronous discussion features on the SiPDa platform for sharing ideas. One student remarked, "I feel more confident expressing my opinions in writing than speaking directly."

Table 1. Frequency and Quality of Discussion Contributions

Group	Frequency	Quality (1–5 scale)
Group 1	82	4.2
Group 2	95	4.5
Group 3	79	4.1
Group 4	88	4.3
Average	86	4.3

Observations of the collaborative process revealed that students contributed an average of 9.6 inputs per session, with contributions ranging from 5 to 15 per student. Additionally, an analysis of contribution quality indicated that 78% of inputs were classified as relevant and informative.

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Table 1 summarizes the distribution of contributions across groups, demonstrating the relationship between the frequency of contributions and the quality of discussions.

A significant 83.3% of students reported that virtual discussions aided their understanding of complex mathematical concepts. Observations of these discussions revealed that students frequently posed critical questions, such as, "Why is this solution valid when using a geometric approach but not applicable in algebraic analysis?" and "What happens if the parameters are changed? Does the solution remain valid?"

These interactions illustrate the dynamic interplay between emotional and behavioral engagement in fostering cognitive engagement. For instance, students who were more motivated emotionally tended to participate more actively in discussions, which ultimately enhanced their conceptual understanding on a deeper level.

Student's Conceptual Understanding

The improvement in students' mathematical conceptual understanding was assessed through pre-test and post-test results, as well as an analysis of group assignments. The average pre-test score was 68.4, which significantly increased to 85.7 in the post-test ($p < 0.001$), demonstrating the effectiveness of this method in enhancing students' conceptual grasp. The distribution of scores across different groups is detailed in Table 2.

Table 2. Improvement of Pre-Test and Post-Test Scores

Group	Pre-Test Average	Post-Test Average	Improvement
Group 1	66.2	84.5	18.3
Group 2	67.8	86.9	19.1
Group 3	70.5	85.2	14.7
Group 4	68.9	86.1	17.2
Average	68.4	85.7	17.3

The analysis of group assignments revealed that groups with higher discussion intensity achieved better task scores. This relationship is illustrated in Figure 1, which depicts a positive correlation between the level of discussion intensity and the group assignment scores.

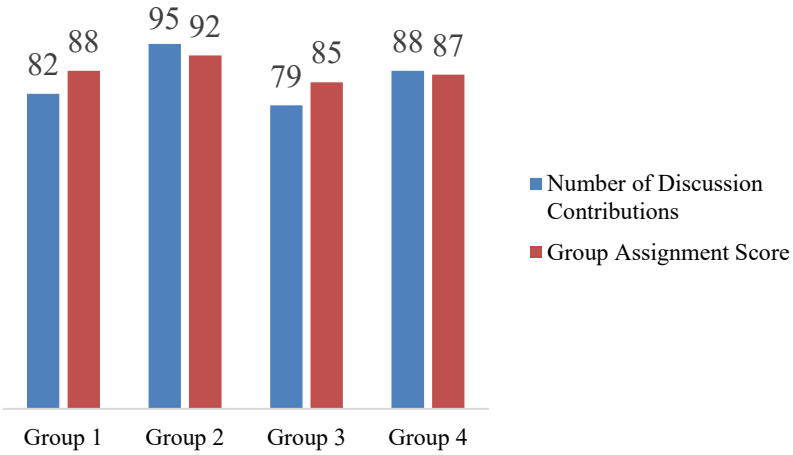

Figure 1. Relationship between Discussion Intensity and Assignment Score Graph

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Figure 1 illustrates that groups with an average contribution exceeding 90 achieved higher task scores, with an average score of 92. The pedagogical implication is that discussion intensity not only enhances conceptual understanding but also fosters innovation in problem-solving approaches. Overall, the findings from pre-tests, post-tests, and group assignments validate the effectiveness of integrating PBL and mathematical discourse in improving students' conceptual comprehension. The presentation of data through tables and graphs clarifies the relationship between discussion intensity and learning outcomes, providing a robust empirical foundation to support the study's conclusions.

Effectiveness of Collaboration

The effectiveness of collaboration within group discussions was evaluated based on students' perceptions of their team-working experiences. A significant majority, amounting to 90% of students, indicated that collaboration within their groups was effective. Most participants highlighted that clear task allocation and asynchronous communication facilitated through the SiPDa platform were instrumental in ensuring productive teamwork. Students' satisfaction levels regarding various aspects of collaboration are summarized in Table 3.

Table 3. Collaboration Satisfaction Level

Collaboration Aspect	Very Satisfied	Satisfied Less	Satisfied	Not Satisfied
Task Division	40	20	0	0
Communication in Discussion	45	15	0	0
Time Flexibility	42	18	0	0

In-depth interviews revealed several challenges encountered during group collaboration, including difficulties in synchronizing schedules with team members and delays in responses from some participants. One student remarked, "Some team members often respond late, which slows down the group's progress." Practical suggestions to address these issues include: (1) establishing flexible scheduling practices that encourage students to set internal deadlines within their groups; (2) leveraging project management tools such as Trello or Google Calendar to enhance coordination and streamline task management; and (3) providing asynchronous communication training to improve response times and overall efficiency in group interactions.

Discussion

The findings of this study indicate that integrating PBL and mathematical discourse within a virtual collaborative environment has a positive impact on student engagement, conceptual understanding, and the effectiveness of collaboration. This section explores the key results of the study by addressing three primary aspects: student engagement, the enhancement of conceptual understanding, and collaboration effectiveness, alongside their implications for both educational theory and practice.

Supporting Student Engagement in Virtual Environments

Student engagement was examined across three dimensions: emotional, behavioral, and cognitive. The high motivation levels reported by 86.7% of participants indicate that virtual environments can effectively support students' emotional engagement despite technological

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challenges. The asynchronous discussion feature on the SiPDa platform provided a comfortable space for students to share their ideas, particularly benefiting those who felt less confident in direct interactions. These findings align with previous research by Darari and Firdaus [11] and Firdaus and Mukhtar [12], which highlighted that the flexibility of virtual platforms enhances students' active participation.

However, the cognitive dimension warrants further exploration. While 83.3% of students reported improved conceptual understanding through discussions, a deeper analysis revealed that critical questioning was limited to a few groups. For instance, students who demonstrated higher levels of emotional and behavioral engagement also exhibited greater cognitive involvement, reinforcing the theory that these dimensions are interrelated [13]. This study underscores the need to prioritize emotional and behavioral engagement as a foundation for fostering deeper cognitive participation.

Enhancing Mathematical Understanding through Asynchronous Collaboration

The pre-test and post-test results demonstrated a significant improvement in students' conceptual understanding of mathematics ($p < 0.001$), indicating that the integration of PBL and mathematical discourse fosters more effective learning. The average post-test score of 85.7 reflects not only students' grasp of the material but also their ability to apply the concepts in group tasks.

The correlation between discussion intensity and group task scores, as illustrated in Figure 1, highlights that more intensive discussions lead to better conceptual understanding. Groups with higher discussion contributions achieved higher task scores. This finding aligns with the research by Firdaus et al. [14], which emphasized the critical role of discussion intensity in driving collaboration and fostering innovative solutions.

Nonetheless, the distribution of scores among groups reveals that even students with lower discussion contributions could achieve substantial improvement. This suggests that discussion intensity is not the sole determinant of success; the quality of interaction and group support also play significant roles. Future research should explore additional factors, such as the facilitator's role in enhancing the quality of discussions, to provide a more nuanced understanding of effective learning dynamics.

Strategies for Increasing the Effectiveness of Team Collaboration

The majority of students (90%) reported that collaboration within their groups was effective, attributing their success primarily to clear task allocation and effective communication. These findings align with the theory that asynchronous collaboration offers flexibility in scheduling, which enhances productivity [15]. However, in-depth interviews revealed certain challenges, such as delayed responses from team members, which affected the overall efficiency of group work.

Practical recommendations to address these issues include the integration of project management tools and training in asynchronous communication. These strategies can streamline coordination and ensure timely responses among group members. Additionally, the study highlights the importance of establishing clear roles and responsibilities within teams to prevent workload disparities, fostering a more balanced and effective collaborative environment.

Pedagogical Implications

The findings of this study offer significant pedagogical implications for teaching mathematics in virtual environments. Firstly, the design of virtual learning environments should prioritize asynchronous discussion features that facilitate meaningful interactions. These features must

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provide opportunities for every student to actively contribute, fostering rich and inclusive mathematical discourse. Previous research by Hamutoglu et al. [16] highlights that designs supporting active participation, such as user-friendly interfaces and clear collaboration guidelines, enhance student engagement. Within this context, facilitators play a crucial role in ensuring equal participation among all discussion participants.

Secondly, strengthening cognitive engagement should be a primary focus. While the study demonstrated improvements in emotional and behavioral engagement, cognitive engagement requires additional interventions to reach its full potential. Facilitators could introduce more structured guidance on formulating critical questions and validating mathematical arguments [17]. This approach aligns with Elembilassery and Chakraborty's [18] findings on the importance of reflective dialogue in enhancing conceptual understanding. For instance, scaffolding question models can encourage students to delve deeper into mathematical solutions and construct robust arguments.

Lastly, collaborative strategies for asynchronous discussions require a more systematic approach to time management and group communication. Morrison-Smith and Ruiz [19] identified that asynchronous collaboration often faces challenges due to a lack of coordination among team members. To address this, initial training in time management and the use of project management tools such as Trello or Google Calendar can help students synchronize schedules and responsibilities more efficiently. Moreover, incorporating such tools can foster a sense of both individual and collective accountability within groups, thereby supporting successful collaboration. This approach not only enhances group productivity but also strengthens collaborative competencies essential for students' professional development.

Research Limitations

This study presents several limitations that should be considered when interpreting the results and implementing the findings. Firstly, the sample consisted solely of third-year mathematics education students, which restricts the generalizability of the results to broader populations, such as students at other educational levels or those with different backgrounds. Secondly, the study relied on a single virtual learning platform, SiPDa, as the primary medium. Consequently, the effectiveness of the findings may vary if applied to other learning platforms with distinct features or interface designs. Thirdly, the relatively short duration of the study may have limited the ability to assess the long-term impact of integrating PBL and mathematical discourse. Future research with extended timeframes is recommended to explore deeper and more sustained changes in student engagement, conceptual understanding, and collaboration effectiveness.

Conclusion

This study demonstrates that the integration of PBL and mathematical discourse within a virtual environment can enhance student engagement, conceptual understanding, and collaboration effectiveness. However, the interplay among the dimensions of engagement requires further analysis, particularly to strengthen cognitive engagement. By implementing strategies that specifically target the reinforcement of cognitive dimensions and collaborative practices, the findings of this research can serve as a guide for developing more adaptive and interactive approaches to mathematics instruction in virtual settings. Future research is encouraged to investigate factors influencing the quality of student interactions and their impact on learning outcomes.

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Development of interactive electronics worksheets assisted with liveworksheet based on an open-ended approach in improving students' creative thinking ability

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Abstract. *In overcoming students' low thinking abilities, lecturers have tried to provide students with lots of example questions to provide an illustration for them in solving various types of problems. However, this method is not efficient enough to improve students' understanding, including their creative thinking abilities, because students are only accustomed to memorizing formulas or following the solution methods taught by the lecturer. For this reason, efforts are also made to ensure that learning is interactive. This will encourage students' creative thinking abilities in creating and finding their own answers regarding the learning material. To create interactive learning, it is necessary to develop student worksheets to support the development of students' creative thinking abilities. For this reason, researchers and the team plan to develop an instrument in the form of an interactive worksheet with the aim of stimulating students' creative thinking abilities accompanied by certain models according to their needs. For this reason, it is planned to use an approach that is in line with the characteristics of mathematics, especially in improving creative thinking abilities, namely the Open-Ended Approach.*

Keywords: *Interactive Electronic Worksheets, Open-Ended Approach, Creative Thinking Ability*

Introduction

Mathematics is one of the scientific disciplines that must be taught in schools. Students are educated to think systematically, practically, critically, realistically and creatively through teaching mathematics. Students must have the ability to think creatively in learning mathematics to overcome the problems they face. According to Krulik and Rudnik (Sari, A.N, *et al,* 2016: 21), creative thinking is defined as thinking that is original, reflective, and has the ability to create something complex with new concepts and determine how effective they are. However, in practice it appears that lecturers pay less attention to students' creative thinking abilities in learning. Lecturers tend to focus on student learning outcomes without paying attention to the learning process that occurs. The result is a lack of motivation in learning and students' inability to improve

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their abilities. This also happens in higher education where students still have an inability to think creatively.

Based on classroom observations, when lecturers ask students to work on questions, it appears that they can only provide one way to solve a problem. Students lack creativity by solving problems only by using examples taught by the lecturer. Students are still rigid in solving problems in their own way or differently from existing examples. Apart from that, based on interviews with students in class, the learning they receive is mostly one-way learning, where learning is centered on the lecturer. During lecture hours, the lecturer provides learning material using the lecture method, then the lecturer gives examples of questions to students and ends by giving them practice assignments. So that during learning there is no active role for students in learning. Apart from that, in learning, lecturers very rarely use questions outlined in the form of worksheets to support the learning process in class.

To obtain students' creative thinking abilities in mathematics, researchers conducted initial ability tests on students. Based on the data obtained, students have not been able to provide ideas that are relevant to problem solving. Apart from that, students are also not able to provide many ways to solve the same problem. Based on the results of the assessment of creative thinking ability indicators, the following student data was obtained: Of the 35 students observed, 21 students (60%) were not creative, 13 students (37.1%) were less creative, and 1 student (2.9%) was quite creative. This is because students are still not able to provide ideas that are relevant to problem solving, students are not able to provide various ways of solving problems, students are not yet able to detail the problem solving process correctly, and students are not able to provide their own opinions correctly.

Several studies show that teaching materials in the form of worksheets can improve students' creative thinking abilities. Juwita, R, *et al* (2019: 31) state that student worksheets are teaching materials or tools that are able to improve students' creative thinking abilities accompanied by certain models that suit students' needs. One of the free online sites that teachers can access to develop interactive student worksheets is the Liveworksheets site. Liveworksheets is a web platform that can be accessed by every teacher to use available electronic worksheets or develop their own student worksheets online. Student worksheets assisted by the Liveworksheets platform can help create varied learning for students with the problems presented. One learning method that is considered capable of improving students' creative thinking abilities is the Open Ended approach. The Open-Ended approach is a learning approach that is able to train and foster creativity, cognitive abilities, interactive communication, critical thinking and openness.

Literature Review

In the creative thinking process, students are given the opportunity to build their knowledge and experience in their own way. In building creative students, learning in the classroom begins by presenting open (divergent) problems to students. This problem will give students the opportunity to answer correctly and in various different ways, thus encouraging students to think flexibly. Today's learning really needs the role of technology. Educational technology is formed into a solution to educational problems, in order to improve the quality of learning. One of the roles of technology in education is the development of interactive teaching materials in learning. Interactive means that there is a reciprocal relationship between the user and the teaching material.

One form of teaching material that can be made interactively is student worksheets. The application of student worksheets gives students the opportunity to think actively and creatively to improve learning in achieving learning indicators and competencies. Student worksheets are useful

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in increasing active student participation in learning, training students to solve critical thinking problems, training students to develop process skills, and saving teaching time. One form of worksheet is a worksheet that is arranged in electronic form as a learning medium to support the learning process. One of the platforms used as a supporter in making electronic-based worksheets is Liveworksheet.

In supporting the creation of interactive liveworksheet, it has several features for creating questions, such as multiple choice questions, matching with line drawing, drag and drop, essays and various other types of questions that can be accessed by teachers. With these features, students have a new experience in learning and doing exercises, thereby increasing students' interest and motivation to learn. In this study, the implementation of the electronic student worksheet that has been developed is carried out with an open-ended approach. The purpose of the Open-Ended approach in mathematics education is to gain experience in discovering new knowledge through the process. In Open-Ended, math problems are formatted with multiple correct answers, allowing students to find solutions that suit their cognitive abilities.

The main reason why this type of approach is chosen is because the Open-Ended approach is an approach that begins with a problem that can be solved in different ways depending on the skills and interests of the students. The Open-Ended approach can build interactive learning activities by giving students the freedom to choose the desired solution method. In the Open-Ended approach, teachers give students problems to solve, and teachers must use students' efforts to solve the problems so that students can learn how to discover something new based on the knowledge, skills, and ways of thinking they already have.

Methodology

This type of research is development research. Research and development, is a research method used to produce a product. This type of research is development research. Research and development is a research method used to produce a product. In this research, the main focus is to produce a product needed to overcome students' low mathematical reasoning abilities. The product developed is interactive teaching material. The research and development model chosen is the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model. The research and development model chosen is the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model developed by Dick and Carry. Researchers use the ADDIE model because the ADDIE development model has systematic work stages, the stages can be modified according to the researcher's needs which helps researchers produce a valid product. The procedure is illustrated as follows:

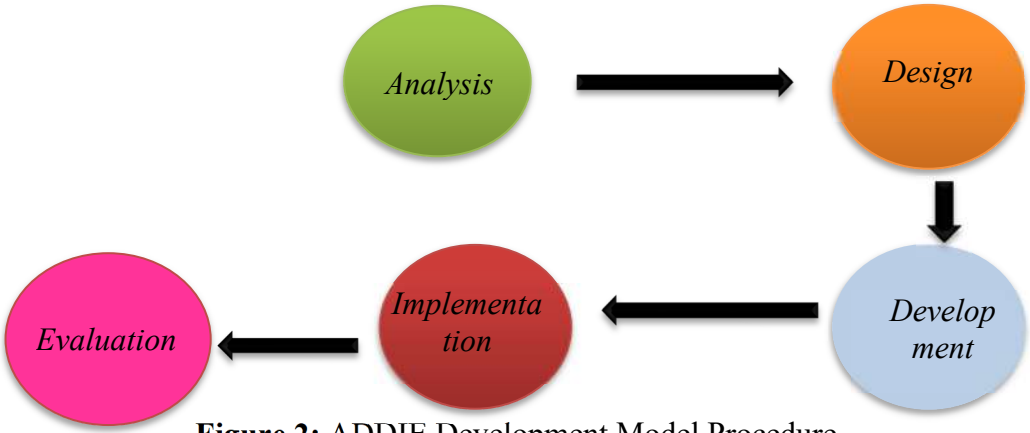

Figure 2: ADDIE Development Model Procedure

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1. Analysis
   The analysis stage is the initial stage in development. The analysis stage aims to find out what is needed in developing teaching materials. This analysis was carried out by observing the learning process, interviews with students, diagnostic tests, and distributing questionnaires to students who were research subjects. At this stage, the process carried out is to carry out an analysis regarding the need for product development (teaching materials, methods, models and media) to be carried out as well as the feasibility of product development requirements. Developing a new product can be done by reviewing problems that existed in the previous product, such as the previous product's incompatibility with target needs, student characteristics, technology, and the learning environment.
2. Design
   At this stage, a design is created based on each development product content, by writing down detailed and clear instructions for implementing and making the product. The product design that has been created is still conceptual during the design stage, which will serve as a basis for the development process in the next stage.
   After the design stage is complete, the next stage is development. This stage is the stage of developing interactive teaching materials which researchers will develop using the following steps: (1) develop teaching materials according to the design that has been previously designed, and (2) the developed teaching materials are then validated by material experts and media experts with provide a questionnaire of predetermined criteria and indicators. Validation is carried out until finally the interactive teaching materials developed are declared valid.
3. Development
   At this stage, the design that has been made is realized. The conceptual framework that has been prepared in the previous stage is made into a product ready to be implemented. Then at this stage an instrument will also be created that will be used to measure product performance.
4. Implementation
   At this stage, the product that has been developed can be applied to get feedback on the product that has been developed. Feedback from products can be in the form of responses or results related to the goals of product development. This implementation is carried out in accordance with the design that has been made.
5. Evaluation
   Evaluation is the final stage in ADDIE research. The final goal of this stage is to determine the achievement of the development goals that have been made, and to evaluate the entire process that has been carried out.

Data Analysis Technique

The data analysis techniques carried out in this research are divided into two, qualitative and quantitative data analysis. Qualitative data was obtained based on the results of interviews, observations, and suggestions from experts regarding the use of interactive student worksheets. Meanwhile, quantitative data was obtained from validation sheet scores and response questionnaires which were distributed after practitioners used interactive student worksheets with an Open-Ended approach.

a) Data Analysis Validity of Electronic Student Worksheets
   Obtain quantitative data results from instrument sheets that have been assessed by experts by changing the score data on the instrument into qualitative data. Next, calculate the average score from the total instrument filling.

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b) Data Analysis Practicality of Electronic Student Worksheets
An assessment of the practicality of interactive electronic student worksheets is obtained through the results of response questionnaires that have been filled in by students.

c) Data Analysis of the Effectiveness of Electronic Student Worksheets
In measuring the increase in students' creative thinking abilities, it can be done by calculating the analysis of the increase in students' creative thinking abilities in each indicator, analysis of overall creative thinking abilities and N-Gain analysis.

Result and Discussion

1. Description of Validity Analysis Results
The Interactive Electronic Student Worksheet that has been developed is validated by expert validators. The validators needed for validation are media validators and material validators. Below are presented the validation results of the Open-Ended Based Interactive Electronic Worksheet from Material Aspects.

Table 1. Validation Results of Open Ended Based Interactive Electronic Worksheets from Material Aspects

Assesment Aspects	Assesment Results					Category
	1	2	3	Total	Average	
Core Competencies	4,00	3.67	3.67	11.34	3,78	Very Valid
Linguistic Components	4,00	3.33	3,67	11	3,66	Very Valid
Presentation Components	3,67	4,00	4,00	11.67	3.89	Very Valid
Graphic Components	3.67	4.00	4.00	11.67	3.89	Very Valid
Average					3.80	Very Valid

The validation carried out by validator experts to provide an assessment of the suitability of Open-Ended based Interactive electronic worksheet media can be seen in the following table.

Table 2. Validation Results of Open Ended Based Interactive Electronic Worksheets from the Presentation Aspect

Assesment Aspects	Assesment Results					Category
	1	2	3	Total	Average	
Identity	4	4	4	12	4	Very Valid
Time Allocation	3	3	3	9	3	Valid

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Formulation of Learning Objectives	4	4	4	12	4	Very Valid
Teaching Materials	4	4	3	11	3.67	Very Valid
Selection of Learning Model Approach	3	4	4	11	3.67	Very Valid
Learning Activities	3	4	3	10	3.33	Very Valid
Selection of Learning Resources	4	4	3	11	3.67	Very Valid
Assessment of Learning Outcomes	4	3	3	10	3.33	Very Valid
Average					3.58	Very Valid

In the development stage, a trial was carried out using the interactive electronic worksheet product on 5 students, by providing student response questionnaires. The results of the analysis of student response questionnaire data are presented in the following table.

Table 3. Student Response Questionnaire Results

Number of Students	5 students
Practicality Percentage	93%
Category	Very Practical

2. Description of Media Practicality Analysis Results
   After the small group trial was carried out, practicality testing activities were carried out to measure the level of practicality of the media in its use. Analysis of practicality data was obtained through a questionnaire response from 35 students, with the following results.

Tabel 4. Results of Student Response Questionnaire Analysis

Number of Students	35 students
Practicality Percentage	96%
Category	Very Practical

Based on Table 4. the results of the questionnaire analysis of student responses were 96%. Based on the practical analysis of the questionnaire results, student responses reached >75% of 35 students. So it can be concluded that the interactive electronic student worksheet developed meets the "practical" criteria.

3. Media Effectiveness
   Interactive Electronic Student Worksheets, after fulfilling the validity and practicality tests, must also meet the effective criteria, if they meet the requirements, namely: (1) students achieve classical completion ≥ 85% of students who take part in the learning and complete

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the minimum score, (2) achievement each indicator/learning objective ≥ 65% of students who are able to achieve a minimum of 75% completeness of the indicator/ learning completeness. The results of individual student completion can be seen in the following table.

Table 5. Percentage of Student Learning Completeness

Information	*Pretes*		*Posttes*	
	Number of Students	**Percentage**	**Number of Students**	**Percentage**
Complete	7	20%	30	85.71%
Not Completed	28	80%	5	14.29%
Amount	35	100%	35	100%

In the table above, it can be seen that the students' completeness level during the pretest was 20% and posttest was 85.71%. So it can be concluded that the class in the research achieved complete classical learning. Meanwhile, the achievement of learning indicators/goals is the students' completeness in creative thinking competence, where the indicator achievement is said to be achieved if 75% of the learning goals can be achieved by at least 65% of students. The results of the percentage achievement of indicators in large group trials can be seen in the following table.

Table 6. Percentage of Indicator Achievement

Indicators	*Pretes*		*Posttes*	
	Percentage	**Information**	**Percentage**	**Information**
Fluency	28.57%	Not Yet Achieved	88.57%	Achieved
Flexibility	20%	Not Yet Achieved	85.71%	Achieved
Originality	14.28%	Not Yet Achieved	85.71%	Achieved
Elaboration	17.14%	Not Yet Achieved	74.28%	Achieved

Furthermore, improving students' creative thinking abilities can be seen based on the overall average score for each indicator. The increase in each indicator of students' creative thinking abilities can be seen in the following table.

Tabel 7. Increasing Creative Thinking Ability for Each Indicator

Indicators	Average Percentage		
	Pretes	***Posttes***	**Improvement**
Fluency	28.57%	88.57%	60%
Flexibility	20%	85.71%	65.71%
Ooriginality	14.28%	85.71%	71.43%

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Elaboration	17.14%	74.28%	57.14%

The increase in students' creative thinking abilities for each indicator can be seen in the diagram of increasing creative thinking abilities below

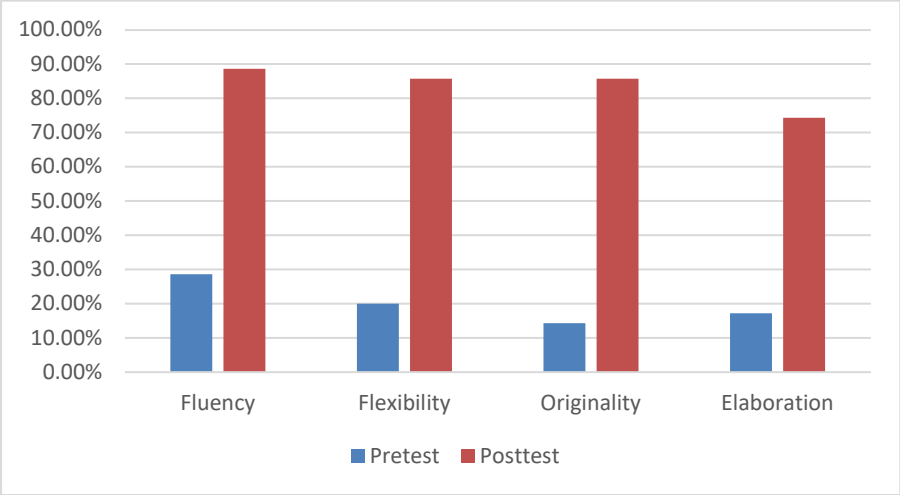

Figure 3. Diagram of Increasing Creative Thinking Ability

Then the increase in students' creative thinking abilities can be seen through N-Gain analysis. The normalized gain is the ratio of the class pretest-posttest gain scores to the maximum gain obtained. The increasing students' creative thinking abilities based on N-Gain analysis can be grouped as follows.

Table 7. The Improved Creative Thinking Based on N-Gain Analysis

Gain	Categories	Number of Students	Percentage	Average
$g > 0{,}7$	Tinggi	15	42,86%	**0,63**
$0{,}3 \leq g \leq 0{,}7$	Sedang	16	45,71%	
$g < 0{,}3$	Rendah	4	11,43%	
Total		35	100%	

Based on the table above, an increase in Gain was obtained of 0.63, where based on the N-Gain analysis category the increase was categorized in the medium category. It can be concluded that the use of interactive electronic student worksheets based on the Open-Ended Approach is able to improve students' creative thinking abilities.

Conclusion

Based on the research results and discussions presented in this research, the conclusions that can be drawn are:

1. In terms of validity, the Interactive Electronic Student Worksheet based on the Open-Ended Approach is declared in the very valid or very feasible category, based on the results of the media validator of 3.58 and the material of 3.66.
2. In terms of practicality, the Interactive Electronic Student Worksheet based on the Open-

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Ended Approach is stated in the very practical category, based on the teacher response questionnaire, the practicality result was 92%, the small group student response questionnaire was 93%, and the large group student response questionnaire was 96%. %.

3. In terms of effectiveness, Interactive Electronic Student Worksheets based on the Open-Ended Approach are declared in the effective category, based on: a) achieving classical completeness by 85.71% of students, b) achieving each indicator, indicator 1 is 88.57%, indicator 2 amounted to 85.71%, indicator 3 amounted to 85.71%, and indicator 4 amounted to 74.28%, c) students' positive response to the Interactive Electronic Student Worksheet is 96% in continuity of learning.
4. Increasing students' creative thinking abilities can be seen from the N-Gain value for each indicator, the first indicator obtained is 0.68 in the medium category, the second indicator obtained is 0.62 in the medium category, the third indicator obtained is 0.64 in the medium category and the fourth indicator is 0.58 in the medium category. The results of increasing overall creative thinking abilities obtained an average N-Gain of 0.63 in the medium category.

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Constructing a hypothetical learning trajectory for research methodology instruction through *rewang*-based research learning

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Abstract. *This study aims to design a Hypothetical Learning Trajectory (HLT) for research methods courses through a research-based learning approach that integrates the local wisdom of "rewang" to enhance the research skills and academic writing proficiency of students in the Mathematics Education Program at the Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan. The designed HLT is the outcome of an initial exploration within Design Research. The development of this HLT is based on the identification and analysis of learning obstacles that students may face during the course on research methods. Through in-depth observation of the learning process, various barriers faced by lecturers in developing students' research skills and scientific writing abilities were identified, as well as several misconceptions students hold about research method concepts. The HLT is designed as an instructional plan that considers the potential progression of students' understanding to achieve learning goals, anticipated levels of comprehension, and a systematically arranged sequence of research activities. This HLT design is carried out by analyzing Learning Obstacles, students' cognitive stages, and curriculum review while adhering to the essential concepts that students need to master.*

Keywords: Hypothetical Learning Trajectory, Research Method Instruction, *Rewang*, Research-Based Learning, Research Skills

Introduction

Enhancing the quality of higher education in Indonesia presents a major challenge, particularly in producing graduates with adequate scientific skills [1]. Research abilities and academic writing skills are crucial competencies that students must master, especially in mathematics education [2 – 3]. Students are expected to grasp fundamental research methods concepts and apply them in

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meaningful, real-world contexts. However, many students struggle to comprehend the various stages of research and often hold misconceptions about basic research method principles [4 – 5]. This situation reveals the presence of Learning Obstacles, or barriers to learning, which impede students' educational progress and require targeted attention from educators and curriculum developers.

Epistemological challenges frequently arise when students struggle to connect abstract concepts with their practical applications. In mathematics education, these challenges manifest as misconceptions about the systematic steps in research design and errors in applying research methods [6]. Many students focus solely on memorizing procedures without understanding the underlying rationale, leading to misunderstandings when conducting research. This highlights an urgent need to identify and address these barriers through a more adaptive and contextual learning approach.

One method to overcome these obstacles involves designing a Hypothetical Learning Trajectory (HLT) rooted in research-based learning while integrating local wisdom. HLT serves as a structured guide aimed at helping students gradually achieve learning objectives, considering the potential progression of their understanding and their responses to the material [7]. With this approach, the learning process is expected to become more focused and better suited to accommodate students' diverse needs in mastering research skills.

A Hypothetical Learning Trajectory (HLT) can be an effective approach for predicting students' learning pathways as they work toward educational goals [8]. HLT is an essential tool for educators, allowing them to foresee potential developments in students' understanding based on their initial comprehension levels, chosen learning activities, and structured interactions [9]. In this context, designing an HLT that incorporates elements of local cultural wisdom, such as *rewang*, aims to support students in more effectively developing their research and academic writing skills. This approach is grounded in identifying the Learning Obstacles students face and addressing these barriers through well-organized, targeted activities.

Rewang is a tradition of cooperation that embodies social values like solidarity, collaboration, mutual responsibility, and selfless assistance [10]. These values resonate strongly with research-based learning, where collaboration among students in research groups can foster a spirit of teamwork and help them understand the importance of active participation in problem-solving [11]. In a learning environment that incorporates *rewang*, students are guided through research by working collaboratively to design, execute, and analyze research data. This process not only enhances technical research skills but also cultivates a scientific mindset supported by the values of teamwork and social responsibility [11].

This study aims to design an HLT that aligns with students' needs in research methods courses while integrating collaborative values from the local wisdom of *rewang*. The goal is for the developed HLT to help students overcome the learning obstacles they encounter and improve their research and academic writing skills. An examination of Learning Obstacles, mapping of students' understanding development, and curriculum analysis were conducted to ensure that this HLT is both relevant and applicable for mathematics education students.

Method

The Design Research approach was chosen as the method for designing this HLT. Design Research allows for the early identification of learning obstacles faced by students, along with ongoing evaluation to refine and adjust the HLT to meet students' real needs throughout the learning process. The HLT for this research methods course is the result of a preliminary design

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phase, a key stage within Design Research. Through direct observation, these obstacles were identified and analyzed to gain a deeper understanding of the challenges students face in reaching the expected competencies. In this study, the HLT was structured based on identifying and analyzing learning obstacles, examining the collaborative model of *rewang* local wisdom in learning, analyzing students' cognitive stages, and reviewing curriculum and essential concepts in the research methods course. The stages of HLT in this study include:

1. Analyzing the thinking characteristics of mathematics education students at the university level by mapping students' cognitive stages during the research methods course.
2. Conducting a theoretical review of the potential of *rewang* as a collaborative model in learning.
3. Reviewing curriculum and research-based learning (RBL) models for the research methods course in mathematics education.
4. Identifying and analyzing learning obstacles faced by students in the research methods course through observations and in-depth interviews with students and lecturers.
5. Developing the HLT by integrating a research-based learning model grounded in *rewang* local wisdom.

Result and Discussion

A. Research Methods in the Mathematics Education Curriculum at Higher Education)

One essential and mandatory course at the university level is research methods. The purpose of this course is to equip students with a foundational understanding of concepts, procedures, instruments, and research applications relevant to mathematics education. Students are expected to master scientific skills, including comprehension of basic research concepts, proposal development, instrument design, data collection and analysis, and report writing. As such, research methods serve as a crucial foundation for students to conduct quality, data-driven independent research. The mathematics education curriculum also emphasizes research-based learning models, encouraging students to actively engage in contextual and applicable research projects. To meet this need, the structure of content and learning activities in research methods is systematically designed so that students not only grasp the theory but also gain hands-on experience in conducting research. Broadly, Table 1 outlines the syllabus for the research methods course in mathematics education.

Table 1. Research Methods Syllabus

Basic Competency	Lecture Materials	Lecture Activities	Achievement Indicators
1.1. Understanding the basic concepts of educational research	Definition of educational research	Discussion on definitions and core concepts of educational research	Students can explain the meaning and objectives of research
	Types of educational research	Identifying types of research (quantitative, qualitative)	Students can differentiate between various research types
1.2. Ability to develop a research proposal	Research proposal structure	Practice in writing a research proposal	Students can create a systematic research proposal
	Problem formulation, objectives, and research hypothesis	Group discussion on problem formulation and hypothesis	Students can accurately formulate problems and hypotheses
1.3. Ability to design research instruments	Research instruments (questionnaire, interview, observation)	Practice in designing research instruments	Students can create research instruments according to needs

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1.4. Ability to conduct data collection and analysis	Data collection techniques (observation, interview, documentation)	Data collection simulation	Students can collect data using appropriate methods
	Data analysis techniques (quantitative, qualitative)	Practice in data analysis (manual and software)	Students can analyze data with appropriate techniques
1.5. Ability to write a research report	Research report structure	Discussion and simulation in writing a research report	Students can systematically compose a research report

The learning activities outlined in the syllabus, such as discussions, group exercises, hands-on practice, and simulations, are designed to maximize student engagement in the learning process. Through discussions and simulations, students are encouraged to develop critical and collaborative thinking skills. Employing a research-based learning model offers the potential for students to actively engage in understanding the various stages of research. In the context of *rewang* local wisdom, for instance, these collaborative learning activities can be facilitated through group work that promotes a spirit of mutual cooperation, enabling students to work together in developing proposals, designing instruments, and analyzing research data as a team.

B. Learning Obstacles in Research Methods Courses

Learning obstacles, which hinder students' understanding of research concepts and practices, are often encountered during research methods courses in mathematics education. These obstacles need to be identified and addressed to ensure that students can develop deep and effective research skills. Learning obstacles in research methods education can be classified into several categories, including epistemological obstacles, conceptual difficulties, and research misconceptions.

Epistemological obstacles refer to difficulties arising from a lack of deep understanding about the nature of science and the research process as a means to seek truth. For instance, students may struggle to grasp the purpose of each research stage, leading them to simply memorize steps without comprehending the connections between them. Conceptual difficulties, on the other hand, focus on challenges in understanding the foundational principles of research methods, which can confuse in selecting the appropriate research method or data collection technique. These difficulties often result in students being unable to distinguish between quantitative and qualitative research or to appreciate the importance of validity and reliability in research instruments.

In addition, research misconceptions serve as a common barrier, where students have incorrect understandings of several fundamental aspects of research methods. For example, many students misinterpret a hypothesis as an outcome that must be achieved, rather than a prediction to be tested. Other misconceptions include the belief that data analysis is merely a numerical processing task without any interpretive aspect. Identifying these obstacles is a crucial step in designing learning experiences that help students overcome these challenges and enhance their understanding of research concepts. Table 2 below outlines the dominant students' learning obstacles in research methods education.

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Table 2. Learning Obstacle in Research Method

Category of Learning Obstacle	Description	Learning Obstacle
Epistemological Obstacles	Obstacles caused by a lack of deep understanding of the nature of science and the research process as a quest for truth	- Students struggle to understand the purpose of each research stage, leading them to memorize steps without understanding the connections between stages. - Students experience confusion in understanding the importance of formulating specific hypotheses or research questions as the basis for systematic research. - Students find it difficult to see research as a dynamic process that can evolve, often assuming results must be perfect and final without considering the possibility of revisions.
Conceptual Difficulties	Obstacles in understanding basic concepts or principles in research methods, leading to errors or ambiguity in thinking	- Students have difficulty distinguishing between quantitative and qualitative research methods, especially regarding differences in approach and purpose. - Students are confused about identifying the appropriate data collection technique, such as when to use questionnaires or interviews depending on research objectives. - Students have a limited understanding of the importance of instrument validity and reliability, often using inappropriate or less valid instruments.
Research Misconceptions	Misunderstandings or incorrect assumptions about specific aspects of research methods	- Students often misunderstand hypotheses as outcomes that must be achieved, rather than predictions to be tested in the research. - Students tend to view data analysis merely as the processing of quantitative or qualitative data, without recognizing that analysis is an interpretive process to answer research questions. - Students often assume that qualitative research does not require careful planning and relies solely on direct observation results.

C. Development of Integrated HLT Components in Research-Based Learning Using Local Wisdom of Rewang

Following the identification of Learning Obstacles and prospective analysis, the HLT was designed to guide students' learning processes in the research methods course. The designed HLT includes learning objectives, activities that support achieving those objectives, and mathematical hypotheses anticipated to emerge throughout the learning process. Table 3 below outlines the initial draft of the Hypothetical Learning Trajectory (HLT) for the Mathematics Education Research Methods course, based on the identified syllabus and learning objectives.

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Table 3. The HLT for the Mathematics Education Research Methods

Phase	Learning Activities	Conjectured Learning Process
RESEARCH PREPARATION	• Group discussion on the definition and basic concepts of research. • Practice identifying types of educational research. • Explaining the *rewang* social interaction model. • Forming *rewang* groups for research.	• Students understand the differences between quantitative and qualitative research. • Students begin identifying research types suitable for mathematics education research.
RESEARCH DESIGN	• Group discussion on problem formulation and research hypotheses. • Practice creating clear and focused problem statements. • Analyzing research articles/journals. • Planning research and selecting research methods. • Practicing research instrument design (questionnaire, interview, observation) within the context. • Validating research instruments for data collection.	• Students can formulate problems based on real situations in the field (local issues). • Students understand the relationship between research objectives and hypotheses, particularly in addressing local issues through the *rewang* model. • Students develop research instruments relevant to local issues. • Students recognize the importance of valid and reliable instruments for accurate data collection.
RESEARCH IMPLEMENTATION	• Simulation of data collection from real situations. • Practice data analysis using quantitative and qualitative techniques. • Collecting data through participatory methods reflecting the *rewang* model.	• Students successfully gather relevant data from their surroundings. • Students understand how to analyze data using suitable analytical tools.
RESEARCH PUBLICATION	• Group discussion on the structure of research reports. • Practice writing a systematic research report. • Reviewing scientific articles and preparing them for publication. • Preparing to disseminate research findings.	• Students successfully gather relevant data from their surroundings. • Students understand how to analyze data using suitable analytical tools.

This HLT is designed to guide the learning process outlined in the learning trajectory in Figure 4, enabling students to develop research skills through a research-based approach and *rewang*

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social interaction. Research-based learning incorporating *rewang* local wisdom aims to combine academic research skills with social values that promote collaboration and mutual support. Within the context of HLT, this learning design creates situations where students not only learn research methods theoretically but also apply them in ways relevant to their social environment. This approach enhances student engagement through active collaboration and problem-solving.

The *rewang* model, which involves close cooperation in completing community tasks, is adapted in this learning experience to facilitate collaborative research. Students work in groups to complete a planned research project. Integrating the *rewang* pattern in HLT aims to create a collaborative structure that allows students to assist one another at each stage of the research process. In this HLT, every phase of learning—from problem identification, proposal development, research instrument design, to data collection and analysis—is conducted with *rewang* social interaction. This approach means that students are responsible not only for individual tasks but also for the group's success in collectively completing the research project.

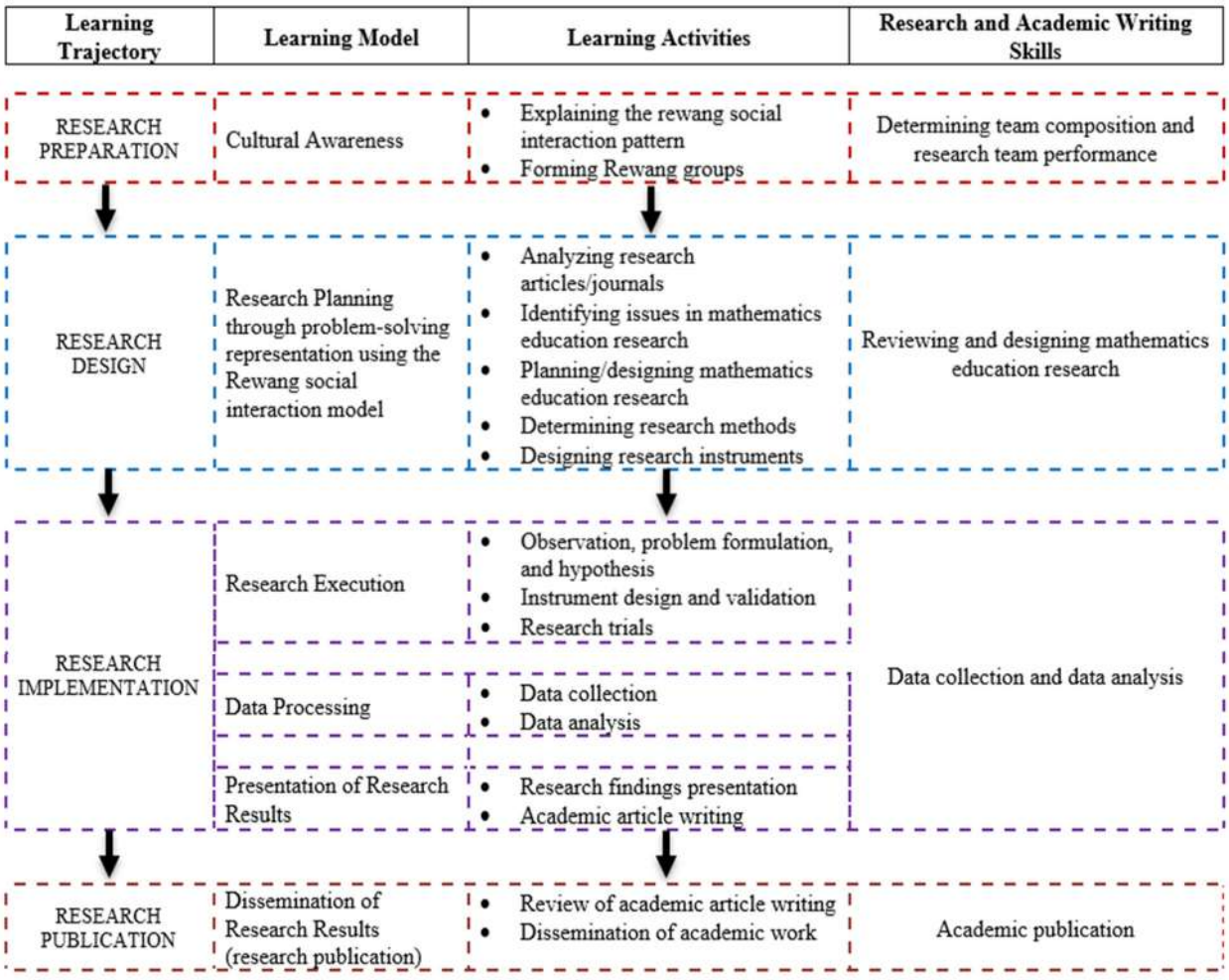

Figure 1. Diagram of Learning Trajectory for Research Methods Using a Research-Based Learning Model Incorporating *Rewang* Local Wisdom

Conclusion

The systematic design of an HLT described in this study illustrates how clear consideration of the implicit trajectory needed to address research-based learning needs of mathematics education

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students addresses their desires for systematic content. Indeed, this HLT design is rooted in theoretical analysis of university-level students' cognitive characteristics that form the basis for how university learners—prospective teachers and educational researchers or other users of research findings—interpret and apply knowledge from research. Moreover, the collaboration of *rewang* local wisdom as a model is a culturally relevant way to foster cooperation between students in a learning environment associated with their social context. The *rewang* interaction model in this framework is not only a collaboration method but also provides an enriched outlook on teamwork, which is fundamental to student research.

The review of the curriculum and the research methods syllabus also shows that HLT is designed to meet the competencies and learning outcomes expected in the mathematics education curriculum. Such alignment guarantees that students will learn relevant skills in the context of academic requirements, starting from proposal development to writing a scientific paper. Identifying students' learning obstacles in the first phase of HLT development is crucial to guiding designers when creating new learning activities that will readily suit their students' shortcomings, such as misconceptions about the concept of research, or problems with problem formulation and data analysis.

In addition, the HLT describes didactic situations that use *rewang* and also forecasts from students' responses among other didactic anticipations that could help the learning dynamics to be well managed. Together with all these components, the HLT represents an integrated and evolving learning trajectory providing space for progressively developing research and academic writing skills in context. In brief, beyond giving students a soundness of knowledge in research methods, this HLT design helps students develop their skills and attitude to work together and think critically — which are prerequisites for the academic and professional demands enjoined by the mathematics education community.

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Pre-service mathematics teachers's zone of promote action based on cognitive style and gender

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Abstract. Zone of Promote Action (ZPA) is a learning activity offered by teachers to students to develop their potential to the fullest. This research aims to describe the implementation of ZPA by pre-service mathematics teachers in terms of cognitive style and gender. This is a descriptive exploratory study using a qualitative approach. The data analysis techniques used in this study consist of data transcription, data examination, data reduction, data credibility, and drawing conclusions. The subjects of this study are pre-service mathematics teachers from the State University of Medan. The instruments used in this research are questionnaires and observation sheets. Based on the research results, it was concluded that: (1) The Zone of Promote Action (ZPA) implemented by pre-service mathematics teachers in each learning activity can be accepted by students with field-dependent and field-independent cognitive style characteristics, (2) Each pre-service mathematics teacher with different gender backgrounds has unique ZPA abilities in terms of time management, guiding discussions, and focusing students on the material.

Keywords: Zone of Promote Action, Mathematics learning, Cognitive Style, Gender

Introduction

Mathematics is frequently one of the most difficult subjects to teach in schools. One of the most difficult tasks is determining how teachers can help their students learn optimally. Teachers that are not only knowledgeable about the content, but also have great teaching skills. A mathematics teacher must be both mathematically proficient and pedagogically competent [1]. Furthermore, a teacher with good knowledge and the right teaching style will assist students in having a better understanding of the material presented; this ability is important for a teacher, particularly for beginner mathematics teachers, who will provide an understanding of abstract material so that students can easily absorb it [2]. In the process of teaching mathematics, a teacher's ability to promote student learning actions is very important in achieving optimal learning

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outcomes.

Zone Of Promote Action (ZPA) is one of the important concepts that highlights areas where teachers can promote students' learning processes. ZPA is essentially an extension of Vygotsky's Zone of Proximal Development (ZPD) theory. Furthermore, Valsiner enhanced the theory by creating ZPA for the interaction between teachers and students, where ZPA symbolises the efforts of teachers or other parties to promote certain skills or approaches. ZPA is a set of activities, objects, or areas in the environment, in which a person's actions are offered [3]. ZPA includes activities, objects, or areas in the environment related to the actions of the individual being promoted [4]. ZPA as a series of activities offered by adults and oriented towards promoting new skills [5]. The learning process carried out by teachers involves several stages, but not all of these stages are included in ZPA. The learning stages included in ZPA are teacher actions that encourage students to act or act so that they can develop new skills.

Valsiner describes ZPA as something that is limitless. This means that students do not have to accept or reject their teacher's actions. The various conditions of students in the classroom require special attention from teachers in determining certain stages of activities in the learning process. These stages or actions must not exceed the students' abilities, so that they can engage in the learning process. ZPA describes actions that teachers promote to students without any obligation for them to accept or reject the action. Thus, students are free to respond to the actions promoted. When ZPA is accepted by students, it becomes an accepted ZPA, meanwhile, when ZPA is rejected by students, it becomes a rejected ZPA [6]. The results of Jauhara's study showed that accepted promote action appears if students are able to understand and master the concepts given and some of the teacher's promote actions are rejected, this is because students are unable to follow the actions offered by the teacher, students are just silent, without doing what the teacher instructs and pseudo promote action appears when students do something not for the students' own understanding, students only imitate and appear to follow the learning but actually do not understand [7]. Thus, it is hoped that teachers would be able to understand when their activities are accepted or rejected by students allowing them to plan the best option for achieving learning goals. The teacher's ability to determine the stages or actions in ZPA can be influenced by various factors, including cognitive style and gender.

ZPA provides space and opportunity for students to be actively involved in learning mathematics, while each student's cognitive style influences the way they interact with the content. Cognitive style refers to how a person knows, remembers problems, seeks and obtains solutions [8]. Cognitive style refers to the balance and continuity of personality that influences attitudes, values and social interactions [9]. Cognitive style is a person's preference in using cognitive abilities to think, learn and solve problems [10]. An individual's cognitive style might indicate variances in attention, information reception, memory, and thinking styles that emerge or vary between cognitive abilities and personality [11]. It is concluded that cognitive style describes students' tendencies in processing and organizing information with different patterns according to the student's personal preferences.

Cognitive style is one of the characteristics of students that may affect how they respond to information delivered by teachers, be it teaching materials, learning activities and solving problems. Cognitive style has a significant potential to improve the effectiveness of the learning process if used optimally. Witkin divides cognitive style into two categories: Field Dependent (FD) and Field Independent (FI) characteristics [12]. The Field Dependent type is characterized by a tendency to capture information as less good at expanding structures and tendencies towards social aspects, whereas the Field Independent type is characterized by a tendency to analyze and

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synthesize information received and is able to develop structures [13]. In addition, the field independent category tends to be independent and unaffected by environmental and social conditions, whereas the field dependent category is the opposite, being more dependent on the environment and society [14]. The use of ZPA to Field Dependent and Field Independent cognitive styles can be adjusted to the differences in cognitive characteristics of the two styles. The use of ZPA that considers cognitive style will support the creation of a more personal and flexible learning environment, according to the needs of each student.

Furthermore, gender characteristics have a significant impact on mathematics learning. Good interpersonal ties between teachers and students, as well as students with students, are essential for efficient classroom management and an effective teaching and learning process [15]. Several factors influence the relationships that form, one of which is the gender of the teacher. Gender is defined as attitudes, feelings, and actions that are formed by culture and are associated with biological sex [16]. Gender differences originate from gender-based labor divisions and socio-structural practices that perpetuate status and power disparities [17]. Teacher gender has significant effects on mathematics learning, both directly through teacher-student interactions, and indirectly through social and cultural roles related to gender.

Male and female teachers have different characteristics, with male teachers being more assertive in giving lessons to students and female teachers using gentler words and a pleasant approach [18]. Female teachers generally perform better than male teachers in terms of classroom management [19]. Female students frequently show greater motivation and performance when taught by female teachers who are thought to be more able to understand and respond to their needs, whereas male students may be motivated by the more competitive approach often associated with male teachers [20]. Female teachers may have a more positive perspective of female students' mathematical abilities than male teachers, who may be more likely to build confidence in male students, which can have a direct impact on how students interact with the subject and perceive their own mathematical ability [21]. The results of these studies indicate that teachers gender effects not only teaching style, but also students' attitudes toward mathematics and the skills they develop in this field.

Overall, the purpose of this study is to explore how differences in students' cognitive styles and gender influence prospective mathematics teachers' ability to apply the Zone of Promote Action (ZPA) in learning. Understanding the combination of these aspects has the potential to make a significant contribution to the development of more inclusive and effective mathematics learning improvements.

Research Methods

This research is an exploratory descriptive research using a qualitative approach. The subjects of this study were 82 pre-service mathematics teacher students from the State University of Medan who were doing PPL at school. The students consisted of 37 males and 45 females. The study's instruments were questionnaires and observation sheets. Data was collected employing questionnaires and observation sheets relating to the ZPA of pre-service mathematics teacher. The surveys supplied included 20 statement questions based on ZPA indicators, such as methods/models/strategies, media/instruments, and themes provided [22]. The ZPA questionnaire was distributed via Google Form to 82 pre-service mathematics teacher. Furthermore, the observation sheet was used to assess the teacher's ZPA competence to provide mathematics learning resources to students. The observation sheet contains three sections: starting activities, core activities, and closing activities. ZPA observations were conducted on pre-service

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mathematics teacher who completed PPL at SMAN 3 Medan. The technical data analysis carried out in this study included data transcription, data reduction, data examination, data credibility, and generating conclusions.

Results And Discussion

The data analysis shows a significant connection between students' cognitive styles and the gender of pre-service mathematics teacher in implementing the Zone of Promote Action (ZPA) in mathematics learning.

Zone Of Promote Action (ZPA) Based On Cognitive Style

The following is the ZPA data for pre-service mathematics teacher in terms of their field dependent and field independent cognitive styles, based on the results of the questionnaire distributed to pre-service mathematics teacher.

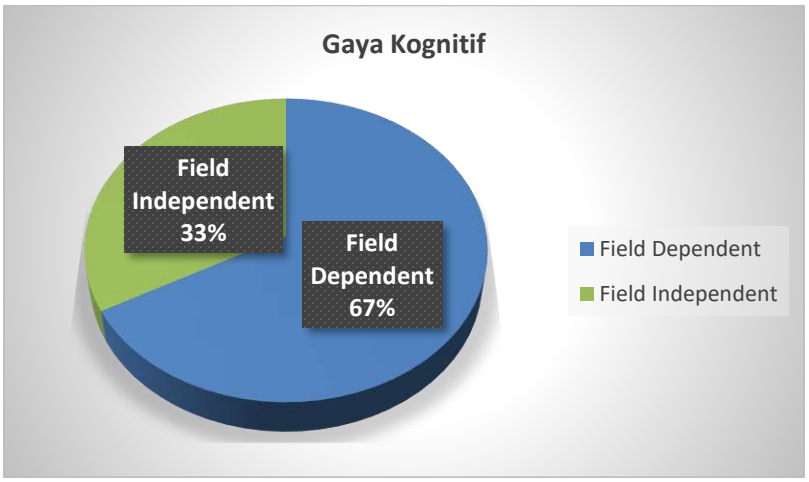

Figure 1. Student Cognitive Style Data Analysis

Figure 1 shows that ZPA activities conducted by pre-service mathematics teacher in mathematics learning are more prevalent in classes with field dependent cognitive style characteristics. Of the 82 classes, 55 are field dependent and 27 are field independent. These results show that pre-service teacher' mathematics content (subject) and pedagogy (teaching methods) are more acceptable to students with field dependant characteristics. The following section shows the results from observations of pre-service mathematics teacher ZPA abilities in terms of student cognitive styles.

Zone Of Promote Action (ZPA) Field Dependent Characteristics

Based on the results of observations conducted through ZPA activities given by pre-service mathematics teacher in mathematics learning on the content of complement probability and expected frequency, students with field dependent cognitive style characteristics perform better in mathematics learning when given instructions or directions in understanding the concept of the content and solving mathematical problems. Students with field dependent characteristics might receive apperception and stimulus from the teacher globally, depending on the situation or environment in which students require more assistance or guidance in understanding the topic and completing mathematical problems.

In the first activity, pre-service mathematics teacher's ZPA to communicate their learning objectives. The teacher uses an initiating question to encourage students to provide a description

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of their current learning objectives. Their responses to the question varied. Some discuss with their friends, some search on the internet via cellphones and some remain silent. Initially, no one responded to the question, but after the teacher assisted by connecting the concept and examples to real-life scenarios, several students raised their hands to try to answer it. The teacher then invited two students to share their ideas.

In the main activity, pre-service mathematics teacher's ZPA is to explain the course of study topic through lecturing. Some students seem to be listening intently, while others appear to be daydreaming or yawning. Furthermore, the pre-service teacher's ZPA encourages discussion groups about the contextual problems provided in the LKPD. Field dependent students are more influenced by the social environment and are more responsive to social interaction. They feel better working in groups and prefer collaborative learning implemented by pre-service mathematics teacher.

The LKPD created by pre-service mathematics teacher missing instructions and methods for problem-solving. When trying to solve these problems, students are directed by the teacher to discuss it with their group members and may ask the teacher about concerns or difficulties they are experiencing. Each group's discussion style differs. There are students who discuss loudly, students who walk around to approach other groups, some students use cellphones to search the internet, some students always ask the teacher about formulas that they don't understand, and some groups divide their groups into two parts to solve problems, then return to discuss together so that they both understand and agree. During this activity, the pre-service mathematics teacher adjusts about and assesses the situation in the group discussion.

Next, the pre-service mathematics teacher directs students in groups to communicate the solution to the problem in front of the class. The situation is that some students correct formula errors while others correct calculation errors. Students argue each other regarding the answer to the problem, specifically the usage of the formula that yielded the calculated findings. When this scenario arises, the pre-service teacher requested time to investigate the problem and read the references, which ultimately provided the correct solution.

In the concluding activity, the pre-service mathematics teacher guide students to reach conclusions about the information they learned while working on problems in the LKPD, as well as the concept of the course content they examined. Several students are given the opportunity to communicate their conclusions in their own language, and the teacher corrects if there are conclusions that are not quite right. The learning ends with the teacher assigning homework to students.

Zone Of Promote Action (ZPA) Field Independent Characteristics

Based on the results of observations conducted on ZPA activities given by the pre-service mathematics teacher in mathematics learning on the topics of complement probability and expected frequency, students with a field independent cognitive style understand mathematical concepts abstractly faster and can solve problems with minimal assistance. Students are comfortable learning individually and like analytical challenges.

In the first activity, the pre-service mathematics teacher directly conveyed the learning objectives without any prompting questions. Students listened closely to the explanation, and some questioned about the relationship between today's learning objectives and the content that was discussed at the previous class. The pre-service teacher responded to the question by allowing other students to answer it. Several students raised their hands to share their thoughts, which concluded in a conclusion from the pre-service teacher. Furthermore, to assist students understand

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the concept of the teaching content, the pre-service teacher assigned challenges as a stimulus. The problems given by the pre-service teacher were contextual problems. These problems were presented in the LKPD made by the pre-service teacher themselves for students to study individually. The LKPD included contextual problems related to the content to be studied, together with information, directions, and processes for solving the problems.

The main activity of the ZPA implemented by pre-service teacher is for students to solve problems individually in the distributed LKPD. Students actively discuss difficulties through books and the internet via cellphones; others even have discussions with their deskmates and ask pre-service teacher for instructions or steps to overcome problems that they do not understand. The learning environment is typically properly organized and pleasant. The first three students with three different ways of solving are asked by pre-service teacher to convey and write them on the board. This is followed by other students who provide similar or different answers. Each student actively participates in communicating the answers they have obtained. The pre-service teacher gives appreciation in the form of praise and gratitude for the participation of all students.

Next, the teacher assigns contextual problems to deepen the understanding and application of the material concepts that have been studied individually. Students seem very focused on their tasks. They focus their full attention on the problem being solved without being easily distracted by things around them such as the voices of other students asking questions to fellow friends or teachers, even the movements made by other friends when borrowing writing equipment. The pre-service teacher allows students space to accomplish their duties. When the task is finished, the prospective teacher allows two students to explain and write on the board the results of their assignments. The students' alternate solutions are then corrected together.

In the last activity, pre-service teacher gives rewards in the form of praise to students who solve the problems presented well and correctly, as well as motivational encouragement to all students who tried their hardest to actively participate in learning. The pre-service teacher also provide homework and explain the content to be discussed at the next meeting.

Overall, it is reasonable to conclude that the cognitive style of pre-service teacher in creating the material (subject) and pedagogical (teaching strategies) of mathematics has a significant effect on the characteristics of students' cognitive styles. The pre-service mathematics teachers' ZPA have significant effects on each student's cognitive style, regardless of whether they are field dependent or independent.

Zone Of Promote Action (ZPA) Based On Gender's Pre-Service Mathematics teacher

The following are the results of respondents' answers regarding ZPA capabilities, which are divided into two respondent characteristics based on gender: male and female.

Table 1. Results of Pre-Service Teachers' ZPA Ability Data Based on Gender

NO	QUESTION ITEM	MALE (percentage agree)	FEMALE (percentage agre)
1	Providing stimulus	38.46	63.77
2	Asking questions	30.77	47.83
3	Checking student readiness	69.23	69.57
4	Delivering learning objectives	84.62	57.97
5	Use of media by students	15.38	21.74
6	Utilization of media by teachers	7.69	30.43

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7	Material correlation	38.46	30.43
8	Focusing on concepts	53.85	50.72
9	Encouraging students to answer	38.46	49.28
10	Building concepts	23.08	37.68
11	Understanding concepts	61.54	66.67
12	Applying concepts	30.77	26.09
13	Proposing opinions	46.15	34.78
14	Guiding discussions	61.54	42.03
15	Correcting answers	23.08	26.09
16	Giving rewards	23.08	20.29
17	Reinforcement to passive students	38.46	33.33
18	Confirming achievement of goals	30.77	28.99
19	Guiding drawing conclusions	69.23	43.48
20	Giving conclusions	61.54	47.83

Based on Table 1, male pre-service mathematics teachers' ZPA ability excels in 11 indicators, including conveying learning objectives, correlating materials, focusing on concepts, applying concepts, submitting opinions, guiding discussions, giving rewards, strengthening passive students, confirming the achievement of learning objectives, guiding drawing conclusions, and providing conclusions. The ZPA ability of female pre-service mathematics teachers excels in 9 indicators, including providing stimulus, asking questions, checking student readiness, use of media by students, use of media by teachers, encouraging students to answer, building concepts, understanding concepts, and correcting answers.

In the first activities, female pre-service teachers tend to be more proficient in the initial stages of learning where this stage is to build student motivation to start the learning process. In the final activities, male pre-service teachers excel in each assessment indicator. Based on these results, male pre-service teachers focus more on the stage of concluding the final process of the learning that is carried out. The highest gap is in the indicator of media utilization by teachers, where only 7.69% of male pre-service teachers agree with this, while 30.43% of female pre-service teachers agree.

Furthermore, based on the results of observations, it shows that the ZPA of male and female pre-service teachers has its own characteristics. With heterogeneous class conditions (male and female students are in the same class), the interaction of male and female teachers also adjusts to class activities. The results of observations show that each pre-service teacher has reinforcement at different stages even though the learning process leads to the same goal. Each pre-service teacher has a unique ZPA ability that is adjusted to class conditions during the learning process. The pre-service mathematics teachers carry out learning according to the stages in the learning process, but have different ways of delivering content.

Conclusion

Based on the results of data analysis and discussion in this study, it is concluded that in terms of cognitive style, the Zone Of Promote Action (ZPA) that has been applied by pre-service mathematics teacher in each learning activity is accepted by students with field dependent and field independent cognitive style characteristics. In terms of gender, the Zone Of Promote Action

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(ZPA) that has been applied by male and female pre-service mathematics teacher has its own advantages and disadvantages in each learning activity with its own characteristics when viewed from the ability of time management, guiding discussions, and focusing students on the content.

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The development of a triarchic intelligence-based realistic mathematics learning model: an innovation in differentiated mathematics learning

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Abstract. *The Merdeka Belajar Curriculum in Indonesia positions students as active participants in the learning process, granting them the freedom to enhance their potential, intelligence, and interests. Differentiated learning addresses the diverse educational needs of students, allowing each individual to develop according to their unique capabilities. One significant aspect of students' learning needs relevant to 21st-century mathematics education is triarchic intelligence. To better support students in constructing abstract mathematical concepts and principles within the Real Analysis course, the Realistic Mathematics Education approach requires development and modification. This research aims to develop a Triarchic Intelligence-Based Realistic Mathematics Learning Model that is valid, practical, and effective for the Real Analysis course. Employing the Plomp development model and considering the product quality criteria proposed by Nieveen, the researchers conducted this study within the mathematics education program, focusing on sixth-semester students of the 2023-2024 academic year as subjects. The following instruments were utilized in the study: (1) validation sheets; (2) expert and practitioner assessment sheets evaluating the practicality and effectiveness of the learning model; (3) observation sheets; (4) student response questionnaires concerning the learning components and activities; (5) mathematical proof ability tests; and (6) questionnaires assessing the learning effects of the model. The researchers systematically validated, revised, and tested the initial draft of the learning model. They conducted a comprehensive analysis of expert assessment data and classroom data to evaluate the model's validity, practicality, and effectiveness, ultimately leading to the production of a final prototype that meets the established criteria for validity, practicality, and effectiveness.*

Keywords: development research, learning model, differentiated learning, realistic mathematics education, triarchic intelligence, real analysis

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Introduction

The implementation of the *Merdeka Belajar* Curriculum in higher education is a form of transformative learning aimed at producing graduates who are excellent, creative, innovative, and able to contribute positively to the advancement of national civilization. The rapidly evolving times require universities to prepare students to become a generation that is faithful, cultured, responsive, and ready to face contemporary challenges [1]. The *Merdeka Belajar* curriculum positions students as active subjects in the learning process, with the freedom to develop their potential, intelligence, and interests [2]. Differentiated learning is one approach that can support the curriculum's goals by meeting the diverse learning needs of students, allowing each to develop according to their potential [3].

One relevant aspect of students' potential or learning needs in 21st-century mathematics education is triarchic intelligence. Sternberg proposed a theory of multiple intelligences (later termed triarchic intelligence), which includes analytical intelligence, creative intelligence, and practical intelligence that align with mathematical thinking [4,5]. These intelligences encompass several abilities: analytical intelligence includes skills for analyzing, evaluating, critiquing, comparing, and contrasting information. Creative intelligence involves creating, exploring, rediscovering, innovating, imagining, and predicting. Practical intelligence includes the ability to apply, use, implement, and practice knowledge [6,7].

Triarchic intelligence aligns with international standards for mathematical competencies. According to the Programme for International Student Assessment (PISA), students should develop mathematical skills such as formulating situations mathematically; using facts, concepts, procedures, and reasoning; and interpreting, applying, and evaluating results [8]. The Trends in International Mathematics and Science Study (TIMSS) outlines three cognitive domains in mathematics: knowing (knowledge of facts, concepts, and procedures); applying (the ability to use knowledge and conceptual understanding to solve problems); and reasoning (solving complex or unfamiliar problems) [9]. The National Council of Teachers of Mathematics (NCTM) establishes five standards in mathematics education: problem-solving, reasoning, communication, representation, and connections [10]. Surveys by PISA, TIMSS, and NCTM indicate that Indonesian students' mathematics performance is still below expectations, as shown by Indonesia's low ranking [11,12,13].

The correlation between triarchic intelligence and the mathematical abilities expected globally (PISA, TIMSS, and NCTM) underscores the importance of incorporating triarchic intelligence in Indonesian mathematics education. Research by Simanullang shows that students with varying levels of triarchic intelligence scores (high, medium, low) often share similar dominant aspects of triarchic intelligence [14]. Cooperative learning typically organizes students by ability level (high, medium, low), which may be insufficient, as students of different abilities may have similar dominant aspects of triarchic intelligence. Therefore, grouping in this study considers students' triarchic intelligence as well as gender, race, and ethnicity.

To address these issues, Sternberg argues that social construction, practice, emotional intelligence, and multiple intelligences can expand human capability, yet the structure in which people choose to act and develop relies on how they optimize their abilities [15,16]. Therefore, social construction, practice, emotional intelligence, and multiple intelligences are necessary for mathematics education so that students can optimize their cognitive, affective, and psychomotor abilities and make informed decisions about what they choose to pursue.

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The philosophy of mathematical knowledge should be based on constructivist philosophy (both social and radical constructivism), which includes: (1) linguistic knowledge, rules, and norms, as language is a social construct; (2) the social interaction between individuals (students) needed to transform subjective mathematical knowledge into objective, socially understood mathematical knowledge [17,18,19].

The practice of teaching Real Analysis in Indonesia still lacks the application of social constructivist-based teaching models. Lecturers present prepackaged material, give exercises, and assign homework. Specifically, at the State University of Medan, the textbooks used directly present abstract mathematical concepts without construction. Some theorems and properties are presented with proofs. Although small-group discussions are applied in the classroom, they have not had a significant positive impact on students' mastery of mathematical concepts.

These issues call for realistic mathematics education (RME) as a solution. Students taught through RME have better conceptual understanding than those taught through traditional approaches [20]. RME exposes students to contextual problems, allowing them to engage in mathematical modeling activities [21]. RME can serve as an alternative to improve students' critical thinking, build democratic educational systems, and foster character education [22,23].

The RME approach needs to be developed or modified to facilitate students' construction of abstract mathematical concepts in Real Analysis courses. Incorporating aspects of triarchic intelligence is essential to address the challenges encountered [4,24]. Lecturers should guide students to balance their triarchic intelligence through interactions with peers, the learning environment, and lecturers. Triarchic intelligence serves as a consideration in developing the RME approach, including the design of the developed learning model components: (1) syntax; (2) social systems; (3) reaction and management principles; (4) support systems; and (5) instructional and nurturant effects [25,26,27,28,29]. This approach results in a Triarchic Intelligence-Based Realistic Mathematics Learning Model that improves upon RME. The development of this learning model is rooted in RME philosophy, principles, and characteristics, with consideration of students' triarchic intelligence.

Methodology

This research is a development study using a development model that follows the stages of development as a result of modifications to the development model proposed by Plomp [30]. The stages consist of the preliminary investigation phase, design phase, realization/construction phase, test, evaluation and revision phase, and implementation phase. The quality criteria for the products in this study refer to three criteria proposed by Nieveen, which are validity, practicality, and effectiveness [31]. The researcher will develop the Triarchic Intelligence-Based Realistic Mathematics Learning Model in the Real Analysis course for the Mathematics Education program at UNIMED.

This research will be conducted in the Department of Mathematics, Mathematics Education program, in the even semester of the 2023/2024 academic year, specifically with the sixth-semester students of the Mathematics Education program, who are taking the Real Analysis course.

The variables in this study are the validity, practicality, and effectiveness of the Triarchic Intelligence-Based Realistic Mathematics Learning Model. The instruments, assessment criteria, and target achievements in this study are presented in Table 1.

Table 1. Variables, Instruments, Assessment Criteria, and Research Targets

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Variable	Instrument	Assessment Criteria	Target
Validity of the Learning Model	a. Learning Model Validation Sheet (Content and Construction Validation) b. Lesson Plan (LP) Validation Sheet c. Real Analysis Book (RAB) Validation Sheet d. Student Worksheet (SW) Validation Sheet e. Proof Ability Test (PAT) Validation Sheet	$1 \leq V < 2$ (not valid) $2 \leq V < 3$ (less valid) $3 \leq V < 4$ (quite valid) $4 \leq V < 5$ (valid) $V = 5$ (very valid)	$V \geq$ Valid
Practicality of the Learning Model	a. Learning Implementation Assessment Sheet (IP)	$1 \leq IP < 2$ (very low) $2 \leq IP < 3$ (low) $3 \leq IP < 4$ (medium) $4 \leq IP < 5$ (high) $IP = 5$ (very high)	$IP \geq$ High
	a. Learning Implementation Observation Sheet (IO)	$1 \leq IO < 2$ (very low) $2 \leq IO < 3$ (low) $3 \leq IO < 4$ (medium) $4 \leq IO < 5$ (high) $IO = 5$ (very high)	$IO \geq$ High
Effectiveness of the Learning Model	a. Learning Effectiveness Assessment Sheet (IE)	$1 \leq IE < 2$ (very low) $2 \leq IE < 3$ (low) $3 \leq IE < 4$ (medium) $4 \leq IE < 5$ (high) $IE = 5$ (very high)	$IE \geq$ High
	b. Learning Management Observation Sheet (IA_1)	$1 \leq IA_1 < 2$ (not good) $2 \leq IA_1 < 3$ (fairly good) $3 \leq IA_1 < 4$ (good enough) $4 \leq IA_1 < 5$ (good) $IA_1 = 5$ (very good)	$IA_1 \geq$ Good
	c. Learning Time Allocation Observation Sheet (IA_2)	$1 \leq IA_2 < 2$ (very low) $2 \leq IA_2 < 3$ (low) $3 \leq IA_2 < 4$ (moderate) $4 \leq IA_2 < 5$ (high) $IA_2 = 5$ (very high)	$IA_2 \geq$ High
	d. Student Proof Ability Test (IA_3)	$0 \leq IA_3 < 40$ (very low) $40 \leq IA_3 < 60$ (low) $60 \leq IA_3 < 75$ (medium) $75 \leq IA_3 < 90$ (high) $90 \leq IA_3 \leq 100$ (very high)	At least 80% of students must achieve a minimum score of IA_3 at the medium level.
	e. Questionnaire of Students' Respond (IA_4)	Positive or negative response	At least 80% of students respond positively

Adopted from Simanullang [14]

Note:
IP : Intended↔Perceived
IE : Intended↔Experiential
IO : Intended↔Operational
IA : Intended↔Attained
V : Total Average of Validity Score

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The validation → revision → classroom trial cycle is carried out until the Triarchic Intelligence-Based Realistic Mathematics Learning Model for the Real Analysis course is obtained, which is valid, practical, and effective. The stages and flow of the learning model development activities in this study are presented in the flowchart in Figure 1.

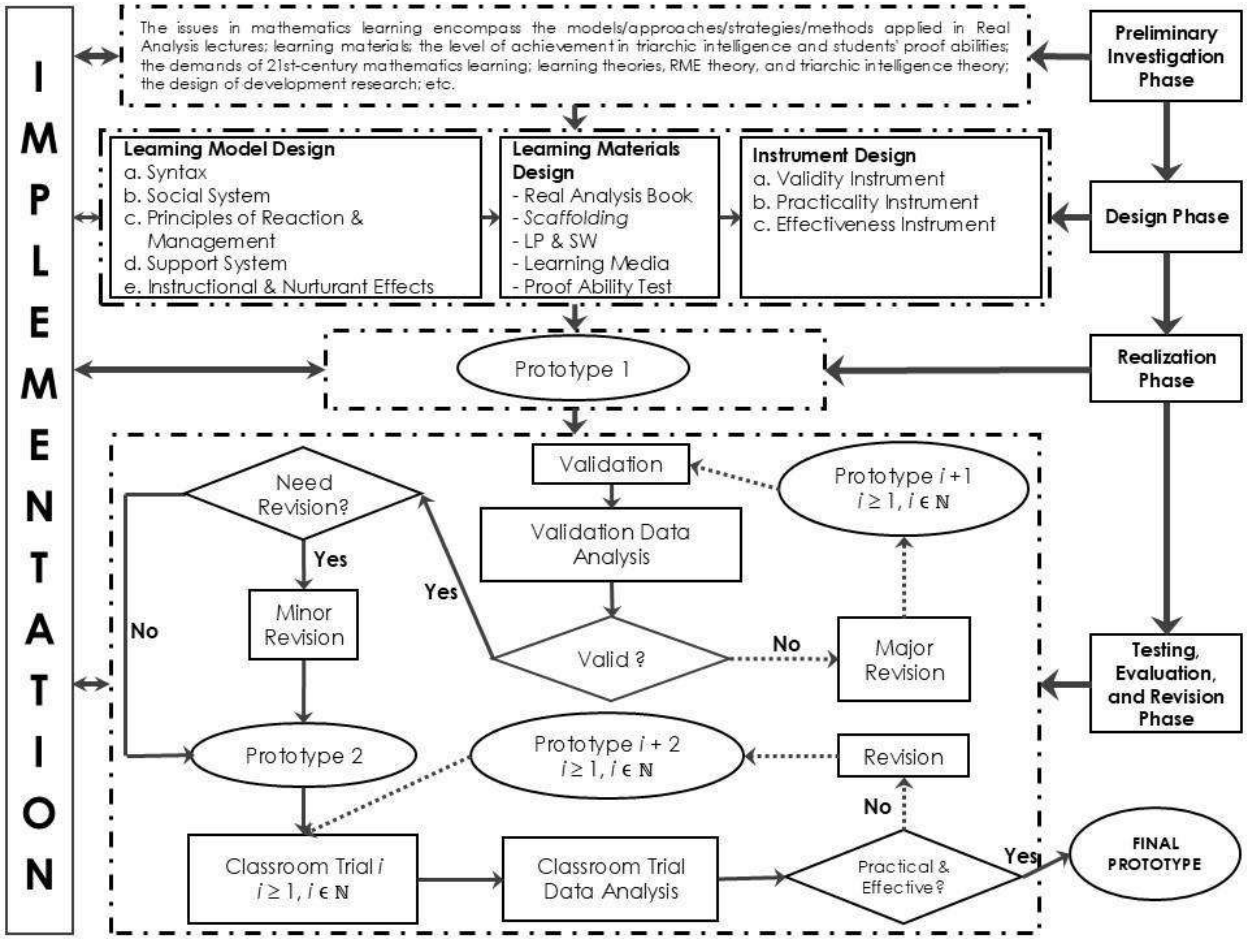

Figure 1. Stages and Flow of Activities in the Development of the Learning Model

Results

The product of this development research is a Triarchic Intelligence-Based Realistic Mathematics Learning Model that is valid, practical, and effective. The development process to obtain the valid, practical, and effective learning model involves the preparation of the model book, learning materials (lesson plans, Real Analysis book, student worksheets, and learning media), and related assessment instruments. Data analysis and the results obtained from each stage of development are presented as follows.

Evaluation of Experts and Practitioners

Content and Construct Validity of Learning Model

The activity carried out was to ask experts and practitioners to assess the theoretical foundation (content validation) and the internal consistency of the components (construct validation) of the

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learning model. Based on the validation results from the experts and practitioners, data was obtained and is presented in Table 2.

Table 2. The Average of Content Validity (Cnt.V) and Construct Validity (Cst.V) of the Learning Model

No.	Assessed Aspects	Cnt.V	Cst.V
1.	Learning Model Component	-	4.64
2.	Supporting Theory	4.71	4.80
3.	Sintax	4.60	4.76
4.	Social System	4.63	4.60
5.	Reaction and Management Principle	4.76	4.76
6.	Supporting System	4.80	4.64
7.	Instructional and Nurturant Effects	4.60	4.67
8.	Learning Implementation	4.69	4.50
9.	Learning Environment and Management Tasks	4.67	4.56
10.	Evaluation	4.47	4.80
	Total Average	4.66	4.66

The total average of content validity and construct validity of RME learning model is 4.66 for each which is further referred to the criteria of level RME learning model determination and its learning aids, and it is deduced that content and construct validity of RME model is valid.

Validity of Learning Materials

The activity conducted was to ask experts and practitioners to assess the validity of the developed learning materials based on the established assessment criteria. Based on the validation results from the experts and practitioners, data was obtained and is presented in Table 3.

Table 3. Average Total Validity of Learning Materials

No.	Assessed Aspects	LP	RAB	SW
1.	Format	4.60	4.83	4.57
2.	Content	4.73	4.60	4.51
3.	Language	4.70	4.55	4.43
4.	Illustrations	-	4.60	-
	Total Average	4.68	4.65	4.50

The average total validity score of the learning materials is then referred to the criteria for determining the validity level of the learning model and learning materials, and it is concluded that the validity of the learning materials falls under the valid category.

Validity of the Proof Ability Test

The activity conducted was to ask experts and practitioners to assess the validity of the developed proof ability test (PAT) based on the established assessment criteria. Based on the validation results from the experts and practitioners, the data obtained is presented in Table 4.

Table 4. Validity of the Proof Ability Test

No.	Assessed Aspects	PAT	
		PAT I	PAT II
1.	Content Validity	Valid	Valid

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2.	Language and Writing	At Least Understandable	At Least Understandable	

A pre-classroom trial activity was also conducted with 49 students who were not part of the trial subjects to measure the statistical validity of the proof ability test. Based on the data analysis, it was concluded that: (1) all problems were valid; and (2) PAT I and PAT II each had a high degree of reliability (0.721 and 0.709, respectively).

Assessment of the Implementation of the Learning Model

The activity conducted was to ask experts and practitioners to measure the implementation of the learning model in the practice of mathematics learning in the classroom using the provided learning materials, based on their perceptions and experiences. The results of the assessment of the implementation of the learning model can be seen in Table 5.

Table 5. Average Indicator Scores for Each Aspect of the Learning Model Implementation Assessment

No.	Aspects Assessed	Average Indicator Scores for Each Assessment Aspect (Validator)					Aspect Score
		A	B	C	D	E	
1.	Syntax	4.87	4.87	4.87	4.93	4.93	4.89
2.	Social System	4.71	4.71	4.57	4.71	4.71	4.69
3.	Principles of Reaction and Management	4.83	5.00	4.83	4.67	4.83	4.83
IP Score or Average Total Aspect Score							4.80

Note: IP is Intended ↔ Perceived

The IP score of 4.80 is then referred to the criteria for determining the level of implementation of the learning model that has been established, and it is concluded that the implementation of the learning model, based on the assessments of experts and practitioners, is categorized as high.

Assessment of the Effectiveness of the Learning Model

The activity conducted was to ask experts and practitioners to measure the effectiveness of the learning model in the practice of mathematics learning in the classroom using the provided learning materials, based on their perceptions and experiences. The results of the assessment of the effectiveness of the learning model can be seen in Table 6.

Table 6. Average Indicator Scores for Each Aspect of the Effectiveness of the Learning Model

No.	Aspects Assessed	Average Indicator Scores for Each Assessment Aspect (Validator)					Aspect Score
		A	B	C	D	E	
1.	Student Learning Outcomes	4.75	4.75	4.75	5.00	5.00	4.85
2.	Learning Time Allocation	5.00	5.00	4.50	5.00	5.00	4.90
3.	Lecturer's Capability to Manage Learning	4.86	4.86	4.86	5.00	5.00	4.91
4.	Student Responses	4.80	4.60	4.80	5.00	5.00	4.84
IE Score or Average Total Aspect Score							4.88

Note: IE is Intended ↔ Experiential

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The IE score of 4.88 is then referred to the criteria for determining the level of effectiveness of the learning model that has been established, and it is concluded that the effectiveness of the learning model, based on the assessments of experts and practitioners, is categorized as high.

Classroom Trial

The classroom trial of the learning model was conducted in two trial classes, with 46 students in classroom trial I and 46 students in classroom trial II. The data analysis results after the classroom trial were as follows.

Data Analysis Results of the Implementation of the Learning Model

The average indicator scores for the implementation of the learning model using learning materials for each observation aspect across 5 meetings are presented in Table 7.

Table 7. Average Indicator Scores for Each Observation Aspect of the Implementation of the Learning Model

No.	Aspects Observed	Average Indicator Scores for Each Observation Aspect									
		Classroom Trial I Meeting					Classroom Trial I Meeting				
		I	II	III	IV	V	I	II	III	IV	V
1.	Syntax	3.36	3.55	3.64	3.45	3.73	4.64	4.55	4.64	4.45	4.64
2.	Social System	3.14	3.00	3.57	3.43	3.57	4.43	4.71	4.57	4.86	4.86
3.	Principles of Reaction and Management	4.00	3.67	4.00	4.00	4.00	4.33	4.50	4.83	5.00	4.83
	IO Score			3.61					4.66		

Note: IO is Intended ↔ Operational

The IO score in the first trial was 3.61. Referring to the criteria for determining the level of implementation of the learning model, this score falls within the medium category, so it was necessary to proceed to the second trial. The IO score in the second trial was 4.66. Based on the established criteria for determining the level of implementation of the learning model, it was concluded that the implementation of the learning model in the second trial, using the developed learning materials, had reached a high level.

Data Analysis Results of the Effectiveness of the Learning Model

Data on Students' Mathematical Proof Ability

The number of students at each level of proof ability mastery in the first and second trials is presented in Table 8 below.

Table 8. Number of Students at Each Level of Proof Ability Mastery (PAM)

No.	PAM	Classroom Trial I		Classroom Trial II	
		f	%	*f*	%
1,	Very Low	1	2.17	–	0
2.	Low	14	30.43	1	2.17
3.	Medium	18	39.13	6	13.04
4.	High	13	28.26	28	60.87
5.	Very High	–	0	11	23.91

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The number of students with at least a moderate level of mastery in the first trial was 31 students (67.39%). Referring to the established learning mastery criteria, it can be concluded that the students' mastery of mathematical proof ability was not yet complete at the classical level. In the second trial, the number of students with at least a medium level of mastery was 45 students (97.83%). Based on the established learning mastery criteria, it is concluded that the students' mastery of mathematical proof ability was complete at the classical level. The data on pre-test and post-test scores were used to measure the sensitivity of each item in PAT I and PAT II to the learning using the learning model (see Table 9).

Table 9. Sensitivity of Problems to Learning

Test Item	Sensitivity Proportion			
	PAT 1		PAT 2	
	Trial I	Trial II	Trial I	Trial II
1.	0.304	0.478	0.087	0.420
2.	0.399	0.399	0.283	0.420
3.	0.167	0.355	0.022	0.333
4.	0.109	0.312	0.246	0.399
5.	0.123	0.348	0.029	0.384
6.	0.297	0.428	0.210	0.442
7.	0.121	0.415	0.014	0.452
8.	0.155	0.316	0.178	0.374
9.	0.487	0.426	0.321	0.457

The sensitivity proportion values for each item on the proof ability test 1 and 2 in the first trial, when referred to the established item sensitivity criteria, lead to the conclusion that items 1, 2, and 9 on proof ability test 1, as well as item 9 on proof ability test 2, are considered sensitive to the learning. Meanwhile, the other items are not. The sensitivity proportion values for each item on proof ability test 1 and 2 in the second trial, when referred to the established item sensitivity criteria, lead to the conclusion that all items on PAT 1 and PAT 2 are considered sensitive to the learning.

Data Analysis Results on Learning Time Allocation

The results of the average calculations for each observation indicator from each learning session are presented in Table 10.

Table 10. Average Indicators of Learning Time Usage Achievement Based on the Lesson Plan

No.	Observed Indicators	Classroom Trial I Meeting					Classroom Trial II Meeting				
		I	II	III	IV	V	I	II	III	IV	V
1.	I_1	4	4	4	4	4	5	4	5	5	5
2.	I_2	3	2	2	3	3	5	4	5	5	5
3.	I_3	3	2	2	3	3	5	4	5	5	5
Total Average		3.07					4.80				

Note:
I_1 : The duration of the lesson does not exceed the usual class time
I_2 : Each learning phase is completed according to the specified time
I_3 : The time allocated for each learning phase is sufficient

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The learning time allocation scores for classroom trial I and II were 3.07 and 4.80, respectively. Referring to the established learning time usage achievement criteria, it is concluded that the effectiveness of learning, in terms of time allocation, in classroom trial I and II, falls within the moderate and high categories, respectively.

Data Analysis Results of the Lecturer's Capability to Manage Learning

The lecturer's capability to manage learning for each learning phase in trial I and trial II is represented in Diagram 1.

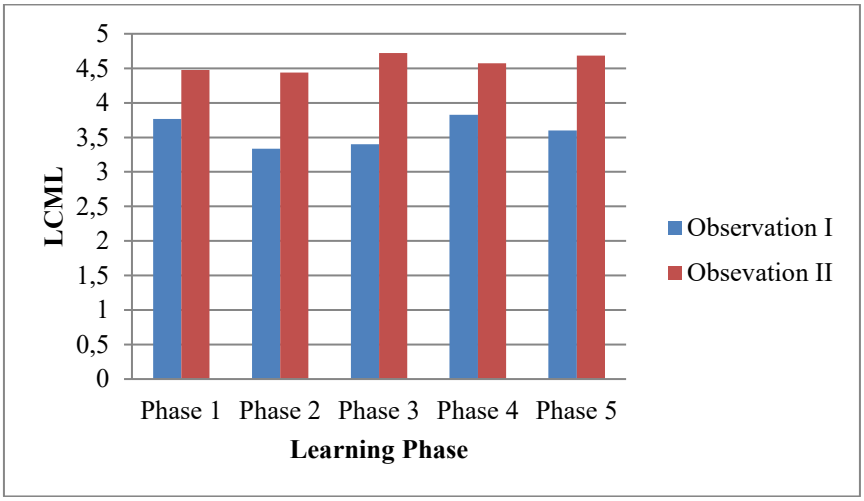

Diagram 1. Lecturer's Capability to Manage Learning

Note: LCML is Score of Lecturer's Capability to Manage Learning

The lecturer's capability to manage learning across all learning phases in classroom trial I and II were 3.05 and 4.58, respectively. Referring to the established criteria for assessing the lecturer's capability to manage learning, it is concluded that the lecturer's capability to manage learning in trial I and trial II falls within the good enough and good categories, respectively.

Data Analysis Results of Student Responses

The results of the data analysis on student responses to the components and activities of the learning process are presented in Table 11. The results of the student response data were then referred to the established criteria, and it was concluded that in classroom trial I, a large number of students had not provided positive responses to the components and activities of learning with the learning model. However, in classroom trial II, this was achieved.

Table 11. Student Responses to Learning Components and Activities

No.	Responded Aspects	Percentage (%)			
		Classroom Trial I		Classroom Trial II	
		Happy	Not Happy	Happy	Not Happy
1.	Do you feel happy or not about the following learning components?	82.17	17.83	91.30	8.696
		New	Not New	New	Not New
2.	Are the following learning components new or not for you?	81.30	18.70	86.52	13.48
		Interested	Not Interested	Interested	Not Interested

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3.	Are you interested or not in attending the next lesson, similar to the one you just followed?	82.61	17.39	93.48	6.522	
		Clear	Not Clear	Clear	Not Clear	
4.	Can you clearly understand or not the language used in (RAB, SW, and PAT)?	79.89	20.11	84.24	15.76	
		Interested	Not Interested	Interested	Not Interested	
5.	Are you interested or not in the appearance (writing, illustrations/images, and image placement) in the RAB and SW?	78.26	21.74	86.96	13.04	

The components of the Triarchic Intelligence-Based Realistic Mathematics Learning Model

Characteristics of Contextual Challenges

The first characteristic of the problems presented in this learning model is contextual problems (connected to the real world) in the form of challenges, which encourage students to analyze, think creatively, and apply prior knowledge to rediscover new knowledge, leading towards formal mathematical knowledge (progressive mathematization).

The second characteristic of the problems is that they are close to the students, meaning that the problems presented are situations that students can imagine and are in line with their level of intelligence, which is within the students' zone of proximal development (ZPD). The third characteristic is that the problems are relevant to society.

Learning Syntax

Pre-Learning

The Triarchic Intelligence Test (pretest) is given to each student before the learning process begins. This aims to identify students who exhibit stronger aspects of triarchic intelligence (analytical, creative, and practical intelligence). Each learning group consists of six to seven students, with at least two students showing analytical intelligence, two with creative intelligence, and two with practical intelligence, while considering gender, race, and ethnicity. The groups are homogeneous, meaning each group is similar to others.

Learning

The stages of learning in this learning model consist of five stages. First Stage: Presenting Contextual Challenges. The lecturer ensures that every student is ready to receive the lesson. The lecturer arranges and ensures that students in the same learning group sit close together (not in a circle). Specifically, for the first meeting, the lecturer provides a brief description of: (1) the learning model and (2) the roles of both students and lecturer in the learning process. The lecturer reminds the connection between the learning content being discussed and: (1) the previous learning content that the students have experienced, and (2) the students' real-world experiences. The lecturer then shares the learning objectives, followed by presenting the contextual challenge to students in a classical setting.

Second Stage: Exploring the Contextual Challenge. The lecturer guides (motivates) students to create a schema, formulate, and visualize the contextual challenge individually. Students who have found solutions to the challenge will compare or discuss their solutions with others in their learning group. Students who are unable to provide a solution should write down the difficulties they face in solving the challenge. The lecturer's reaction to these situations is to guide students (provide scaffolding), both in class and individually, with guiding questions, illustrations, or

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relevant simple problems, which students have encountered. The order of guiding questions, if given individually, should be adapted to the student's thinking process.

Third Stage: Reflecting on the Contextual Challenge. The lecturer organizes students into groups, meaning the students who have already been sitting close together will now position themselves to sit in a circle. The lecturer distributes three exemplars of the student worksheets to each learning group. Each group must fill out these exemplars, noting that one will be submitted to the lecturer as a group report, one will be posted on the designated wall space in the classroom, and one will be kept as a record for each group. Each student must write down the results of their group discussions in their notebook. The lecturer guides the students to use the student worksheet, motivating them to be active in their group, not working individually, and ensuring that each student discusses the solutions or difficulties they encountered in the second stage. The lecturer provides scaffolding to each learning group (in a class-wide setting) to create a model/schema for the contextual challenge. The scaffolding given should align with the needs of each group. Differing opinions between students in each group are expected because: (1) students with analytical intelligence will improve their analytical skills; (2) students with creative intelligence will enhance their creative thinking skills; and (3) students with practical intelligence will develop their practical skills. These interactions also allow students with different types of intelligence to examine the thinking processes of their peers with other types of intelligence. The exchange of opinions does not occur in a mechanical order but rather spontaneously. This learning situation will lead students to create a mathematical model (model for) to solve the contextual challenge.

Fourth Stage: Sharing Solutions (Classical Sharing, Formalization, and Generalization). The lecturer facilitates a class-wide group discussion, allowing one learning group (on a rotating basis) to present their results to the class. The lecturer guides all the groups (via group representatives) to post their discussion results (completed student worksheet) on the designated wall space. The lecturer guides the other learning groups to: (1) prepare questions based on difficulties they faced during their group discussions, and (2) compare their results with those of the presenting group. The lecturer then gives other groups a chance to respond or ask questions about the presentation. In response to disagreements among students who do not have a consensus, the lecturer provides scaffolding in the form of guiding questions, illustrations, or simple, relevant problems related to the contextual challenge. Students who have reached an agreement on solving the challenge are then guided by the lecturer to formulate and summarize the mathematical concepts and principles that should be achieved.

Fifth Stage: Implementing Formal Mathematical Knowledge. The lecturer instructs students to return to their seats. A new contextual challenge is presented to students in a class-wide setting for individual completion, without using the books or other relevant learning materials. The lecturer motivates each student class-wide to trust in their abilities and apply the mathematical concepts and principles they discovered in the previous stages. The lecturer reminds students who have completed the new challenge to review their work. The lecturer then collects the students' work at a predetermined time. The lecturer may assign homework related to the learning experience. Finally, the lecturer reminds students class-wide to: (1) reinforce their understanding of the material based on their learning experience, and (2) prepare for the next lesson by reading the book or exploring other reading materials.

Social System

The role of students in the learning process using the learning model can be categorized into three main categories: (1) the individual role of the student in solving the initial contextual

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challenge; (2) the role of each student both within their own triarchic intelligence group and in inter-group discussions in a classical setting; and (3) the individual role of the student in solving a new contextual challenge after mathematical concepts and principles are discovered.

Active student participation is indicated by the contributions they make in the problem-solving process based on the aspects of intelligence they excel in. Differences of opinion among students, both within each learning group and in classical group discussions, are expected to occur because: (1) students with analytical intelligence will improve their analytical skills; (2) students with creative intelligence will enhance their creative thinking skills; (3) students with practical intelligence will increase their practical skills; and (4) interactions among students with different types of intelligence help facilitate students in investigating the thinking processes of their peers with different forms of intelligence. This process impacts each student, allowing them to balance all aspects of the triarchic intelligence they possess. The sequence of opinions expressed by students with different types of intelligence does not occur in a mechanical order but rather spontaneously among one another. The lecturer's role in achieving this student participation in the learning process is as a facilitator, guide, and provider of scaffolding.

Principles of Reaction and Management

As a facilitator, the lecturer plays the role of providing learning experiences that align with the students' triarchic intelligence aspects, guiding students to achieve the learning objectives. The lecturer's activities as a facilitator include: (1) designing contextual challenges that function as the formation of concepts, considering the aspects of triarchic intelligence and the topic or subtopic to be built by the students; (2) forming learning groups; and (3) facilitating group discussions in a classical setting. As a guide, the lecturer's role is to help students (both individually and in groups) undergo a process of reconstruction or reinvention of mathematical concepts and principles. This means the lecturer must ensure that each learning syntax is carried out properly, and that students, as subjects of learning, perform their roles in constructing mathematical concepts and principles. As a provider of scaffolding, the lecturer provides minimal assistance to students when all students require such help.

Support System

The learning materials developed in this research include the Lesson Plan, Real Analysis Book, Student Worksheet, and Learning Media, which are based on the RME approach, emphasizing the students' triarchic intelligence. This means that the mathematical knowledge content of these materials is based on the principles and characteristics of RME and aims to enhance the students' triarchic intelligence.

Instructional and Nurturant Effects

The application of the learning model has direct (instructional) and indirect (nurturant) effects on students. The types of instructional effects on students include: (1) the meaningfulness of mathematics; (2) triarchic intelligence; (3) higher-order thinking; (4) self-regulated learning; and (5) collaborative skills within groups, all of which can be achieved and are consistent with the learning objectives of mathematics. The types of nurturant effects on students include: (1) the freedom to express opinions; (2) valuing differing opinions; (3) being open to constructive criticism and feedback; (4) being accustomed to viewing problems from various relevant perspectives; (5) arguing with strong reasoning; and (6) being responsive to emerging issues, all of which can be achieved and are consistent with the learning objectives of mathematics.

Discussion

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The design of this development research, which is a development process, follows the Plomp [30] design model to produce a valid, practical, and effective learning model [31], based on expert and practitioner assessments as well as classroom trial data. This learning model consists of five components: (1) learning syntax; (2) social system; (3) principles of reaction and management; (4) supporting system; and (5) instructional and accompanying impacts [32,25]. The learning syntax of this model consists of five stages: (1) presenting contextual challenges; (2) exploring contextual challenges; (3) reflecting on contextual challenges; (4) sharing solutions (sharing) in a classical manner (formalization and generalization); and (5) implementing formal mathematical knowledge.

The syntax of this learning model indicates that the resulting learning is based on constructivist understanding [17,18], which minimizes the dominance of the lecturer in the learning process. There is a shift in the lecturer's role in the learning model compared to direct instruction. Based on the principle of reaction and management components, the lecturer does not act as the source of information providing ready-made mathematical concepts and principles to students, as in direct instruction. Instead, the lecturer facilitates interactions [21] between students (within their learning groups and in a classical setting) and between students and their learning environment (individually or in groups with the learning materials used). The lecturer does not dictate students with a series of mechanical instructions [33] in constructing formal mathematical knowledge or solving contextual challenges. Instead, the lecturer plays the role of a guide or scaffolder, helping students rediscover mathematical concepts and principles or solve the given contextual challenges. The lecturer must ensure that the syntax of the learning model is carried out as intended, but the interactions between students or between students and their learning environment should occur as naturally as possible. This means that the lecturer provides students with opportunities to use their potential (triarchic intelligence) and previous learning experiences during the construction process.

The role of students in this learning model begins with an exploration activity [34] of the contextual challenge they receive individually using books (or other learning materials) and guided by the lecturer. This exploration helps students utilize their triarchic intelligence, as they attempt to: list known information and relate it to what is asked in the contextual challenge; create a model of the challenge in the form of images, tables, or diagrams; or try out possible solutions for the contextual challenge. This exploration activity allows students to find solutions to the challenge, but the main outcome is that students at least identify the difficulties they face in solving the challenge or constructing formal mathematical knowledge. The exploration contributes to each student by identifying aspects that need to be discussed later in their triarchic intelligence group.

Next, students engage in discussions within their triarchic intelligence groups or in a classical setting. Students, depending on the aspect of intelligence they excel in, will use their abilities to discuss their findings from the previous exploration process [6]. The outcome of the interaction within each triarchic intelligence group is a formal solution process for the contextual challenge, which is a shift from the informal model (model of) to the formal model (model for) [17,18]. The process of solving the contextual challenge and the discovery of new formal mathematical knowledge by each triarchic intelligence group indicates that students have different ways of implementing the formal mathematical knowledge they already possess. The lecturer's scaffolding for each triarchic intelligence group should be based on their specific needs (thinking process or solution process).

This learning model facilitates students to collaborate, thus it is a cooperative learning model. Cooperative learning is based on two key elements [35]: group goals and individual accountability. This means that every student in each learning group or in a classical setting is an individual who

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depends on others (based on differing potentials) and requires participation from each student in the learning process. The concept of triarchic intelligence in this research clarifies these two key elements. The inclusion of triarchic intelligence in the learning model is based on the understanding that triarchic intelligence is interactively related to: (1) sociocultural context; (2) motivation; (3) metacognition; (4) learning abilities; (5) thinking abilities; (6) declarative and procedural knowledge; and (7) creativity [36,16]. The fact shows that organizing students into learning groups is based on: (1) three categories of academic abilities—high, medium, and low; (2) gender; (3) race; and (4) ethnicity. The triarchic intelligence aspect is used in this research as the basis for organizing students into learning groups, considering their academic abilities.

Conclusion

The purpose of this development research is to develop a Triarchic Intelligence-Based Realistic Mathematics Learning Model. This development research design is based on the Plomp development design to produce a valid, practical, and effective learning model (based on expert and practitioner assessments, as well as classroom trial data). The conclusions of this research are outlined as follows.

1. The validity of the learning model is achieved based on: (1) content validity being categorized as valid; (2) construct validity being categorized as valid; (3) the validity of learning materials (Lesson Plan, Real Analysis Book, Student Worksheets, and Proof Ability Test) being categorized as valid.
2. The practicality of the learning model using learning materials in classroom implementation is based on: (1) the syntax being categorized as high; (2) the social system being categorized as high; and (3) the principles of reactions and management being categorized as high.
3. The effectiveness of the learning model is based on: (1) the classical learning completeness of students based on the achievement criteria of the proof ability of students, where 97.83% reached the minimum medium level; (2) the criteria for the achievement of learning time allocation being categorized as high; (3) the criteria for the achievement of the lecturer's capability to manage learning being categorized as good; and (4) the large number of students giving positive responses to the components and activities of the learning has been achieved.

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Exploring the mental models, strategies, and active schemas of prospective mathematics teachers in solving plane geometry problems

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Abstract. The mental model is an important element that affects the quality of problem solving. Mental models in mathematics are internal representations used by a person to understand, analyze, and solve mathematical problems. Mental models reflect how individuals process information and form an image of mathematical concepts in their minds. This research is an exploratory case study method to explore mental models, strategies, and schemes that are active in solving triangle wide problems. The approach used in this study is a descriptive qualitative approach. A total of 27 prospective mathematics teachers of Medan State University for the 2023/2024 period as prospective mathematics teachers involved in this research. Data collection is done by providing task sheets to solve triangular area problems. Data reduction, data presentation, and conclusion are the three stages in analyzing research data. This study shows three mental models of mathematics teachers in solving triangular problems: initial, adaptive, and formal. Each has different strategies and schemes that are active when solving problems. Conclusion the results of this study revealed that the mental model affects the quality of the problem-solving process until the results are obtained.

Keywords: Mental Modelling, Problem Solving, Triangular Area, Schematics, Strategy

Introduction

Mental models are a central issue in cognitive science and science because they affect the problem-solving process. The influence of mental models in the problem-solving process also affects the accuracy of the resulting solution [1-2]. Therefore, the mental model plays a crucial role in the problem-solving process. The mental model is an internal representation built by

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individuals during the learning process [1-8]. Because the mental model exists in the mind [9]. The mental model cannot make direct observations or measurements. However, mental models can be identified through a variety of external representations. Contains behaviors written on answer sheets through written text, namely images, symbols, mathematical equations, graphs, and verbal results using interview rules that contain generative [10-12].

The mental model in this study is defined as the internal representation of an object that is built from the learning experience of the individual and then built into an external representation when solving problems. Several studies on mental models have been conducted at the preschool level [13-14], primary school [15-16], and secondary schools [17]. Kildan et al. [13] examined mental models by analyzing the content in the images drawn by prospective teacher students and produced two groups of mental models: scientific and non-scientific.

Furthermore, Saçkes [14] researched the mental model of the day and night cycle and came up with three mental models, namely naïve, synthetic, and scientific. On the other hand, Bofferding [15] researched the mental model of integers and came up with five mental models: initial, transition I, synthesis, transition II, and formal. Finally, Turk et al. [16] examined the mental model of seasons with the result that students build season formation in different ways in their minds. Chinnapan [17] researched mental schemes and models to solve geometric problems. The result is that the quality of geometric knowledge that students develop can greatly influence their mental model and the subsequent use of that knowledge. Based on several studies that have been conducted, it is necessary to conduct research at the level of prospective mathematics teachers because they have learned many concepts, and this will provide a variety of mental models that can be explored [18]. This variation arises because individuals experience interactions between stimuli and thoughts during the learning process, resulting in changes in mental models [19]. The mental model research conducted by Chinnapan [17] does not clearly describe the characteristics of the mental model of the subjects studied, and the various strategies applied in solving the problem are kept secret.

In fact, problem-solving strategies rely on mental models [1], and mental models rely on confidence [20]. In addition, strategy plays an important role in successful problem-solving [21]. Several strategies can be applied when one solves a problem, such as the strategy of finding patterns, adopting, taking pictures, calculating all possibilities, and working backwards [21-22]. The instrument used by Chinnapan [17] also provides a limited opportunity to activate schemas from various domains that can be accessed during troubleshooting. The schema in this study refers to a knowledge structure that contains information about core concepts and relationships between concepts. In addition, neither Chinnapan [17], Bofferding [15], nor Greefrath et al. [23-24] reveal and describe the process of mental model accommodation during problem solving. Meanwhile, Piaget [25], Santhanam & Sein , Oleson et al. [27], and van Ments & Treur [28] stated that the mental model undergoes an adaptation process through two forms, namely assimilation and accommodation, but according to Ifenthaler et al. [2] and Seel [29-30] the mental model only experiences an accommodation process.

Nonetheless, neither Van Ments & Treur [28] nor Ifenthaler et al. [2] explain how the process of mental accommodation is explained when solving problems. The formation process is to change the representation that it has or form a new representation of an object to fit the structure of the problem at hand. The description of the mental model used as a framework in this study is presented in Table 1.

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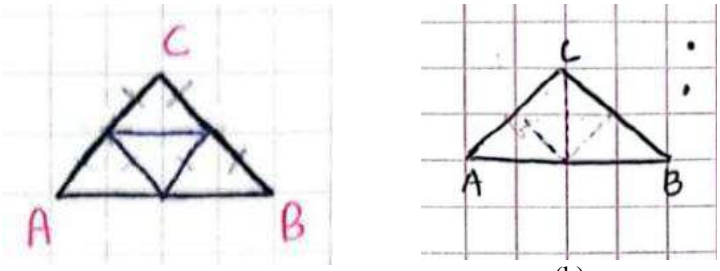
Table 1. Description of mental model process accommodation

Components of the Mental Model Formation or Adaptation Process	Descripton
Accomodation	• Create an image representation of a triangle • Create a quadrilateral image representation

The process of accommodation of the mental model is triggered by a situation of imbalance (disequilibrium), which is an imbalance of a person's mental processes (assimilation and accommodation) when an individual is faced with problems in a person's mental state [31]. Norman et al. [32] mentioned several characteristics of mental models, including: mental models are incomplete, unstable, and change over time. Changes in mental models show changes in mental structure caused by conceptual changes [33-35]. During conceptual change, individuals often develop alternative conceptions to build formal models, which are considered goals, and seek to incorporate new information into their conceptual structure to provide insights into how they think about concepts [36] This conceptual shift is rooted in Piaget's idea of accommodation [37]. So, accommodating this mental model is likely to happen, especially since mental models are dynamic [28].

Based on this literature review, several prospective mathematics teacher students were given a pre-test with the command "draw a model of a triangle and give it a name then divide the triangle into four equal parts". Most of the triangular images produced by them are shown in Figure 1.



(a) (b)

There were 13 student teachers who made isoceles triangles out of 27 students

Figure 1. Isoceles Triangle

Based on the results of this test, the researcher was interested in exploring why more isosceles triangles were drawn than other types of triangles. When students are asked to draw a triangle, they tend to rely on the mental image that is strongest or most frequently encountered. Prospective Mathematics Teachers tend to draw isosceles triangles when asked to draw triangles because these triangles have several visual characteristics and symmetries that make them easy to recognize and draw. This suggests that the resulting model of an isosceles triangle is firmly embedded in the mind and comes from long-term memory, and this is how mental models work [38]. Research related to mental models has been conducted on several aspects, including analogical problem solving [39], deductive and inductive reasoning [40] and probabilistic inference [41], but research related to problem solving in terms of finding the area of a triangle has not been conducted. Finding the area of a triangle is a mathematical problem because it is challenging for individuals

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but cannot be solved directly with a specific algorithm [42] due to constraints limiting the problem, namely the size of the given triangle. During the process of solving the triangle area in flat geometry, individuals may come up with various mental models of objects that are used to explain and obtain the expected solution. Flat geometry provides an important foundation for more complex mathematical concepts, such as space geometry, trigonometry, calculus, and even algebra. An understanding of shapes, sizes, and relationships between shapes in the flat plane helps students in developing essential visualization skills. A deep understanding of flat geometry will help prospective teachers deliver the material in a more structured and engaging way for students.

Based on the literature review and initial test analysis, it shows that there has been no research related to mental models and mental model changes when solving problems, precisely the problem of finding the area of a triangle, what strategies are used, and what schemes are active during the problem solving process. This study aims to explore mental models, what strategies are used, and what schemas are active in solving more complex triangle area problems. The results of this study provide information about the importance of mental models in solving problems and form the basis for designing learning based on mental model construction [43-44]. That is because mental models influence the application of active strategies and schemas to produce the right solution to the problem at hand.

Metodology

This research is an exploratory case study design to understand the mental models, strategies, and active schemas used by prospective mathematics teachers. Qualitative descriptive research method through Participant Observation by observing how these prospective teachers solve geometry problems directly or through the tasks given. Document the steps and approaches taken that have the aim of knowing the mental image of prospective teacher students in drawing and dividing flat shapes, such as triangles and quadrilaterals, as well as how they understand the difference in shape and proportion of equal parts. This study aims to get an in-depth picture of students' understanding of basic geometry and their thought process in drawing flat shapes. Descriptive qualitative research is a type of research that describes precisely a certain situation or symptom that produces qualitative data in the form of oral or written sentences from a subject.

The subjects in this study were 27 students of Medan State University in the period 2023/2024 who were prospective mathematics teachers and the object of research was the analysis of mental images of prospective teachers in visualizing images of triangles, quadrilaterals, and ducks. The main instrument in this study is the task of drawing flat shapes consisting of several types of shapes, namely triangles (equilateral, isosceles, and right-angled) and quadrilaterals (square, rectangle, trapezoid, and parallelogram). The question instructions asked students to draw the shapes manually and divide them into equal parts. Question number one asked students to draw a triangular flat shape and divide it into four equal parts, then question number two according to the same instructions given in question number 1. Each drawing was analyzed to see the type of figure drawn, the way of division, and conformity with the instructions.

Research Results and Discussion

The results showed that three mental models were developed to solve the triangle area problem,

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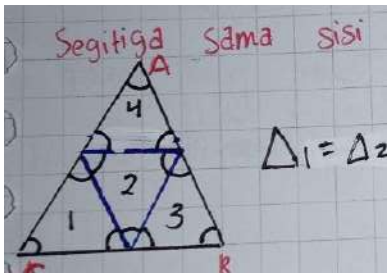
namely the initial, adaptive, and formal mental models. In addition, it was also found that there were differences in the strategies used and active schemas. Adaptive mental model refers to a mental model that undergoes an accommodation adaptation process. This is different from the characteristics of mental models found by several other researchers, such as Bofferding (2014) and Saçkes (2015). The question instructions asked prospective math teachers to draw the shape manually and divide it into equal parts. Question number one asked prospective math teachers to draw a triangular flat shape and divide it into four equal parts, then question number two according to the same instructions in question number 1 was given. Each drawing was analyzed to see the type of shape drawn, the way of division, and conformity with the instructions. The results obtained are as shown in Table 2 below:

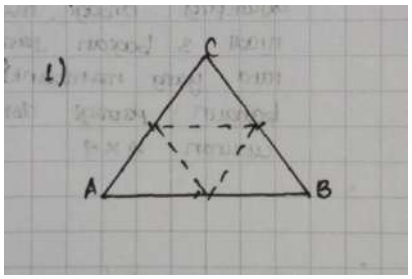
Table 2. The Number of Students Prospective Teachers Drawing Triangles

No	Triangle Name	The Number of Students	
		Question 1	**Question 2**
1.	Equilateral triangle	11	6
2.	Isosceles triangle	13	5
3.	Right triangle	3	16
4.	Arbitrary triangle	-	-

There are 11 prospective mathematics teachers who make an equilateral triangle in question no 1, and there are 6 prospective mathematics teachers who make 6 equilateral triangles in question no 2 with the same conditions. There were 13 students who made isosceles triangles in question number 1, and there were 5 prospective mathematics teachers who made isosceles triangles in question number 2. Likewise, when there are 3 prospective mathematics teachers who make a right triangle in question no 1, and 16 prospective mathematics teachers who make a right triangle in question no 2.



(a) P1



(b) P2

From the figure above, the prospective mathematics teacher participant-1 (P1) stated that an equilateral triangle can be divided into 4 equal parts according to the one in the figure. The concept of an equilateral triangle is a triangle that has 3 sides of equal length, all three angles are the same size and have a total of 180 degrees of angles.

The results of the analysis: from the sense of an equilateral triangle that is closer to the image is shown in figure 2, where participant-2 (P2) in figure 2 has the same side size of the same length. Figure 1 only needs measurement improvements. Because it is seen for picture 1 it is not an equilateral triangle but an isosceles triangle. Based on visual perception and direct experience. The initial mental model of prospective mathematics teachers (P1) considers triangles as three-

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sided shapes without understanding the concept of angles or sizes. They may solve the problem by looking at similar shapes without understanding the formal properties of the triangle.

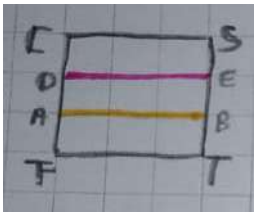
If an equilateral triangle is divided into 4 parts, it will satisfy, provided that the division is right in the middle of the third line, more or less as shown above. Here the representatives of these two images show the same division, where the two images are divided right in the middle. From figure 2 we will know that it will be just as large. That is why figure 1 is less accurate to be said to be an equilateral triangle.

Next, question number three of the prospective mathematics teacher is asked to draw a flat rectangle and divide it into three equal parts, then problem number four according to the same instructions in question number three is given. Each drawing result is analyzed to see the type of drawing figure, how it is divided, and how it conforms to the instructions. The results obtained are as follows table 3:

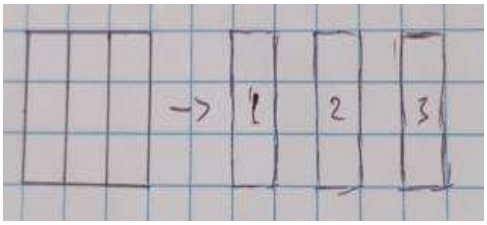
Table 3. The Number of Prospective Mathematics Teachers Drawing Flat Quadrilateral Shapes

No	Rectangular Name	The Number of Students	
		Question 3	Question 4
1.	Rectangle	8	14
2.	Square	17	3
3.	Trapezoid	2	7
4.	Split	-	-
5.	Parallelogram	-	2
6.	Kite	-	1

In question number 3, prospective mathematics teachers are asked to draw a rectangle, then divide it into 3 equally large parts. From the problem, as many as 8 prospective mathematics teachers drew a rectangle, 17 prospective mathematics teachers drew a square and 2 prospective mathematics teachers drew a trapezoid, and 1 student drew a parallelogram.



(a) P3



(a) P4

From the picture above, the prospective math teacher states that the square can be divided into three parts that are equal in size according to the one in the picture.

Analysis results: The definition of a square is a two-dimensional flat figure that has four sides of equal length and four angles that are all right (90 degrees). From the sense of the square, participant-3 and participant-4, the two images that represent have correctly depicted the square. To divide it into three equally large parts, figure 3 (P3) divides it horizontally while figure 4 (P4) divides it vertically, from all the answers of students who drew a square in question number three, they divided the square in only 2 ways, namely vertically and horizontally. Adaptive mental

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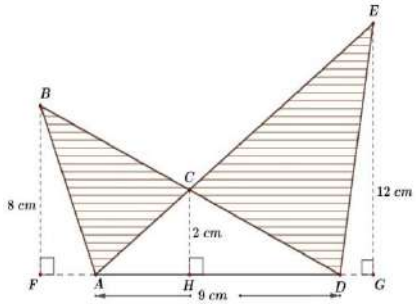
models are able to adapt to the context. It begins to involve logic and basic relationships between geometric elements. Prospective teachers (P3 and P4) began to understand that all triangles have a total angle of 180 degrees. They can use this information to solve problems, although they still rely on visual observation in some ways.

Furthermore, given question number five, this study uses a qualitative approach to explore and provide an accurate description of the characteristics of situations or phenomena that occur in the field [45]. The subjects of this research are 27 prospective mathematics teachers from the second year who have taken calculus and analysis courses to support the problem solving presented. Data collection was carried out using the snowball sampling technique in universities in Medan using the most significant area problem-solving task sheets and semi-structured interviews. This is done to ensure that the data obtained is saturated. Figure 2 shows the assignment sheets performed by the participants.



Determine the area to be shaded?
How do you solve this problem, find the area that is shaded, write down the order of the answer process and what are the obstacles faced?

Figure 2. Worksheet for Triangle Area Problem

This problem-solving task is developed taking into account the different mental models that may arise from the subject. This assignment is foreign to prospective teachers because it is a problem of the area of the triangle as shown in figure 2. In addition, the problem is complex and dynamic to solve because it will allow the research participants to identify the sides of the triangle in various representations. In line with what Funke [46-47] expressed, in diagnosing mental models, one can use problem-solving tasks with criteria unfamiliar to the subject, complex and dynamic. Three mental forms of the model are identified from the side of the triangle that is commonly encountered in problem solving with shaded area, namely as the initials that are defined, the initials that are changed to the variables that are sought, and the variables as symbols to shorten the problem solving. Finding an area will become more complex when the mental model of the triangle is identified as an initial and then converted into a variable, thus triggering the accommodation process. The identification of the mental model of the triangle plays a dual role and is an important prerequisite in the modeling process before the study participants can activate the right schemes and strategies to find the expected areas.

The research data was in the form of 27 task answers which were then categorized into three categories, The data categories were based on different representations of triangles, strategies

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used, and schemes that were active in solving problems. Below is the data of 27 participants in the following figure 3:

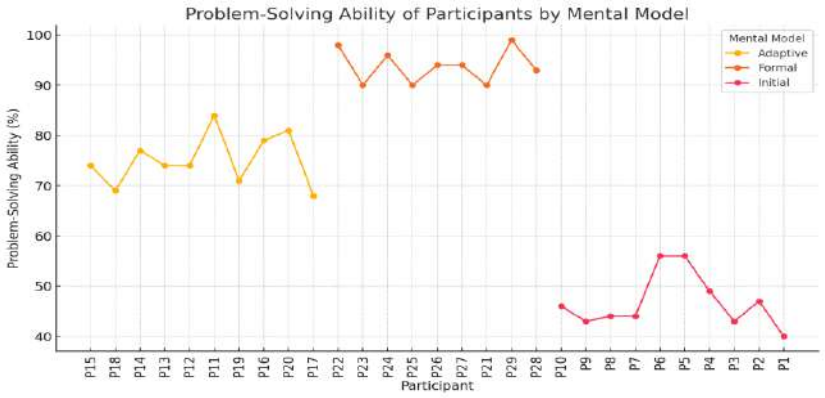
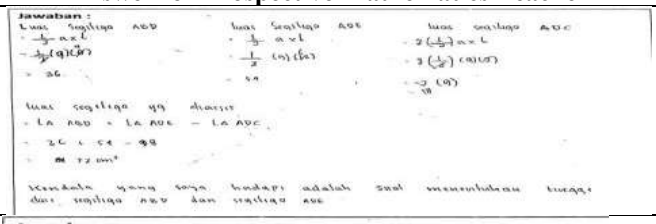
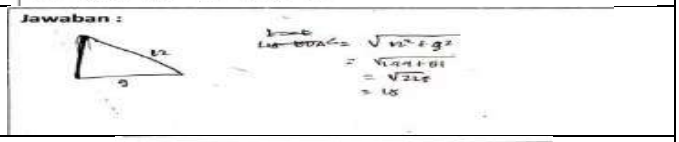
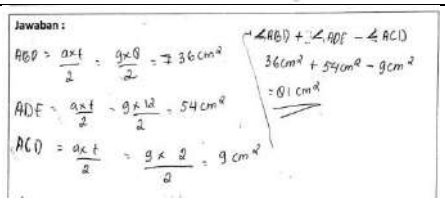


Figure 3. Participant's Problem-Solving Ability from 3 Mental Models

The line graph above shows each participant's problem-solving abilities based on their mental models (Initial, Adaptive, and Formal). Participants were grouped according to their mental models, and the lines on the graph showed the variation in problem-solving abilities in each group.

The following in table 4 is presented the answers of prospective mathematics teachers and descriptions of errors in type 1 problems.

Table 4. Mathematics Teacher Candidate Answers and Error Descriptions on Type 1 Problems

Error description	Answer for Prospective Mathematics Teacher
Students do not understand the concept of flat buildings which include the shaded part of flat buildings. Students are wrong in identifying the combination of flat buildings listed in the question. Solving an area problem by calculating all possible areas of a triangle by combining	 
Prospective mathematics teachers do not give names to the triangles contained in the problem. They tend to change their mental models to adapt to the structure of the problem they face and use adoption strategies to get the expected solution	

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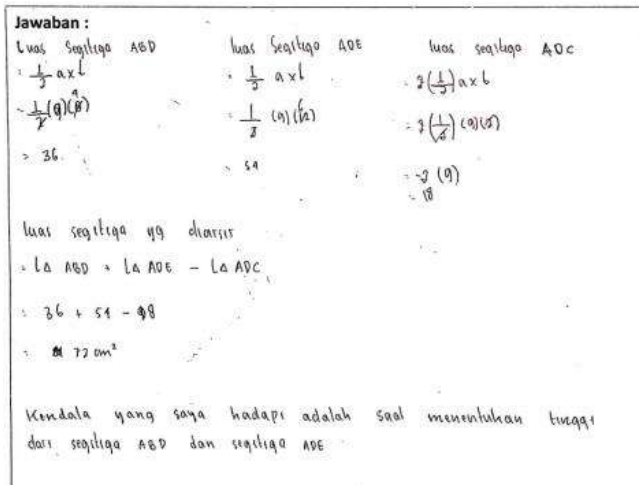
Prospective mathematics teachers as participant-5 (P5) interpreted the solution of shaded flat buildings by subtracting the entire building from the unshaded buildings so that the values obtained began to match. They can use formal mental models using adoption strategies and activate sophisticated schemes to solve their problems. At this stage, prospective teachers are not only familiar with various geometric shapes and properties, but also able to apply them to solve complex problems. They are able to visualize more abstract concepts without having to rely on physical representations	 Jawaban : Luas Segitiga ABD = $\frac{1}{2}$ a x t = $\frac{1}{2}$(9)(8) = 36 Luas Segitiga ADE = $\frac{1}{2}$ a x t = $\frac{1}{2}$ (9)(12) = 54 Luas segitiga ADC = 2($\frac{1}{2}$) a x t = 2($\frac{1}{2}$)(9)(6) = 2 (9) = 18 Luas segitiga yg diarsir = La ABD + La ADE − La ADC = 36 + 54 − 98 = 72 cm² Kendala yang saya hadapi adalah soal menentukan tinggi dari segitiga ABD dan segitiga ADE

These three models, the initial mental model, the adaptive mental model, and the formal mental model in flat geometry reflect progressive cognitive development from intuitively understanding basic concepts to the stage of in-depth formal analysis. This model illustrates how aspiring teachers can evolve in their approach to flat geometry problem solving.

Conclution

There are three mental models of prospective mathematics teachers in solving triangular wide problems, namely beginner (initial), adaptive, and formal, each of which has different active strategies and schemes during problem solving. Candidates for prospective mathematics teachers with beginner mental models (initials) tend to solve broad problems by calculating all possible areas of a triangle by joining. Meanwhile, prospective math teachers with adaptive mental models tend to change their mental models to adapt to the structure of the problem they are facing and use adoption strategies to get the expected solution. Prospective math teachers with formal mental models have models that are more in line with experts; that is, it is abstract. They can use adoption strategies and enable advanced schemes to solve their problems. Mental models have a dynamic character which means that mental models change over time due to learning, and these changes in mental models have an impact on problem-solving skills. Therefore, mental models have a central role in solving problems.

In addition to having an impact on quality and determining the accuracy of the resulting solution, mental models also trigger the implementation of active strategies and schemes during the problem-solving process. Prospective mathematics teachers with a beginner mental model (initials) need to be given triggers in the form of learning based on mental model construction and group discussions so that their mental model changes for the better. This is necessary because the mental model can influence (or vice versa) the strategies used and the schema that is active in solving the problem until the results are obtained. This research needs to be improved in identifying the initial abilities and differences in learning methods and models they follow in the classroom. Therefore, this study provides an opportunity to conduct further research by considering these two things.

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ICT-based student activity development increasing critical and creative thinking skills of students

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Abstract. *In order to deal with challenging issues in the era of Industrial Revolution 4.0 and Society 5.0, university graduates must possess more adaptable and creative thinking abilities. The issue is that a lot of students still struggle with critical and creative thinking since conventional approaches to teaching do not encourage the growth of soft skills. The objective of this study is to enhance students' critical and creative thinking abilities by creating activities that utilize information and communication technology (ICT). An ICT-based student program was designed and implemented in this study using the Research and Development (R&D) technique. Surveys, interviews, and in-person observations were used to gather information about how well the curriculum was enhancing students' capacity for critical and creative thought. The research results proved that ICT-based learning activities greatly enhanced students' attentive engagement, critical thinking abilities, and inventiveness in coming up with novel solutions to pressing issues.*

Keywords: Student Programs, ICT, Digital Era, Critical and Creative Thinking Capabilities

Introduction

The development of technology in the Society 5.0 era has a significant impact on various aspects of life, economy, and society. A dynamic environment is also swiftly created by the technological revolution, necessitating that each person be able to comprehend, evaluate, and adjust to information fast. The education sector is also confronted with this challenge; in addition to transitioning to a learning environment centered on information and communication technology, it also equips university graduates with exceptional and highly competitive human resource capabilities. Excellent human resources are a group of skilled, competitive, professional, and prepared Indonesian workers who are prepared to take on the challenges of the fourth industrial revolution and the world. The Indonesian government designed Making Indonesia 4.0 as an

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integrated roadmap to implement a number of strategies in entering the Industrial Age 4.0, which is a big leap for the industrial sector, with information and communication technology simultaneously being fully utilized [1]. The Indonesian government supports education for the twenty-first century that emphasizes creativity and innovation skills [2]. In order to produce graduates with the problem-solving, critical-thinking, and creative-thinking abilities necessary to thrive in the modern world, universities must integrate HOTS-oriented learning with character education strengthening. 5.0. education in the 21st Century [3].

A favorable opportunity for the implementation of education and student activities, both academic and extracurricular, is presented by the quick development of communication and technology. In fact, the availability of technology offers chances to enhance students' problem-solving skills. The availability of information technology encourages everyone, but especially educators, to solve problems more creatively and without regard to time or location. Technology, particularly information technology, has changed people's perspectives and ways of thinking, both as students and as teachers. Information and communication technology use in both academic and non-academic domains is one of the requirements for students to grow, adapt, and become proficient problem solvers. Information and communication technology proficiency is therefore a crucial and essential prerequisite for students to enhance their problem-solving skills [4].

The outcome of this development research is an activity program designed to help students develop their critical and creative thinking abilities using information and communication technology.

Literature Review

A person who has a solid plan on how to solve a problem can overcome it. If a correlation is found between the problems that students face and their schemata, then the problems will have a good and valid solution. Students in this situation are in the adaptation phase, which entails activities that are carried out impulsively between the brain and motion in order to discover a rule for solving the issue. Students use the process of problem solving to identify principles from previously learned material that they can use to solve novel problems [5].

Individuals with problem-solving skills are able to analyze information from a problem, organize potential solutions to problems, and select the best solution by applying their knowledge and logical reasoning. Five steps make up the ability to solve problems: a) recognize the problem, b) define and formulate the problem, c) investigate problem-solving techniques, d) put the techniques into practice, and e) review the outcomes and assess the impact of the approaches used [6].

Indicators to measure critical thinking skills focus on assessing a person’s ability to analyze, evaluate, and synthesize information in a logical and reasoned way. In this research, the indicators are (1) Analyze complex information and relationships, (2) Evaluate sources, arguments, and evidence critically, (3) Infer conclusions and solutions based on logical reasoning, (4) Reflect on and regulate one’s thought processes. These indicators provide a framework for evaluating critical thinking skills and guiding effective instruction and assessment across different educational and professional contexts [7

Based on J.P. Guilford identified core aspects of creative thinking within his *Structure of Intellect Model,* Torrance Tests of Creative Thinking, Componential Model of Creativity of Amabile, Triarchic Theory of Intelligence of Sternberg, indicators of creative thinking skills on these research core indicators for assessing creative thinking skills are (1) **Fluency**: Producing a high quantity of ideas, (2) **Flexibility**: Adapting to different perspectives or generating diverse

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ideas, (3) **Originality**: Creating unique and novel ideas, (4) **Elaboration**: Adding detail and depth to ideas, (5) **Persistence and Motivation**: Continuing the creative process despite obstacles, (6) **Problem Sensitivity**: Identifying challenges and opportunities for creative solutions, and (7) **Evaluation**: Assessing the practicality and value of ideas [8].

The educational process benefits greatly from the use of ICT, which can guide the implementation of case-based reasoning exercises, simulations, knowledge and multimedia organization, individual studies through personal channels, tracking and pooling of various source materials, collaborative discussions, and joint project development. It also enables students to work independently alongside one another in time and space [9].

Methods

Increasing the caliber of academic work is the aim of this development research. Research is conducted alongside development, which is carried out gradually. Every step that needs to be completed involves using past outcomes to generate new ideas [10].

Information gathering, planning, the creation of preliminary product forms, preliminary field testing, major product revisions, playing field testing, operational product revisions, final product revisions, dissemination, and application are some of the phases that comprise this research. Activity design is a process of developing ICT-based student activity development, increasing critical and creative thinking skills of students as presented in Figure 1.

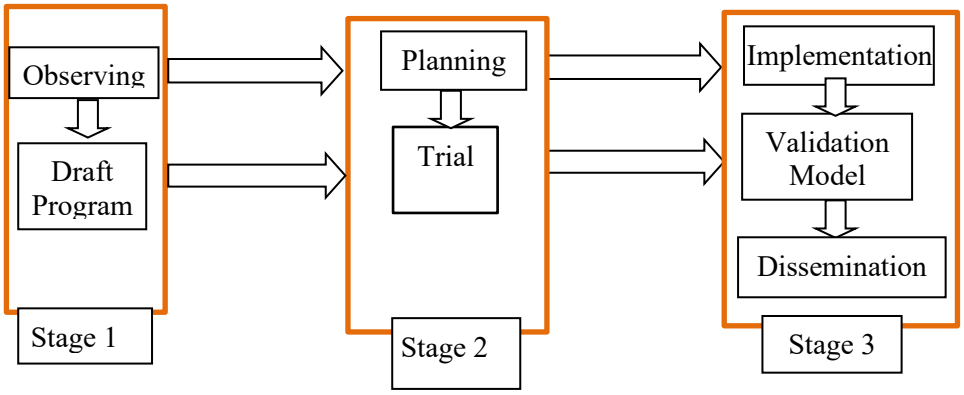

Figure 1. Research Design of Critical and Creative Thinking Skills Based ICT

Result and Discussion

The results of observing students' critical thinking skills in connection to the given tasks are shown in Table 1

Table 1. Critical thinking skills of Student

Indicators	Score	Categories
Analyze complex information and relationships	45	Enough
Evaluate sources, arguments, and evidence critically	55	Good
Inferring conclusions and solutions based on logical reasoning	55	Enough
Reflect on and regulate one's thought processes	50	Enough

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Average	51.25	Enough

In accordance with Table 1, obtained that analyzing complex information and relationships is the first step that must be done and obtained a score of 45 and is in the sufficient category. The second and third indicators are evaluating sources, arguments, and evidence critically and inferring conclusions and solutions based on logical reasoning with the same score, which is 55. The score obtained by students on this indicator is 50 and is in the less category. Overall, it is found that the average critical thinking skills of students are still in the enough level; this is indicated by the large score obtained of 51.25.

Table 2. Indicators of creative thinking skills of Student

Indicators	Score	Categories
Fluency: Producing a high quantity of ideas	72	Good
Flexibility: Adapting to different perspectives or generating diverse ideas	70	Good
Originality: Creating unique and novel ideas	65	Good
Elaboration: Adding detail and depth to ideas	60	Good
Persistence and Motivation: Continuing the creative process despite obstacles	55	Enough
Problem Sensitivity: Identifying challenges and opportunities for creative solutions	55	Enough
Evaluation: Assessing the practicality and value of ideas	60	Good
Average	**62,43**	Good

Table 2 indicates that it is found that the indicator of fluency: producing a high quantity of ideas is in the category of good; this is indicated by a score of 72. For the second indicator obtained on the indicator Flexibility: Adapting to different perspectives or generating diverse ideas and Originality: Creating unique and novel ideas is in the good category. This indicator is the same as an indicator of originality: creating unique and novel ideas. This is indicated by the score on these two indicators being more than 60. For the indicator of elaboration, adding detail and depth to ideas as a means of increasing creativity is in the good category. The score obtained is 60. Although there are two indicators that are in the category enough, all around the ability of creative thinking skills of students is in the good category with a score obtained of 62.43.

The researcher developed a program scheme to enhance ICT-based student activity development, increasing critical and creative thinking skills of students based on the findings of observational data analysis and theoretical analysis.

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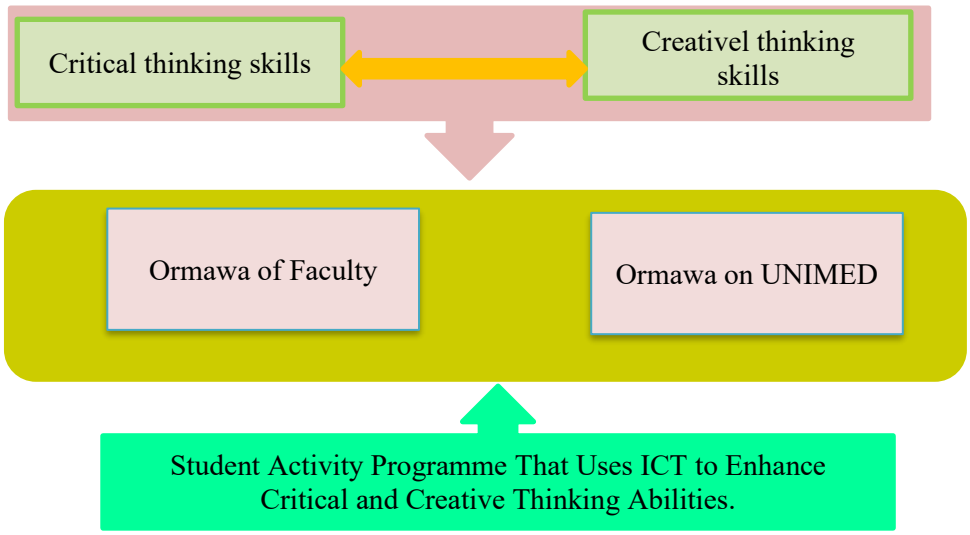

Figure 2. Scheme of Critical and Creative Thinking Skills Based ICT Program

Figure 2 shows the interrelationships between the Critical and Creative Thinking Skills-Based ICT Program's indicators. In order to bring about a new approach or curriculum that will eventually be implemented by the university, study programs and faculties must collaborate and pay particular attention to this connection pattern.

Conclusion

Based on the study's findings, it is highly probable that activity programs targeting ICT programs based on critical and creative thinking skills will be developed; this is demonstrated by the critical thinking skills' ability to fall into a sufficient category. Naturally, the development of creative thinking skills is no longer a barrier because students are already well-versed in the information technology that is currently evolving.

Acknowledgments

At the end of this research report, the Ministry of Research, Technology, and Higher Education is thanked, with particular thanks to the Rector of Unimed, for the funding that enabled this study. It is expected that the results of this study will be helpful in enhancing Unimed students' educational experiences and, more generally, help to improve the Unimed institution as a whole.

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Analysis of waste transportation system using vehicle routing problem model with multiple trips in medan city

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Abstract. *Urban waste in Indonesia is a problem that has not been completely resolved, especially in Medan City. The waste problem in Medan City is waste management related to waste pile control. This problem can be overcome by regulating the waste transfer and transportation process based on the optimal route. This study aims to analyze and optimize the waste transportation system in Medan City with a sample of Medan Denai District, especially in Tegal Sari Mandala (TSM) II Village, using the Vehicle Routing Problem with Multiple Trips (VRP-MT) approach. The stages carried out are collecting data in the form of distance from Google Maps, determining the coordinates of each route and intersection point, compiling a grid, formulating a mathematical model. Data on the location of waste collection points, waste volume, and transportation capacity are used to build a mathematical model to minimize the total distance traveled and vehicle operating costs. The results of the study show that the application of the VRP-MT model can increase the efficiency of waste transportation in TSM II Village by reducing vehicle distance traveled and operating costs. This study contributes to more effective waste management in urban areas, as well as being the basis for designing a more environmentally friendly and sustainable waste transportation system in Medan City.*

Keywords: *Vehicle Routing Problem with Multiple Trips, Waste Transportation, Route Efficiency, Optimization.*

Introduction

Waste is one of the environmental problems that requires serious handling. [1] Based on Law No. 18 of 2008, waste is the remains of human daily activities and/or natural processes in solid form. In general, waste is divided into three, namely organic/wet waste, inorganic/dry waste. Along with the increasing population in an area, it also results in an increase in the volume of waste [2]. Community consumption patterns also contribute to an increase in the volume of waste which is increasingly diverse in type.[3]. Therefore, to overcome the problem of pollution, waste management and control are needed. The rapid population growth in Medan City cannot be separated from the influence of various advances in technology, transportation and so on. This has become a reality that Medan City is the most efficient and effective location for production

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activities.[4]. The increasing purchasing power of the community for various types of basic necessities and technological products as well as the increasing number of businesses or activities supporting the economic growth of a region also contribute greatly to the quantity and quality of waste produced. [5]. Medan City, which consists of 21 sub-districts, produces around 2,000 tons of waste every day and around 800 tons of it ends up in the landfill. More than 1,000-1,200 tons of the rest are at risk of not being handled.)

One way that the City Government can do is to regulate and optimize waste transportation activities. Waste transportation is the activity of moving waste that has been collected into a means of transportation to be taken to the final disposal site.[6]. Determining the route for waste transportation will affect the operational costs of the transportation used, such as the fuel oil used. Various problems such as inconsistent scheduling, inefficient routes, and lack of transportation capacity continue to haunt the Medan City waste transportation system, especially in Tegal Sari Mandala (TSM) II Village, Medan Denai District. An effective waste transportation system requires careful planning, one of which is by creating the best route that can be passed by waste transport vehicles. One method of solving this problem is to use the Vehicle Routing Problem (VRP) model, especially the Vehicle Routing Problem with Multiple Trips (VRP-MT) [7]. The VRP-MT model is used to create a transportation route that takes into account the time required to complete the waste transportation task and the limitations of vehicle capacity in addition to optimizing the number of trips[8]. The use of Genetic Algorithm (GA) as a method for finding optimal solutions in this VRP-MT model was chosen because of its ability to explore a wide solution space and find solutions that are close to optimal, even for complex problems. GA can be used to find efficient transportation routes, by minimizing travel distance, travel time, and vehicle operating costs.[9-10] (K. et al., 2019).

This study aims to analyze the waste transportation system in TSM II Village, Medan Denai District, using the VRP-MT model optimized with the GA algorithm. This study will focus on planning waste transportation routes to reduce travel distance, operating time, and costs, as well as increase the efficiency of waste transportation in the area. By using representative sample data from TSM II Village, it is hoped that this study can contribute to the development of a better and more efficient waste transportation system in Medan City.

Research methods

This research carries out a research study on a system run which aims to see the effectiveness in the use of system. And field studies was using Google Maps by searching for sources of information and collecting data from the object to be studied. This research was conducted in Medan Denai sub-district which consists of 6 urban villages, namely Binjai, Denai, Medan Tenggara, Tegal Sari Mandala I, Tegal Sari Mandala II, Tegal Sari Mandala III. Data were obtained from the Medan Denai Sub-district Office with samples in Tegal Sari Mandala (TSM) II urban village. The data used in this study are in the form of areas in each TSM II urban village and the roads passed. Waste transportation in TSM II urban village uses 3 Bestari becaks with each maximum waste capacity of $500cm^3$

Data analysis using Vehicle Routing Problem with Multi Trips with several stages:

- Determining the starting point and ending point of waste transportation, data in the form of distance based on the grid and points obtained from Google Maps
- Determining the coordinates of each Bestari becaks route and the intersection points determined by taking the longitude and latitude points on Google Maps.

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- Arranging a grid by illustrating all the data obtained, starting from the points and edges that connect one point to another.
- Formulating a mathematical model based on Determining the optimal route that must be taken by the transport vehicle, taking into account the distance between waste collection points and vehicle capacity
- Selection of algorithms and model completion
- Implementation of the resulting route is tested whether the solution found can be applied in the field.
- Data analysis
- Conclusion

Waste collection location data for Medan Denai sub-district, TSM II sub-district, as shown in figure 1

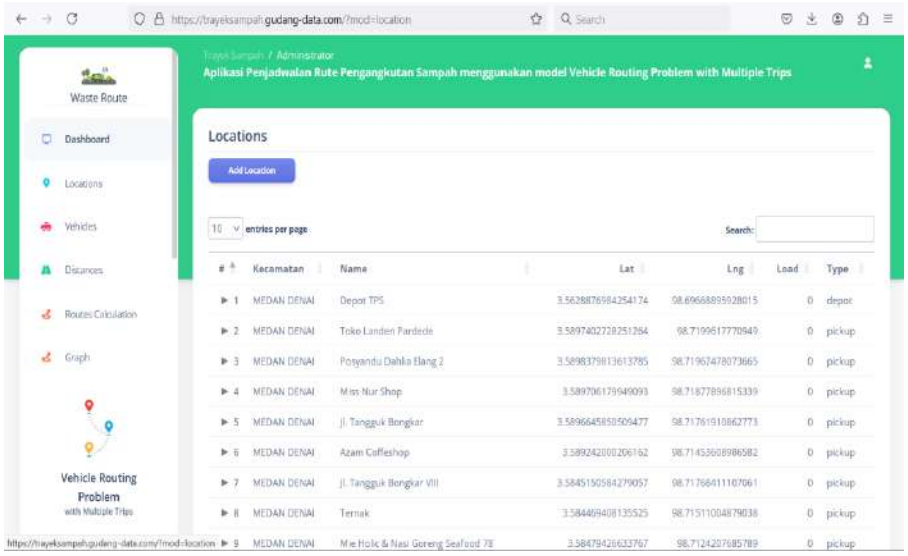

Figure 1. Areas and coordinates for waste collection points

Figure 2 shows that Maximum capacity data for Bestari becaks

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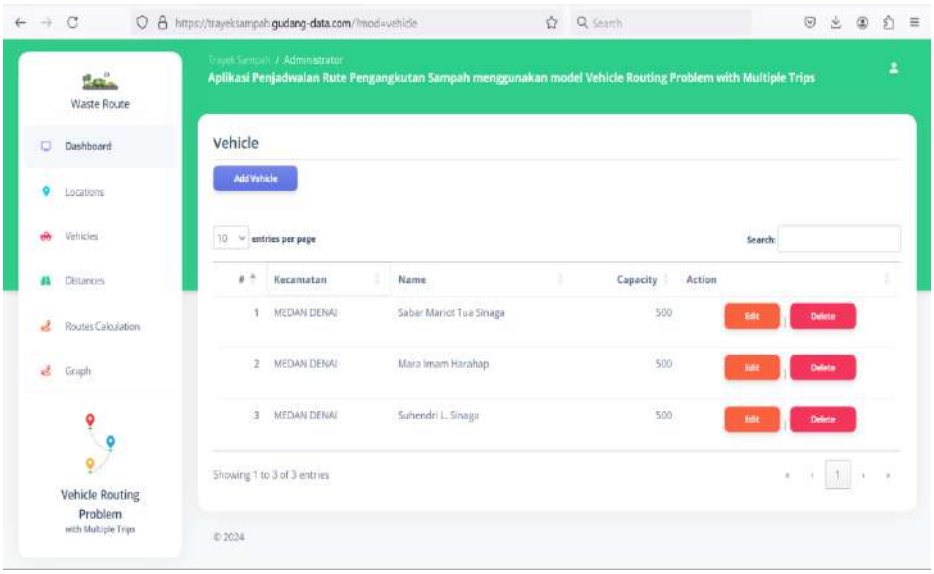

Figure 2. Maximum waste capacity

Results and Discussion

The application of the Vehicle Routing Problem with Multiple Trips (VRP-MT) model optimized using the Genetic Algorithm (GA) for the waste transportation system in Tegal Sari Mandala (TSM) II Village, Medan Denai District, includes travel distance, transportation costs, and increasing the efficiency of vehicle capacity usage. Furthermore, the results obtained will be analyzed in depth to evaluate the effectiveness of the optimization model applied, as well as the practical implications of its application in the waste management system in the area.

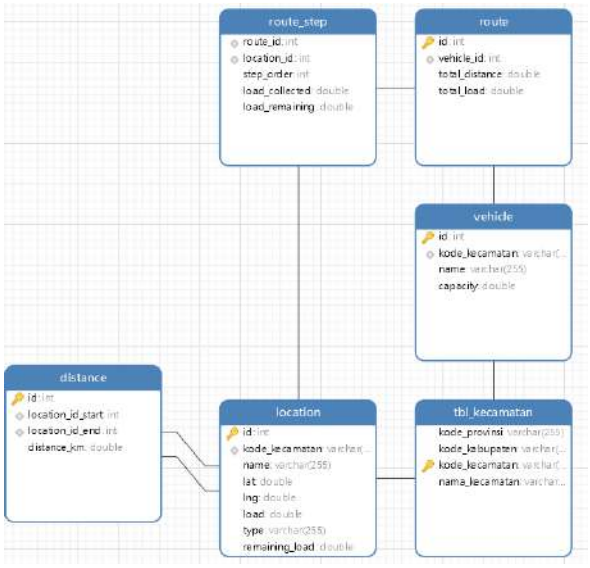

Figure 3. system development stages flow

System development stages flow:

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- location → district: Each location is associated with a specific district.
- distance → location: Stores the distance between two different locations (start and end points).
- vehicle → district: Indicates the district in which the vehicle operates.
- route → vehicle: Links each route to the vehicle that operates it.
- route_step → route and location: Provides detailed steps of the journey along the route and associates each step with the locations visited.

These relationships work together to build a more structured system in planning and managing transportation routes or vehicle trips in logistics or waste management systems.

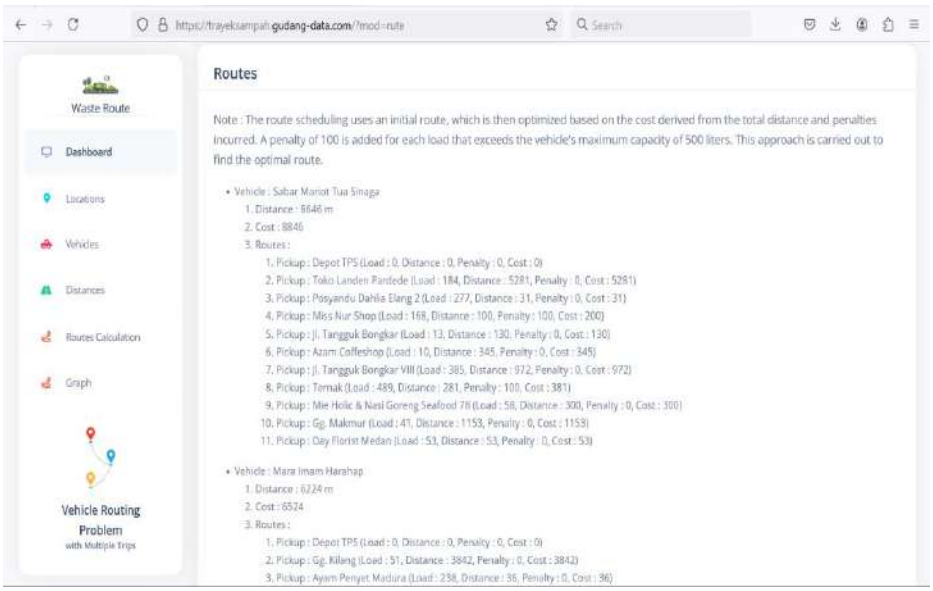

Figure 4. Application Displays search results for distance, cost and route.

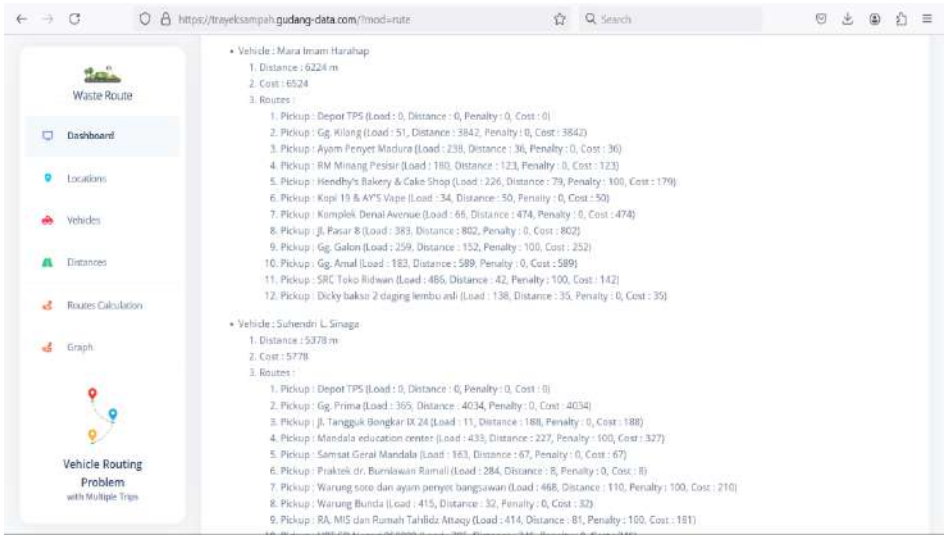

Figure 5. Application Displays search results for distance, cost and route.

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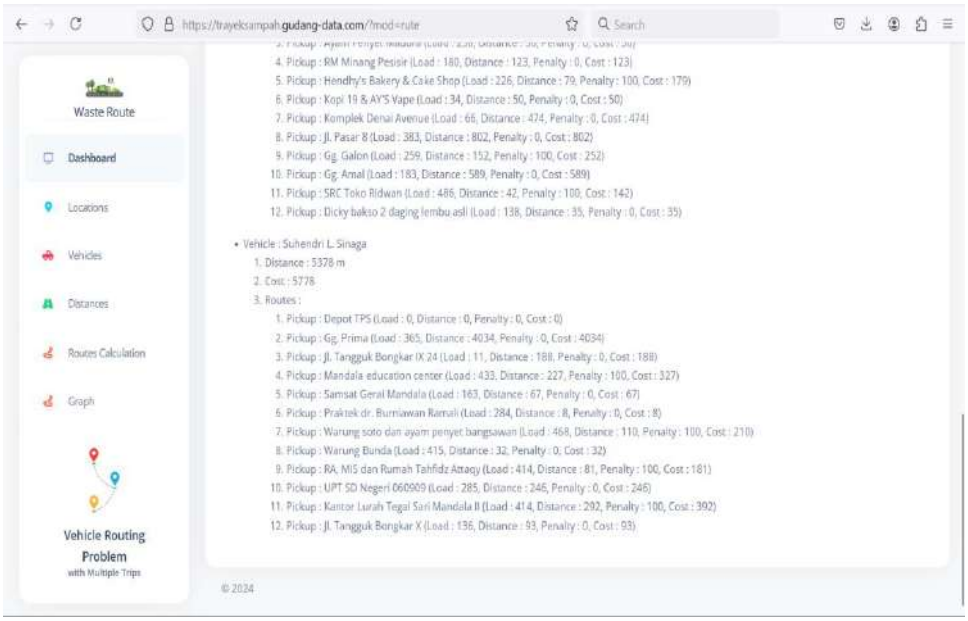

Figure 6. Application Displays search results for distance, cost and route.

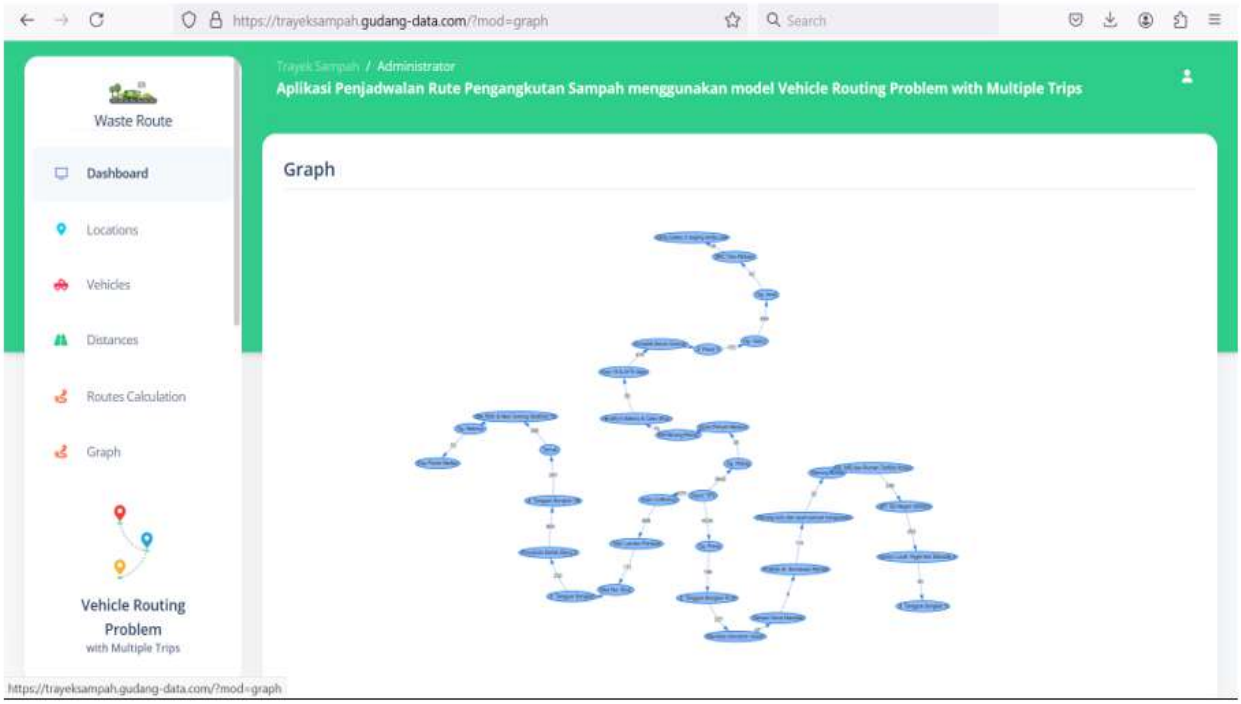

Figure 7. Optimum route for each transport

The calculation process using the Vehicle Routing Problem with Multiple Trips model in finding the shortest path between all points on the network is carried out by analyzing the shortest distance from the starting point to the destination point so that the smallest distance solution estimate is obtained using distance values and heuristics.

Flowchart: Multi-Vehicle Waste Collection Route Optimization Using Simulated Annealing

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1. Start
2. Initialize Parameters
   - Input initialRoutes, distanceMatrix, loadAtPoints, maxCapacity, initialTemp, coolingRate, and minTemp.
3. Calculate Initial Total Cost
   - Use calculateTotalCost to compute the total cost of the initial routes based on distanceMatrix and loadAtPoints.
4. Set Initial Best Solution
   - Set currentRoutes and bestRoutes as initialRoutes.
   - Set currentCost and bestCost to the calculated initial total cost.
5. While Temperature > Min Temperature
   - Generate Neighbor Route
   - Use generateNeighbor to create a neighboring route by swapping points between two random routes (vehicles).
   - Calculate Neighbor Cost
   - Use calculateTotalCost to determine the cost of the neighborRoutes.
   - Acceptance Check
   - If neighborCost < currentCost:
   - Accept the neighbor route, set currentRoutes = neighborRoutes and currentCost = neighborCost.
   - Else, calculate acceptance probability using exp((currentCost - neighborCost) / temperature).
   - If the probability is greater than a random value, accept the neighbor route.
   - Update Best Solution
   - If currentCost < bestCost, update bestRoutes to currentRoutes and bestCost to currentCost.
   - Cool Down Temperature
   - Update temperature = temperature * coolingRate.
6. End Loop
7. Output Best Route and Cost
   - Return bestRoutes as the optimal routes and bestCost as the minimum cost for waste collection scheduling
8. End

Conclusion

From the results of this research analysis, the application of the VRP model with Multiple Trips can significantly increase the efficiency and effectiveness of the waste transportation system in Medan City, providing sustainable and responsive solutions to community needs. The search for the shortest waste transportation route from the initial position to the destination position begins with the transformation of road coordinate data obtained from Google Map ApI.

Acknowledgments

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express our thousand thanks. also thank the head of the FMIPA Unimed mathematics department for allowing us to carry out this research activity within the mathematics department of FMIPA Unimed. As well as our deepest thanks to all parties who have helped carry out this research activity well.

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Implication of case method based on collaborative project learning on students' algebra structure ability

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Abstract. *Collaboration is one of the 21st century skills that are indispensable in daily life. The ability of students to collaborate can be used in mathematics classes, especially for mathematics students to improve their learning skills. One of the courses that mathematics education students do not like is algebraic structure, even though this course aims to improve student reasoning. The selection of Case Method based on collaborative project learning aims to improve students' algebra structure skills. This study aims to find out how much collaborative project-based Case Method learning contributes to students' algebraic structure ability. The population of this study is students of the Mathematics Education Study Program in the sixth semester of the 2023/2024 academic year consisting of six classes. While the sample is students who take the algebraic structure course consisting of 2 classes, namely one experimental class and 1 control class. The results of data analysis showed that there was an influence of collaborative project-based case-methods on students' algebra structure ability with a medium-size effect. From this research, it can be recommended that collaborative project-based learning can be used for mathematics courses.*

Keywords: Case Method, Collaborative Project Learning, Algebraic Structure

Introduction

Mathematics as a deductive science is a discipline that is used in almost all other fields of science and has unique characteristics. The conclusion or generalization of mathematics is not based on observation or inductive, but through deductive proof. Mathematics is closely related to abstract ideas or concepts that are arranged hierarchically and use deductive reasoning. This has a

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direct impact on the approach used in the mathematics learning process, which must be designed to support the development of deductive and abstraction understanding. Mathematics is not only the study of abstract things but also puts forward deductive processes that require logical and axiomatic reasoning [1]. However, the process of learning mathematics can begin with an inductive approach, which includes the preparation of conjectures, the development of mathematical models, and the use of analogies and generalizations based on observed data. This process supports the main goal of mathematics learning, which is to form a logical, critical, systematic, and creative mindset. Another characteristic of mathematics is its structured and systematic nature, in which its various parts are arranged hierarchically and interrelated in close functional relationships. With its inherent nature of regularity, mathematics not only has aesthetic appeal through beautiful regularity, but also strong analytical ability, which is essential in the development of mathematical models that can be applied in problem-solving in various disciplines as well as in everyday life.

At each level of education, there is a tendency that the higher the level of education, the higher the demand for independence in learning. This becomes more relevant at the higher education level, where students are expected to be able to develop learning independence optimally. One of the courses given in the Mathematics Education Study Program at Medan State University is the Algebra Structure course, which is taught in semester VI. This course requires students to study mathematical concepts that are mostly abstract in nature, with a special emphasis on proving theorems. Mathematics learning in higher education, especially in the Algebra Structure course, must be done by paying attention to the need for student learning independence. Given the characteristics of courses that are abstract and require a lot of theorem proofs, the learning process must be able to encourage the development of students' level of reasoning and critical thinking. If learning is delivered in a monotonous way and limited to delivery by lecturers, it can cause a lack of student involvement and hinder the development of their reasoning skills. However, on the other hand, there are still many students who face difficulties in proving theorems independently without direct guidance from lecturers. When faced with the challenge of understanding and applying the necessary steps in theorem proof, many students find it difficult, which indicates the need for a more innovative and interactive approach to learning. Therefore, it is important for educators to create a learning environment that supports the development of independence while also providing the necessary guidance to assist students in mastering abstract material and improving their reasoning skills.

Based on the results of observations made by the researcher in the initial Algebra Structure lecture before being given a case topic to be discussed with the group team in class, students were less active and did not understand the content of the lecture material from the learning process and questions and answers related to the material that had previously been explained during the lecture. One of the efforts to overcome this problem is to use the case method. Case-methods are alternative teaching and learning activities with an application pattern in the form of case studies of problems related to lecture materials that can be sourced from the internal environment of the organization or from the external environment. With the emergence of issues and problems in case studies, it becomes a forum for students to position themselves as decision-makers of the problems found in the case objects displayed, so that students not only know or understand the problems that have been discussed but also think about finding solutions related to problems, With the application of this case method, participatory learning based on problem-solving discussions will stimulate, improve critical thinking skills for problem-solving, active communication, collaboration and innovation. In this study, the case method is integrated with collaborative project learning. This

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collaborative project activity is carried out by giving students a case to be solved together in a group to understand a theorem and definition discussed in the algebraic structure course. By doing the case method in solving a project, students will be more active and work together to solve the given problem.

Literature Review

Case Method

The case method learning model provides opportunities for students to develop their potential, self-actualize, innovate, and find solutions from the cases that will be discussed. This is a challenge for the lecturer in charge of the course in making final assessment decisions. In case method learning, students are focused on achieving superior achievements, so that potential remains potential. As a lecturer, every lecture that is carried out always reconstructs the learning results that have been given. As conveyed by [2].

As stated by [3], the case-solving learning method emphasizes more on the process of solving the problem of a case faced scientifically. The application of this case method emphasizes the selection of teaching materials that have solvable cases. The case method in learning has the following characteristics:

1. Students and teachers can participate in discussions in person;
2. The discussion material is case cases related to the subject matter;
3. Case material is read, studied and discussed by participants in groups;
4. Learning activities are directed to solve cases;
5. Case solving is done by thinking critically scientifically.

The big benefit of the case method learning method that can be taken is: problem-solving skills can be improved. Cases given by educators to be solved provide opportunities for students to experience in dealing with a problem. These various cases used are relevant, real problems of theoretical illustrations and subject matter. The existence of case solving will train students to think critically to find solutions in solving cases. In finding solutions, students will use various concepts that can be used to solve these cases. It is said by [4] that this case method is applied to develop the ability to integrate various concepts of learning materials to solve a problem.

Collaborative Project Learning

Collaboration according to the Indonesian Dictionary is an act of cooperation. Collaboration is one of the skills of the 21st century, in this case, collaboration is an interaction between students and other students to achieve a common goal. Based on the understanding of some of these experts, it can be concluded that collaboration is a form of cooperation with each other that helps and complements each other to carry out certain tasks in order to achieve predetermined goals. Collaboration involves the division of tasks, where everyone performs every task that is their responsibility to achieve a common goal.

Skills related to collaboration in learning that can be used as indicators include the following:

1. Have the ability to work together in groups.
2. Adapts to a variety of roles and responsibilities, works productively with others.

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3. Have empathy and respect for different perspectives.
4. Able to compromise with other group members to achieve the goals that have been set.

According to [5], the benefits of collaboration include:

1. Able to provide quality business or services by developing professional expertise.
2. Maximizing effectiveness and productivity in the use of resources so that their use can be efficient
3. Increase loyalty, professionalism, and satisfaction at work.
4. Increase cohesiveness between actors involved in it.
5. This can provide clarity about the role of individuals in the interactions between the members involved in it. The use of the learning model can be adjusted to the type of subject and subject, school conditions, student characteristics and student learning readiness.

Table 1. Indicators of Collaborative Leaning Ability

Indicator	Description
Actively contribute	Show flexibility and compromise
Work productively	Actively conducting discussions, completing tasks effectively and efficiently, focusing on discussions in finding solutions and communicating smoothly in discussions
Demonstrate an attitude of responsibility	Responsible for assigned tasks, completing tasks on time, fulfilling given instructions
Demonstrate flexibility and compromise	Responsible for assigned tasks, completing tasks on time, fulfilling given instructions

Source: [6]

Factors that affect collaborative skills, namely:

1. Forming, which is the most basic skill and possessed to create a cooperative study group
2. Functional, which is the student's skill in managing group activities or completing tasks and maintaining effective working relationships between students.
3. Formulation, which is the skill to build students' concepts and understanding of the material being taught to spur the use of high-level reasoning methods or strategies, as well as maximize mastery of the material being taught, and
4. Recognize, which is a skill that stimulates the reconceptualization of understood material, cognitive conflicts, and the search for more information and communicating conclusions.

Several learning models that use the principles of collaborative learning include the following:

1. Problem Based Learning

   Problem Based Learning is a learning activity that can shape student activities in the teaching process because students are required to be active in solving a problem. Problem-based learning is a learning model that uses real, unstructured and open-ended problems. This trait allows students to develop problem-solving and critical thinking skills while building new knowledge.

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2. Project Based Learning

   The Project-Based Learning Method is a form of constructivism-based learning that allows students to gain an understanding of a material by giving them the opportunity to complete important projects and develop products that are needed in the real world. In this method, students engage in real problems.

3. Case-Method Learning

   The case method can be considered a collaborative learning model because it encourages cooperation between students in analyzing, discussing, and solving problems together in the context of complex cases. This not only strengthens their understanding of the subject matter, but also develops their social skills and critical thinking skills.

Many learning models have been developed to achieve learning objectives optimally. One of them is project-based learning. Project-based learning is a constructivist approach that gives students a central role to be actively involved in the development of knowledge and skills through research and project creation [7]. Students will learn directly by solving various real problems with their knowledge. This learning allows students to learn collaboratively and develop creativity in problem-solving.

This learning model has been applied in various countries with positive outcomes such as increased motivation, social skills, meaningful learning, and academic achievement. However, its application in Indonesia is still limited. In fact, project-based learning is able to increase student collaboration and creativity in finding solutions to problems. According to [8] defines collaborative learning as a personal philosophy, not just an educational method in the classroom. Collaboration, according to him, is a philosophy of interaction and lifestyle that sees cooperation as an interaction structure that allows collective efforts to achieve common goals. Collaboration is a way to relate to each other in any situation where a number of people are in a group. It is a way to relate to mutual respect and appreciate the abilities and contributions of each member of the group.

Collaborative learning is a way of teaching that involves groups of students working together to complete a task, solve a problem, or create an item. Collaborative learning emphasizes how students learn together. Collaborative learning is a philosophy: work together, build together, learn together, improve together. The philosophy of collaborative learning includes cooperation, learning together, building common knowledge, changing common knowledge, and improving ourselves together [9].

Collaborative skills are essential for every individual student and need to be developed. Collaboration skills are very important in classroom activities because they can increase students' knowledge in achieving learning goals. Students who can demonstrate collaboration skills if they can fulfill three components, namely:

1. Demonstrate the ability to work effectively and appreciate the differences that exist within the group
2. Able to accept the opinions of others for the same purpose

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3. Responsibilities and contributions of each member.

Collaborative learning is not only a method in the classroom, but also involves a sense of appreciation, respect, or full respect for each member of the group [10]. It also emphasizes the abilities and contributions of each member of the group. For each group action, there is a division of authority and responsibility. Collaborative learning is based on cooperation and collaboration by group members. It involves social interaction involving a community of students and teachers, where its members share experiences and information. Some of the characteristics of collaborative learning are:

1. Positive dependence between students in a group is a prerequisite for positive cooperation.
2. Because cognitive activity is important and dynamic interpersonal skills can only occur in dynamic interactions, interactions between group members are essential. Various activities, such as checking the understanding of others, sharing information with other group members, and presenting the results of discussions, are examples of these dynamic interactions.
3. All members of the group should be responsible for their contributions, and the group should be responsible for achieving the goals.
4. More competitive group learning is different from individual learning. In addition to academic skills, collaborative learning will teach social skills. Keep in mind that social skills do not arise spontaneously during collaborative learning. Continuous shared learning is expected to improve social skills such as leadership, decision-making, communication, trust building, and conflict resolution.
5. Forming a heterogeneous group allows everyone in the group to talk about how to achieve their goals and build effective working relationships. To form a collaborative group, there are several principles. One of them is the need to accept various types of students, such as combining students who are quiet with students who are easier to communicate, students who have low ego and optimism, and students who have high motivation and low selfishness. Work habits, ethnicity, and gender should be considered when forming a group. The exact number of groups is unknown.
6. When teachers use collaborative learning, they value and develop learning based on the experiences, knowledge, strategies, and cultures that students bring to the table.
7. Assessing (evaluating) what students have learned, setting learning goals, and designing learning tasks are the dominant teacher duties in traditional learning. Cooperative learning is not. In a collaborative classroom, educators share their audience with students in a certain way. Students actively participate in setting learning objectives, assigning tasks, and evaluating the achievement of learning objectives.
8. Teachers act as mediators in collaborative learning. In this case, teachers help students to relate new knowledge to what they already know, provide an overview of what to do when they encounter a problem, and help them "*learn how to learn*".

There are several benefits of collaborative learning, including:

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1. Increase individual responsibility as all group members are aware of shared responsibilities and responsibilities.
2. Increase the commitment of group members to help each other help people in need, provide appropriate feedback, and encourage them to achieve common goals.
3. Facilitates interaction between individuals and groups among group members, allowing each group to demonstrate social skills and communication skills.
4. Provides stability to the group so that members can work together with other groups for a long period of time without becoming tired and establishing norms of shared hard work, and interaction patterns.

Methods

This type of research is a quasi-experimental research with an unequal control group design model. This study is almost the same as the design of the pretest posttest control group, only the experimental class and the control class are not randomly selected [11]

The research design of this non-equivalent control group design is:

Table 1.2. Non-equivalent Control Group Design

Class	Pretest	Intervention	Posttest
Experiment	O1	X	O2
Control	O3		O4

Source : [12]

Description,

O1 = Experimental class pretest results

O2 = Posttest results of the experimental class

O3 = Control class pretest results

O4 = Control class posttest result

X = Providing experimental classroom care with collaborative project-based case-methods

This study uses a pretest instrument to measure students' abilities before being given treatment and a posttest to measure students' abilities after being given treatment. To find out the results, calculations were carried out with the SPSS 26 Application with T – Sample Independent Test. This test is specifically used to determine if there is a significant difference in the observed group mean [13]. The assumption for performing a T-Sample Independent Test is that the data should be distributed normally and homogeneously. The normality test aims to find out whether the data that has been collected is distributed normally or taken from a normal population. The homogeneity test aims to see the similarity of variants between two or more groups [14]. However, if the assumption of the t-test is not met, then the Mann Whitney U test can be used. The basis for decision-making on the Mann Whitney U Test is:

- If the Asymp.Sig (2-tailed) value < 0.05 means that the hypothesis is accepted that there is

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a significant difference between two or more groups.

- If the Asymp.Sig (2-tail) value > 0.05, the hypothesis is rejected i.e. there is no significant difference between two or more groups [15].

Result and Discussion

This study aims to test the influence of the use of collaborative project-based case-methods on students' algebra structure skills. After obtaining the students' pretest and posttest scores in the experimental class and control class, an assumption test was carried out to perform calculations with the T-Sample Independent Test. The description of the data of the research results is as follows.

Table 1.3. Descriptive Analysis of Pretest and Posttest Data of Experimental Class and Control Class

Treatment	Total Number of Student	Minimum Score	Maximum Score	Mean	Variance
Pretest Control Class	32	20	60	40.16	152.394
Posttest Control Class	32	10	94	69.88	321.339
Pretest Experiment Class	32	15	51	38.88	89.919
Posttest Experiment Class	32	65	98	79.72	113.822

Source : Data Processed by Researchers, 2024

Based on the table above, there are 32 students in the experimental class and the control class, respectively. In the pretest results of the control class, the minimum score was 20 and the maximum score was 60 with an average of 40.16. In the control class posttest results, the minimum score was 10 and the maximum score was 94 with an average of 69.88. In the results of the pretest of the experimental class before being handled with the collaborative project-based case-method learning model, the minimum score was 15 and the maximum score was 51 with an average of 38.88. In the posttest results of the experimental class after being processed with a collaborative project-based case-method learning model, the minimum score was 65 and the maximum score was 98 with an average of 79.72. The variance value in the control class pretest data was 152,394, the experimental class pretest data variance was 89,919, the control class posttest data variance was 321,339, and the experimental class posttest data variance was 113,822.

Normality Test

The normality test in this study uses the Kolmogorov Smirnov test. The basis for making a decision on the Kolmogorov Smirnov normality test is:

- The Sig. value or signification value or probability < 0.05 then the distribution is abnormal.
- The Sig. value or the value of significance or probability > 0.05, then the distribution is normal [16].

Based on pretest data and posttest data of the experimental class and control class, the results of the data normality test were obtained as follows.

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Table 1.4. Results of Pretest and Posttest Data Normality Test for Experimental and Control Classes

		Kolmogorov-Smirnova		
	Class	Statistik	Df	Sig.
Pre Tes	Experiment	.235	32	.000
	Control	.107	32	200*
Post Test	Experiment	.158	32	.040
	Control	.228	32	.000

Source : SPSS 26 Data Test Processing Results, 2024

Basis for retrieval based on the table above, it is obtained that the pretest data of the experimental class has a sig. 0.000, which means that the pretest data from the experimental class is not distributed normally. Meanwhile, the pretest data of the control class has sig. 0.200, which means that the pretest data from the distributed control class is normal. For posttest data, the experimental class has a sig. 0.040 and for posttest data, the control class has a sig. value. by 0.000. This means that the posttest data from the experimental class and the control class are not distributed normally.

Homogeneity Test

The basis for decision-making is that if the significance value (Sig.) is based on an average > 0.05, then the data can be declared homogeneous [17]. Based on the pretest data and posttest data of the experimental class and the control class, the results of the data homogeneity test are as follows.

Table 1.5. Results of Pretest and Posttest Data Homogeneity Test for Experimental and Control Classes

	Variance Homogeneity Test				
		Levene Statistic	df1	df2	Sig.
Pre Test	Based on Mean	2.089	1	62	.153
	Based on Median	2.778	1	62	.101
	Based on Median and with adjusted df	2.778	1	61.634	.101
	Based on trimmed mean	2.394	1	62	.127
Post Test	Based on Mean	1.428	1	62	.237
	Based on Median	1.412	1	62	.239
	Based on Median and with adjusted df	1.412	1	41.058	.242
	Based on trimmed mean	1.466	1	62	.231

Source : SPSS 26 Data Test Processing Results, 2024

Based on the homogeneity test table above, it is obtained for the value of sig. Based on the average of 0.153 in the pretest, where 0.153 > 0.05, which means that the variance of the data of

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the pretest value is the same or homogeneous. Then, for the value of sig. Based on the average in the posttest is 0.237, where 0.237 > 0.05, which means that the variance of the posttest data is the same or homogeneous.

In the results of the normality test of the research data, it was shown that there were abnormal data but the pretest data and posttest data were homogeneous. This means that 1 assumption is not met, so it cannot continue the calculation using the T - Sample Independent Test. Therefore, this study uses the Mann Whitney U Test.

Table 1.6. Average Rating Data, Pretest and Posttest Results of Experimental and Control Classes

			Rating	
	Class	N	Average Rating	Number of Ranks
Pre Test	Experiment	32	32.39	1036.50
	Control	32	32.61	1043.50
	All	64		
Post Test	Experiment	32	38.30	1225.50
	Control	32	26.70	854.50
	All	64		

Source : SPSS 26 Data Test Processing Results, 2024

Based on the table above, there are 32 data from the experimental class and 32 data from the control class. For the pretest data, the average rating of the experimental class was 32.29, while the average rating of the control class was 32.61. This means that the pretest score of the control class is higher than that of the experimental class with a difference of 0.32. For posttest data, the average rating of the experimental class was 38.30, while the average rating of the control class was 26.70. This means that the experimental posttest score is higher than the control class posttest score by a difference of 11.6.

Table 1.7. Mann Whitney U Stats Test Results

Test Statistics[a]

	Pre Test	Post Test
Mann-Whitney U	508.500	326.500
Wilcoxon W	1036.500	854.500
Z	-.047	-2.506
Asymp. Sig. (2-tailed)	.962	.012
a. Grouping Variable: Class		

Source : SPSS 26 Data Test Processing Results, 2024

Based on the table above, the Asymp value. Sig. (2-tailed) in the pretest data was 0.962. This means Asymp. Sig. (2-tailed) > 0.05, so it can be concluded that there is no difference between the pretest values of the experimental class and the control class. For posttest data, the value of Asymp. Sig. (2-head) is 0.012. This means Asymp. Sig. (2-tailed) < 0.05, so it can be concluded that there is a difference between the posttest values of the experimental class and the control class. This

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shows that there is an influence of collaborative project-based case-methods on students' algebra structure ability.

To measure the high and low influence of collaborative project-based case methods on students' algebra structure ability, the effect size value can be calculated. According to [18], to calculate the effect size with Cohen's d formula is as follows.

$$D = \frac{\bar{X}_e - \bar{X}_k}{S_{gab}}$$

with,

$$S_{gab} = \sqrt{\frac{s_1^2 + s_2^2}{2}}$$

Description:

S_{gab} = Combined standard deviation
s_1^2 = Experimental class variance
s_2^2 = Control class variance
D = Effect size value
$\bar{X}_e$ = Average posttest of the experimental class
$\bar{X}_k$ = Average posttest of the control class

The effect size criteria are:

Table 1.8. Effect Size Value Criteria

Interval	Criteria
$ES \leq 0.2$	Low
$0.2 < ES \leq 0.8$	Medium
$ES > 0.8$	High

Source : [19]

Based on the calculation results, the combined standard deviation value of 14.7506 was obtained, so that the effect size value obtained was 0.667. The effect size value is between 0.2 to 0.8 so it is included in the medium category. This can be interpreted that collaborative project-based case methods have a moderate effect on students' algebra structure ability.

This is in line with [20], the results of the study show that there is a positive influence on project-based learning methods on students' mathematics learning achievement because project-based learning emphasizes knowledge so that students can develop an understanding of mathematical concepts. A similar study was conducted by [21], which showed that there was an increase in student understanding which could be seen from the increase in the average score of group project learning outcomes with the average of cycle I which was 72.2 and the average of cycle II which was 86.09.

Learning models related to collaboration, technology, and interactivity are a way to ensure

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education that is in line with the times. Project-based learning is one of the models that can be applied to lectures because it has a great opportunity to create meaningful experiences for students to enter the world of work that can train collaboration [22]. Collaborative project learning has been implemented in various countries with positive outcomes such as increased motivation, social skills, meaningful learning, and academic achievement. Algebraic Structure courses tend to be abstract and require a lot of theorem proof, so a learning process is needed that is able to encourage the development of students' level of reasoning and critical thinking. Thus, through the collaborative project-based case method model, it can help students to understand abstract mathematical concepts and help students in proving theorems, so that this learning model is able to encourage students' level of reasoning and critical thinking.

Conclusion

Based on the results of data analysis, it was shown that there was an influence of the implications of the collaborative project-based case method on students' algebra structure ability. This is because students gain meaningful experience in solving a given problem. The effect size value obtained was 0.667 and was in the medium category.

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Prostate cancer diagnosis analysis using the k-nearest neighbors algorithm

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Abstract. This study was conducted to diagnose the classification of prostate cancer by medical record data from 100 prostate cancer. The study used 8 determinants to diagnose the classification of prostate tumors. Using principal component analysis (PCA) to reduce the data dimension and then continuing with the K-Nearest Neighbor (KNN) algorithm, it was studied how high the accuracy of these two algorithms was in determining prostate classification. The results showed that PCA reduced the dimension from 8 to 6 principal components while maintaining 94% of the variance information. The KNN model showed a decent accuracy of 70%. However, there were still errors in detecting benign tumor cases. This is due to the unbalanced data distribution.

Keywords: K-Nearest Neighbor Algorithm, Principal Component Analysis, prostate cancer, classification, data mining.

Introduction

Prostate cancer is one of the most common malignancies affecting men and contributes significantly to the increasing mortality rate in men worldwide. Patients affected by prostate cancer present with localized or advanced disease. In the United States, prostate cancer (CaP) remains the second leading cause of cancer deaths in men. The CaP is predominantly indolent at diagnosis, with a small fraction (25–30%) representing an aggressive subtype (Gleason score 7–10) that is prone to metastatic progression [1]. Currently, the available treatment options are more effective when used as a combination therapy; however, despite the available treatment options, prostate cancer remains incurable[2]. Therefore, the detection of prostate cancer is crucial to appropriate treatment that can be carried out according to the patient's condition. Imaging techniques such as

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CT, MRI, and bone scans have traditionally been used for diagnosis and staging. PSMA PET has been combined with other modalities, such as multiparametric MRI for better diagnostic and prognostic performance[3]. In recent years, several new biomarkers supplementing the role of prostate-specific antigen (PSA) have become available for men with prostate cancer. Although widely used in an ad hoc manner, the role of PSA in screening asymptomatic men for prostate cancer is controversial. In addition to its role in screening, PSA is also widely used in managing patients with diagnosed prostate cancer, such as in surveillance following diagnosis, monitoring response to therapy, and in combination with both clinical and histological criteria in risk stratification for recurrence.[4]. The annual rate increased from 0.9% for those under age 60 to 2.1% for those over age 70. For men with Gleason score ≥ 7 prostate cancer, the annual prostate cancer death rate peaked 2–3 years after diagnosis and then declined. For men diagnosed with Gleason score ≤ 6 prostate cancer, the annual prostate cancer death rate continued to increase for 20 years after diagnosis and peaked after age 85. This suggests that high-grade prostate cancer is aggressive early on, but low-grade prostate cancer can enter a dormant state and reactivate as patients age[5]. Therefore, this study uses morphological dimensions (radius, perimeter, area) and texture features such as smoothness, compactness, symmetry, and fractal dimension.

Principal Component Analysis (PCA) is used to extract features for medical data classification to detect leukemia, colon tumors, and prostate cancer[6]. Also, many studies have used KNN in classifying lung cancer, breast cancer, and prostate cancer [7, 8]

Literature review

K-nearest neighbor algorithm

K-Nearest Neighbors (KNN) is a widely used supervised learning algorithm for classification and regression tasks. It operates on a simple yet effective principle: to predict the outcome for a given data point, KNN considers the *k*-closest data points in the training dataset and uses their values or class labels for decision-making. Introduced formally by Cover and Hart in 1967, KNN remains a cornerstone of machine learning due to its simplicity and interpretability[9].

KNN works firstly, the algorithm assumes all data points exist in a multi-dimensional space where each dimension represents a feature. For instance, in a two-dimensional dataset, every data point is represented as a coordinate. When a new data point is presented, KNN calculates its distance to every data point in the training dataset. Commonly used distance metrics include Euclidean Distance, Manhattan Distance, and Cosine Similarity. After computing the distances, the algorithm selects the *k*-nearest neighbors to the query point. The parameter *k* is a hyperparameter that must be chosen carefully; it directly affects the algorithm's accuracy and generalization. For classification, the algorithm assigns the most common class (majority vote) among the *k*-nearest neighbors. We use KNN to predict the output by averaging the values of the *k*-neighbors, optionally weighted by their distances using Regression. KNN is a lazy learning algorithm, meaning it does not learn an explicit model from the training data. Instead, the training phase involves merely storing the dataset, making it straightforward to implement. Additionally, KNN is non-parametric, meaning it makes no assumptions about the underlying distribution of the data [10]. KNN is also an intuitive algorithm that remains relevant in many fields of machine learning. While it has limitations, such as its sensitivity to dataset size and irrelevant features, these can be mitigated with feature scaling and careful choice of hyperparameters like *k*. Tools like Scikit-learn provide robust implementations of KNN, making it accessible for practitioners [11]. The K-Nearest Neighbors (KNN) algorithm has emerged as an intuitive yet surprisingly sophisticated tool for prostate cancer analysis. By comparing new patient profiles to historical

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cases, this method provides what [12] described as a "topological approach to malignancy prediction" - particularly valuable when interpreting ambiguous biopsy results or borderline PSA levels. Recent methodological innovations have transformed KNN from a basic classifier to a clinically relevant tool. The development of hybrid KNN-SVM architectures [13] has achieved over 92% accuracy in distinguishing critical Gleason score boundaries, a task that challenges even experienced pathologists.

Principal Component Analysis

Principal Component Analysis, or PCA, has become a powerful tool in prostate cancer research, especially when it comes to making sense of large and complex medical data. In imaging, for example, PCA helps researchers pull out the most important patterns from detailed MRI scans. One study used PCA on dynamic contrast-enhanced MRI (DCE-MRI) to highlight subtle differences between cancerous and healthy tissues [14]. By simplifying the data and focusing only on the problems, this method made it easier to detect prostate cancer more accurately. Another study found that PCA could extract key features from medical images better than traditional approaches, helping doctors classify tumors with greater confidence [15]. Thanks to this, we're getting better at catching prostate cancer early—when treatment is most effective.

But PCA isn't just for imaging. It's also helping doctors understand how treatments affect patients, and even how people make decisions about their care. In radiation therapy, researchers have used PCA to look at dose-volume histograms (DVHs) basically maps of how much radiation different parts of the body receive. They found that certain patterns in these maps were linked to side effects like bowel or urinary problems [16,17]. With this information, doctors can now tailor treatments to reduce those risks. Therefore, when it comes to understanding patient choices, PCA has helped sort through the many factors like age, beliefs, finances, and fear that influence how men choose their prostate cancer treatments [18]. In short, PCA is helping us move toward more personalized, safer, and more informed care for people facing prostate cancer.

Result and discuss

To analyze the prostate cancer dataset, we implemented a three-stage computational pipeline. First, preprocessing involved removing non-numeric identifiers and irrelevant columns while encoding categorical diagnostic labels numerically. Feature standardization was applied using z-score normalization to ensure equal contribution of variables like PSA levels and tumor volume to subsequent analyses. Principal Component Analysis (PCA) then reduced dimensionality while preserving diagnostic information, with the first two principal components collectively explaining 62.93% of the variances (PC1: 37.04%, PC2: 25.89%) - suggesting these transformed features effectively capture the dataset's discriminative structure. The KNN classifier was subsequently trained on the PCA-transformed data, where the reduced feature space addressed the curse of dimensionality while maintaining clinically relevant patterns. Model performance was quantitatively evaluated through classification accuracy and confusion matrix analysis, with component weighting visualized through biplots to interpret the contribution of original features to the principal axes. This integrated approach balances computational efficiency with diagnostic interpretability, which is particularly valuable for clinical decision support systems handling heterogeneous oncology data. The first two components account for 62.93% of the variance in the dataset. Figure 1 below is the PCA-transformed data to see how the samples are distributed in this reduced 2D space.

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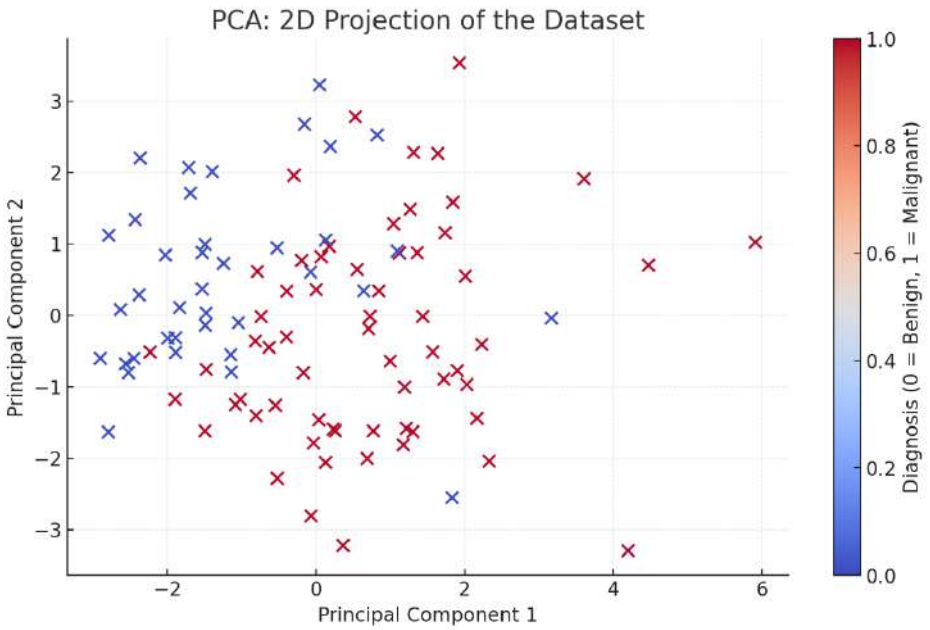

Figure 1. PCA Transformed Data

The PCA plot shows the dataset projected onto two principal components. The points are colored by their diagnosis result (0 = Benign, 1 = Malignant). There appears to be some separation between the two classes, indicating that PCA effectively captures variance in the data.

The next step is to use this PCA-transformed data to train and evaluate a K-Nearest Neighbors (KNN) classifier. The KNN classifier's performance using the PCA-transformed data is as follows:

- **Accuracy**: 76.67%
- **Confusion Matrix**:

$$\begin{bmatrix} 7 & 4 \\ 3 & 16 \end{bmatrix}$$

  - True Negatives (0 classified as 0): 7
  - False Positives (0 classified as 1): 4
  - False Negatives (1 classified as 0): 3
  - True Positives (1 classified as 1): 16
- **Classification Report**:
  - Precision:
    - Benign (0): 70%
    - Malignant (1): 80%
  - Recall:
    - Benign (0): 64%
    - Malignant (1): 84%
  - F1-score:
    - Benign (0): 67%
    - Malignant (1): 82%

The model performs better for malignant cases (class 1) compared to benign cases (class 0).
When using PCA and KNN, the accuracy of the model is 76.67%. This means that the model was able to correctly classify about 76.67% of the test sample.
Of the 30 samples in the test data:

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Benign (0): 7 out of 11 cases were correctly classified.
Malignant (1): 16 of the 19 cases were correctly classified.

CONCLUSION

This research concludes that PCA (Principal Component Analysis) managed to reduce the data dimension to two main components that still maintained about 62.93% variance from the original data. With only two dimensions, the data still has enough information to separate the classification classes (Benign and Malignant). And KNN (K-Nearest Neighbor) is used to classify data based on the results of the PCA transformation. This model utilizes the proximity between data points in the PCA space to predict diagnosis.

With PCA, although the data is reduced to two dimensions, the model is still able to achieve quite good accuracy (76.67%). However, if you want more optimal results, higher dimensions or non-reduced features may be more effective for the KNN algorithm. You can also try tuning KNN parameters (such as the number of neighbors, n-neighbors) to see if performance improves.

Acknowledgments

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The analysis of computational thinking skills through gender-based teaching materials

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Abstract. *This study aims to analyze computational thinking skills through gender-based preferences in teaching materials, exploring how various formats—digital, print, and interactive tools—affect skill development. The survey, completed by 55 respondents, investigates key computational skills, including decomposition, pattern recognition, abstraction, and solution evaluation, concerning material types preferred by gender. Findings reveal a strong preference for digital materials, particularly among male respondents, while female respondents demonstrated balanced preferences for both digital and print formats. The results underscore the significance of illustrations in learning, with 95% of respondents indicating that visual aids enhance comprehension, particularly for complex concepts. Additionally, female respondents' frequent use of software and automation tools highlights a gender trend in technology engagement. Regarding computational skills, materials were most effective in promoting abstraction, with 73% of respondents reporting improved understanding. However, gaps were identified in supporting pattern recognition and solution evaluation skills, suggesting the need for more examples and interactive content tailored to these areas. The study concludes with recommendations for integrating diverse, gender-inclusive materials, emphasizing real-world applications and interactive tools to foster computational thinking skills equitably. This research contributes to understanding the role of gender-based preferences in computational learning, providing insights for designing inclusive educational materials that support diverse learning needs.*

Keywords: *Computational Thinking Skill, Teaching material, Gender, qualitative research, quantitative research*

Introduction

This study investigates how gender-based preferences in teaching materials impact the development of computational thinking skills. With the rise of digital learning resources and the importance of computational thinking in education, understanding gender-specific preferences can provide insights for creating inclusive and effective learning environments. Computational thinking involves problem-solving through key skills such as decomposition, pattern recognition,

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abstraction, and algorithmic thinking, which are crucial across various disciplines. This research aims to identify gender-based differences in preferences for teaching materials and examine their effectiveness in enhancing computational skills.

Recognition of the importance of computational thinking has helped fuel the rapid development of related educational efforts and programs over the past decade[1]. Therefore, computational thinking skills must be improved in all parts of learning, including learning techniques, teaching materials, and learning strategies. Collaborating between Problem-solving and discussion techniques is recommended in teaching[2]. [3] stated that teaching materials of the developed scientific literacy concepts were effective in improving the students' computational thinking skills. Control of learning material is also worked in developing computational thinking student [4]. Based on this, researchers are interested in analyzing the impact of using teaching materials on computational thinking abilities. Furthermore, researchers analyze focusing on gender-based preferences. However, according to inferential analysis, that [5] have done, that there are no significant differences between male and female students in any computational thinking skills. It is due to the educational strategy focused on solving real problems in the student community and generated the same enthusiasm in female and male students compared to other activities. Even so, researchers remain focused on how differences in preferences in reading teaching materials affect students' computational thinking abilities.

Literature review

Computational thinking

In today's rapidly evolving world, developing computational thinking (CT) skills is essential to preparing students to succeed in complex problem-solving environments. Teachers play a critical role in developing these skills by embedding CT principles into instructional materials, regardless of subject area. In doing so, educators can equip students with the ability to break down problems, identify patterns, and develop solutions in a structured manner, which fosters creativity and analytical thinking. In math lessons, teachers can encourage students to solve complex word problems by breaking them into smaller, sequential steps. For example, when teaching fractions, educators might first guide students to understand the numerator and denominator separately before tackling operations with fractions. Interactive tools like online fraction manipulatives or worksheets with visual aids can make decomposition engaging[6].

Computational Thinking (CT) is a systematic process that involves several key steps to solve problems effectively. These steps guide individuals in approaching challenges logically and breaking them into manageable components. The first step is Decomposition, where a large and complex problem is divided into smaller, more manageable parts. This makes the problem less overwhelming and allows each part to be addressed individually. The second step, Pattern Recognition, focuses on identifying similarities, patterns, or trends within the problem or by comparing it to previously encountered problems. Recognizing these patterns simplifies the problem and allows for the application of known solutions. Next comes Abstraction, where unnecessary details are ignored to focus on the most important aspects of the problem. This step helps in simplifying complex problems by concentrating on the core elements. The fourth step is Algorithm Design, which involves creating a step-by-step plan or rules to solve the problem. Algorithms provide clear instructions that can be followed systematically by humans or machines. Finally, Evaluation ensures the solution is accurate and efficient. During this stage, the solution or algorithm is tested to verify its effectiveness, and necessary refinements are made if it falls short. By following these steps, computational thinking helps individuals analyze tasks systematically,

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make informed decisions, and approach challenges with a structured mindset. This thought process is applicable across disciplines and encourages creativity, logical reasoning, and innovation [7,8]

Gender differences in learning preferences

Studies suggest that gender can influence learning preferences, impacting engagement and comprehension[6]. While males may prefer more direct, algorithmic approaches, females often find value in collaborative and context-rich materials. This study contributes to this field by examining how these gender-based preferences affect computational thinking skills.

Cognitive and emotional factors contribute significantly to how individuals of different genders process information and engage with educational tasks. Studies suggest that males tend to exhibit a more abstract and logical approach to learning. They often favor structured tasks with clear goals, preferring activities that are task-oriented and results-driven. Males may excel in subjects such as mathematics and engineering, where the focus is on problem-solving and clear outcomes. They tend to thrive in environments where tasks are well-defined and can be approached in a systematic, linear manner.

In contrast, females often show greater strength in verbal communication and are more likely to engage in collaborative, social learning experiences. They tend to excel in environments that require reflection and communication, and they are more inclined to value the relational and emotional aspects of learning [9]. Females often prefer tasks that involve social interaction and real-world applications of knowledge, such as discussing literature or collaborating on group projects. This tendency reflects a more empathetic and cooperative approach to learning, which is often linked to a stronger ability to work in groups and consider multiple perspectives.

By understanding the preferences of both genders, educators can design curricula that incorporate a range of learning styles, encourage collaboration, and foster a more supportive classroom atmosphere. Ultimately, recognizing and addressing gender differences in learning preferences will help ensure that all students, regardless of gender, can achieve their full potential.[10,11]

The role of teaching materials

Different formats of teaching materials digital, print, and interactive have been shown to support diverse learning styles. [12] demonstrated that interactive materials like coding platforms enhance computational skills effectively. This study further explores whether gender differences exist in material preference and the perceived efficacy of each format in fostering computational thinking.

Methodology

A total of 55 participants responded to the survey, with balanced representation across genders. The survey was distributed among university students enrolled in computational thinking and related courses. The survey contained questions on preferred teaching materials (digital, print, and interactive), the frequency of software use, and perceived effectiveness in enhancing computational skills such as decomposition, pattern recognition, abstraction, and solution evaluation. The responses were analyzed to identify trends in gender-based preferences and their impact on computational skill development.

Data analysis involved descriptive statistics and comparative analysis by gender. Responses were categorized based on computational thinking skill components and examined for trends and differences in gender-based preferences.

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Results and discussion

Teaching material preferences

Digital materials: accessibility and flexibility

A significant majority of male respondents (65%) expressed a preference for digital materials. The primary reasons cited for this preference were accessibility and flexibility. Digital resources, such as online textbooks, videos, and interactive platforms, allow students to access learning materials at any time and from any place, which is particularly appealing in today's fast-paced, technology-driven world. Digital tools also often provide instant feedback, enabling students to assess their understanding and adjust their learning accordingly. The flexibility of digital resources, allowing students to engage with content at their own pace, has made them increasingly popular among male students, who value the autonomy these tools provide in their learning journey.

Print materials: focus and structure

In contrast, female respondents displayed a more balanced approach toward teaching materials. About 45% of female students preferred print materials, citing their ability to enhance focus and minimize distractions. Print materials, such as textbooks and printed worksheets, provide a structured and linear format for learning, which many students find helpful for maintaining concentration. The tactile nature of printed resources also allows students to engage in a more focused, immersive study experience, free from the potential distractions of digital devices. For some, the physical act of turning pages and highlighting key information in a print textbook enhances their comprehension and retention of the material.

Interestingly, the other 45% of female respondents favored digital materials for their convenience and multi-dimensionality, showing that digital resources are also well-regarded for their interactive features, such as videos and links to supplementary resources. This balanced preference suggests that female students value the versatility and depth that both digital and print materials can offer.

Interactive materials: bridging the gap

Regardless of gender, both male and female students highly valued interactive materials, particularly for their ability to support the understanding of complex concepts. Interactive tools such as simulations, online quizzes, and problem-solving platforms offer students the opportunity to engage with content actively. These resources allow students to experiment with mathematical problems, visualizations, and scenarios in ways that traditional materials cannot. Interactive tools are especially effective in subjects that involve abstract concepts, as they provide a hands-on experience that fosters a deeper understanding.

By incorporating interactive materials, educators can create more engaging and effective learning experiences, catering to the shared preference across genders for resources that encourage active participation and critical thinking. And it's visualized in Figure 1.

Importance of illustrations and software

Visual aids were seen as essential by 95% of respondents, with females expressing a slightly higher preference for illustrated content. This indicates the universal value of illustrations in enhancing understanding across gender Female respondents reported a higher frequency of using software for learning purposes, with 60% using automation and digital tools regularly. Male

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respondents, while frequent users of software, showed a lower engagement in automation tools. The result is expressed in chart in Figure 2.

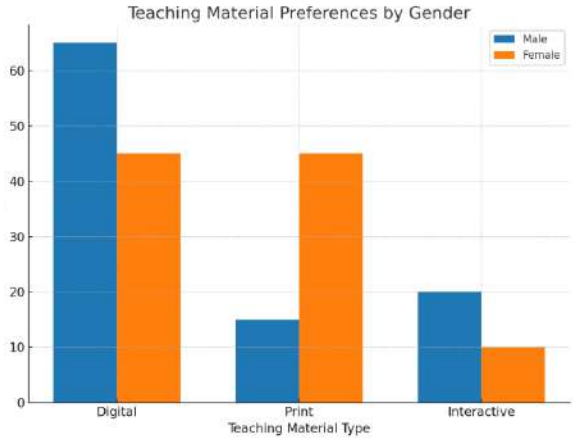

Figure 1. Teaching material preference by gender

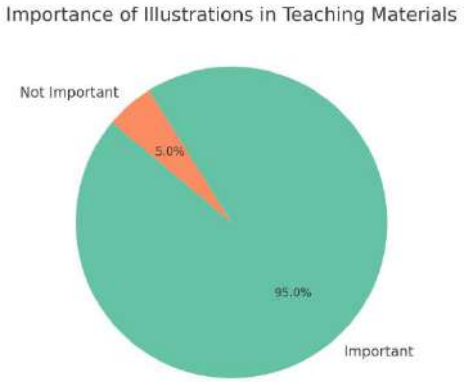

Figure 2. The importance of illustrations in teaching materials

Computational thinking skill development

There are 4 parts that we visualized, such as:

Decomposition: 47% of respondents felt that current teaching materials support decomposition, although improvements were desired.

Pattern Recognition: Only 40% found materials effective in supporting pattern recognition, indicating a need for more examples and practice exercises.

Abstraction: Abstraction received the highest support, with 73% of respondents reporting improvement due to the teaching materials used.

Solution Evaluation: Solution evaluation was the least supported skill, with only 35% indicating that materials sufficiently aided in this area.

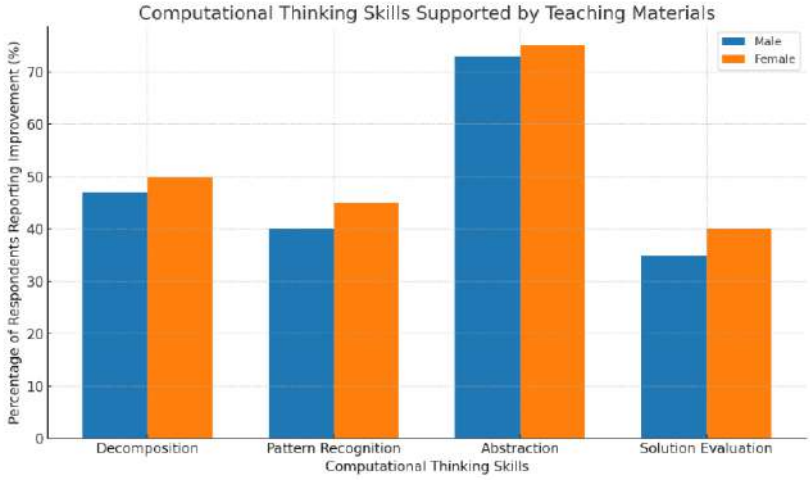

Figure 3. Computational Thinking Skills Supported by Teaching Materials

Based on the result**,** there are three points that we provide from the study, such as:

1. Gender differences in teaching material preferences

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The findings align with previous studies suggesting that gender can influence learning preferences. The strong preference for digital materials among male respondents may reflect a greater inclination for flexibility, while the balanced approach observed among females indicates a preference for varied resources, which may support engagement and comprehension.

2. Effectiveness of materials in developing computational skills

The results highlight the importance of abstraction in computational thinking, as it was the most effectively supported skill. However, the gaps in supporting pattern recognition and solution evaluation suggest a need for enhanced teaching materials that provide real-world applications, guided practice, and interactive feedback.

3. Implications for designing gender-inclusive teaching materials

These findings suggest that gender-inclusive materials should incorporate diverse formats, blending digital flexibility with print's focus-enhancing properties and interactive tools for deeper engagement. Additionally, more visual aids and illustrative content could benefit all learners, particularly in explaining abstract or complex concepts.

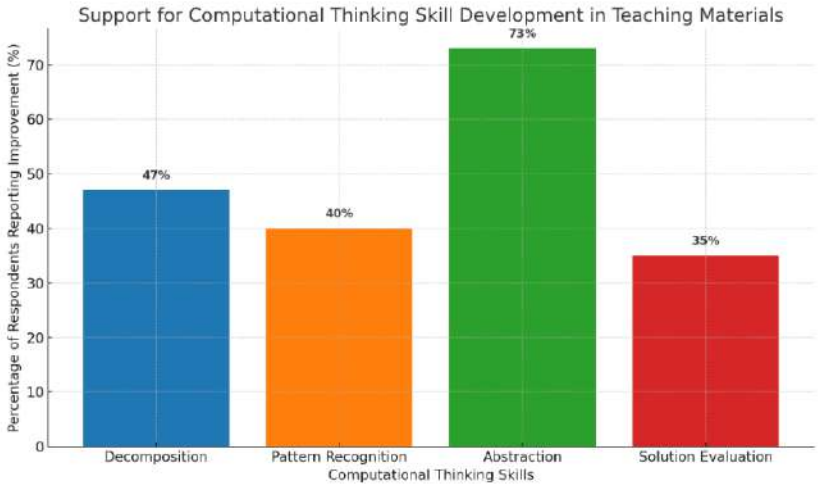

Figure 4. Support of computational thinking skill development in teaching materials

Conclusion

This study underscores the influence of gender-based teaching material preferences on the development of computational thinking skills. By understanding these preferences, educators can design materials that cater to diverse learning needs, enhancing engagement and skill acquisition. Future research should explore how specific material formats impact computational skills over extended periods and further investigate the role of gender in learning material preferences.

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Development of learning media with artificial intelligence (ai): innovation in learning economics mathematics

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Abstract. *Artificial Intelligence (AI) is a very valuable technology nowadays, especially in education. Through effective coaching and feedback, as well as a personalized and adaptive learning experience, AI-based learning technologies can raise the standard of learning. Using artificial intelligence (AI) technology, this research attempts to create learning materials for mathematics. An application called Curipod was used to create this AI-based media. Teachers utilize this resource to implement the learning process on phytagoras. This study's specific goals are to 1) explain how using AI-based learning materials can be used to increase student motivation and comprehension of mathematical concepts, and 2) explain how effective AI-based learning materials are at increasing mathematical comprehension.*

Keywords: *Artificial Intellegence, Economics Mathematics, Learning Media*

Introduction

The integration of technology in learning refers to the use of tools and applications in the teaching and learning process [1].With the rapid development of technology, this integration has become increasingly important in ensuring effective learning that is relevant to the times. The importance of technology integration in learning includes enhancing teaching efficiency, enabling access to various information resources, and strengthening students' technological skills[2]. By understanding and addressing these challenges, the integration of technology in learning can provide significant benefits in enhancing the quality of education[3].

In addition, the integration of technology can also help enhance students' engagement and motivation in the learning process[4]. With the presence of technology, students can learn interactively and enjoyably, making learning more engaging and effective. In addition, technology

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also allows for collaborative learning, where students can work together and share ideas through digital platforms[5]. This provides students with the opportunity to develop social skills and cooperation, which are essential in today's increasingly global and digitally communicating job market. For example, the use of digital learning platforms like Google Classroom allows students to interact with their classmates in group assignments online. They can share ideas, provide feedback, and collaborate efficiently without the limitations of the classroom.

The use of technology in education also allows students to easily and quickly access a variety of information sources and learning materials[6]. With access to the internet, students can seek additional information, watch educational videos, and take online courses to enrich their learning. This not only broadens students' knowledge but also helps them become more independent in the learning process. With technology, learning is no longer limited to textbooks alone, but encompasses various forms of media that can enrich students' learning experiences. Students can also interact with peers and teachers through online learning platforms, allowing them to exchange opinions and contribute ideas collaboratively. This not only enriches their learning experience but also builds essential communication and collaboration skills in this digital age. With continuously evolving technology, students can also access interactive and fun learning applications, making the learning process more engaging and effective [7].All of this proves that technology has brought positive changes to modern education, preparing students to face the challenges of an increasingly complex and rapidly changing world.

Currently, one of the technologies that is very beneficial for education is artificial intelligence[8]. Artificial Intelligence (AI) in learning media refers to the use of advanced technologies such as machine learning and natural language processing to enhance the educational experience[9]. By incorporating AI into learning platforms, educators can personalize learning content, provide real-time feedback, and adapt instruction to meet the individual needs of students. This innovative approach has the potential to revolutionize the way we teach and learn, making education more engaging, effective, and accessible for all learners. Furthermore, AI in learning media can also help educators identify areas where students may be struggling and provide additional support in those areas. This targeted assistance can lead to improved academic performance and increased student confidence. Additionally, AI can analyze data on student progress and performance to help educators make informed decisions about their teaching methods and curriculum. Overall, the integration of AI in learning media holds great promise for creating a more personalized and effective educational experience for students of all ages.

By utilizing AI in learning media, educators can also save time by automating certain tasks, such as grading assignments and providing immediate feedback to students [10]. This allows teachers to focus more on facilitating discussions, engaging students in hands-on activities, and providing individualized support. Furthermore, AI can help identify patterns in student learning and behavior, enabling teachers to intervene early and provide additional support to those who need it most. Overall, the integration of AI in learning media has the potential to revolutionize the way education is delivered and improve student outcomes across the board [10]. For example, in a mathematics class, AI can track each student's progress on specific concepts and provide personalized practice exercises to reinforce understanding. This targeted approach can help struggling students improve their skills and excel in the subject. Additionally, AI can generate detailed reports on student performance, allowing teachers to tailor their instruction to meet the diverse needs of their students effectively.

AI be possible can improve the understanding of concepts, especially in the field of mathematic [11]. However, on the contrary, the researcher found that students' understanding of the concept

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was still in a low category, especially related to the concept. Understanding mathematical concepts, such as the Economics Mathematics, is crucial as it allows individuals to grasp and apply basic mathematical principles effectively). It involves the ability to comprehend mathematical concepts deeply and relate them to different situations or problems encountered. The results of the researcher's initial observation of concept comprehension ability showed that out of 45 students, only 10 students had moderate concept comprehension ability, while students had low concept comprehension.

In fact, this Economics Mathematics is very important in developing the understanding of other mathematical matter to higher dimensions, as in the case of Pythagoreans' theorem in three dimensions, which states that the square of the hypotenuse length of a right triangle in three dimensions is equal to the sum of the squares of the other two sides. This theorem has many practical applications, such as in calculating distances in three-dimensional space or in designing structures with right angles. Overall, the Economics Mathematics is a fundamental concept in mathematics that is constantly being studied and applied in various areas of life. However, the problem in learning phytagoras is that students cannot understand the concept well, let alone develop it to the higher dimension.

Based on the observations made by researchers, there are still many teachers who do not use media in learning[12] , Some who use media are not in accordance with the material, so that for students the Phytagoras theorem is only a memorization, not to the competence of application, let alone to the development. Therefore, researchers are interested in conducting research and development to produce products in the form of learning media. This media will be tested for its feasibility, then it will be tested for practicality in the learning process, especially phytagoras material and finally its effectiveness will be tested by looking at the increase in students' understanding of the concept in the phytagoras .

Literature Review

Artificial Intelligence (AI)

Artificial Intelligence is a field of computer science that specializes in solving cognitive problems commonly related to human intelligence, such as learning, problem solving, and pattern recognition[13,14]. Applications and instructions related to computer programming to do something that in the eyes of humans is intelligent. Artificial intelligence, often abbreviated as "AI", can evoke robots or futuristic landscapes. Artificial Intelligence is moving beyond science fiction robots to modern and sophisticated non-fiction computing. Recently, advances in statistical computing efficiency have allowed Bayesians to successfully advance this field in a number of areas known as "machine learning". Similarly, advances in network computing have led network activists to expand into a subfield called "deep learning." Machine learning (ML) and deep learning (DL) are fields of computer science that originated from the discipline of artificial intelligence[15,16]. Artificial Intelligence is grouped based on its types, including:

1. Weak Artificial Intelligence (Weak AI), Weak Artificial Intelligence is a system designed to perform a specific task using predetermined algorithms and data. Examples of weak Artificial Intelligence are search engines, virtual assistants, voice recognition, and facial recognition. Weak Artificial Intelligence cannot exceed the limits set by programmers.
2. Strong Artificial Intelligence (Strong AI), Strong Artificial Intelligence is a system that is able

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to understand and simulate human cognitive abilities in general, including reasoning, problem-solving, creativity, and awareness. Powerful Artificial Intelligence does not yet exist, but many researchers are trying to develop it. Powerful Artificial Intelligence can pose a threat or opportunity to humans, depending on how we use it.

Machine Learning (ML) according to the Task Force Application System (SAS) is a data analysis method that automates the creation of analytical models. Machine learning is a branch of artificial intelligence that is based on the idea that systems can learn from data, identify patterns, and make decisions with little manual human intervention. With Machine Learning, computers can handle new situations through self-training, experience, analysis, and observation. The relationship between the two is very close. Come to think of it, Artificial Intelligence is an umbrella that includes machine learning. As already explained, Machine Learning is one of the branches or parts of Artificial Intelligence. The task of Machine Learning is to train machine learning. Machine Learning is used to study historical data to find network trends. This means that if a problem arises and is resolved, the problematic data will be examined by Machine Learning to understand what problem is happening in the network.

This allows Network Performance Monitoring to immediately recognize future malicious data. In this way, Network Performance Monitoring alerts you to potentially harmful information without having to conduct in-depth analysis every time. In addition, in the world of artificial intelligence (Artificial Intelligence), there is the term deep learning which is a subfield of machine learning, deep learning is a field of machine learning whose algorithms are inspired by the structure of the human brain. Currently, deep learning techniques are very popular among data practitioners and attract the attention of many parties. It is true, deep learning technology has been applied to many different high-tech products such as self-driving cars. In addition, deep learning is the source of products and services that we use every day. Examples include digital assistants, Google Translate, and voice-activated devices (smart devices that can be activated by voice). Deep Learning not only has a big impact on the development of artificial intelligence, but also poses challenges that need to be overcome in the Artificial Intelligence security landscape.

Understanding mathematical concept Ability

Comprehension ability is an important aspect that must be possessed by every student in teaching and learning activities, because comprehension ability allows students to be involved in overcoming various problems. Comprehension is also described as the ability to express, explain or draw conclusions that differ from textbooks. Understanding is the ability of a person to understand what he has acquired or learned and to explain from one form to another so that he can develop his knowledge [17]. The term "concept" refers to an individual or group of ideas that have a specific definition that states that the idea is the basis of science, including principles, laws, and theories. A concept is an abstraction that allows a person to group objects or events and describe whether or not the object or event is an example of a given ide[18]. Understanding mathematical concepts is an important factor in improving learning outcomes.

Understanding mathematical concepts refers to the ability of students to understand, explain,

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apply, and internalize the idea of ideas about mathematical concepts [19]. So that they can express it in their own words through the mathematics teaching and learning activities that they have undergone. Concept understanding is one of the mathematical skills or knowledge achieved during mathematics teaching and learning activities [20]. This shows students' understanding of the concepts they are learning, their ability to explain their relationships, and their ability to apply concepts or algorithms flexibly, accurately, efficiently, and precisely in solving problems. Therefore, understanding mathematical concepts has a very important role**.** The ability to master mathematical concepts will provide students with assistance in learning mathematics and applying it in real life. Understanding concepts is also the basis for the development of other mathematical skills and is a basic achievement for students. Based on some of the definitions presented, it can be concluded that concept understanding is the ability of students to understand, explain, apply and re-implement ideas or ideas related to mathematical concepts. With an understanding of the concept, students can remember and utilize the learning that has been obtained. Here are the indicators of concept understanding based on several experts [21].

Restate learned concepts

1. Classifying objects based on mathematical concepts
2. Providing examples instead of Examples
3. Using and utilizing and having certain procedures or operations
4. Applying concepts or algorithms in problem-solving

Methods

The research method used in this study is the development of the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) model developed by Reiser and Mollenda. In this ADDIE development design model, there are five stages of research implementation, which are as follows at Figure 1: Analyze Stage, at this stage the activities carried out are to analyze the needs of the learning process. Where later the products developed can meet the needs of the desired targets. The analysis is applied based on learning needs and learning materials. The analysis was carried out by conducting an initial survey and assessment on SMP Negeri 27 Medan students to become the basis for differentiated learning treatment, both in the form of processes, assessments and products.The research design of this non-equivalent control group design is:

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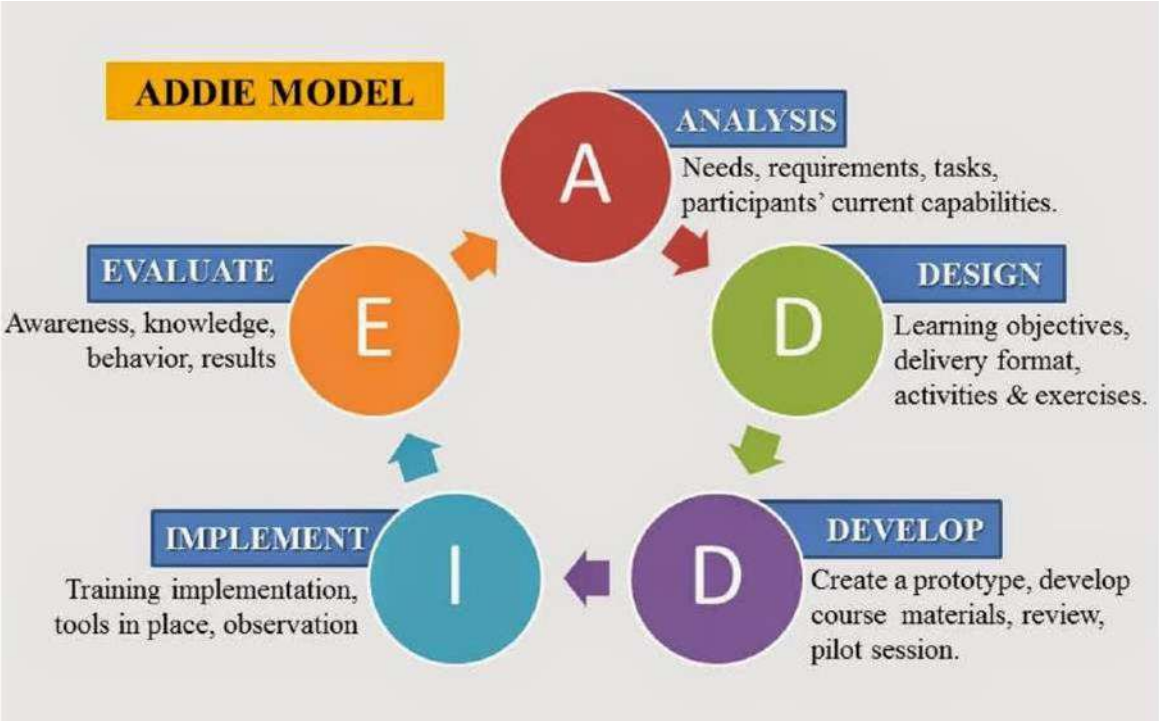

Figure. 1 Stages of the ADDIE Model

Design Stage, his activity is a design activity based on a needs analysis that has been carried out previously. At this stage, the researcher conducts: 1) Designing Differentiated Learning, 2) Designing AI-based Teaching Materials (Story Board), 3) Designing AI-Based Student Worksheets (LKPD) (Story Board), 4) Selecting AI tools that are used in development 5) Designing Research Instruments in the form of concept comprehension tests, learning motivation questionnaires, student response questionnaires, rubrics and interview items, practicality questionnaires, effectiveness questionnaire.

Development Stage, then developing a Differentiated Learning Design (Teaching Module), Developing Teaching Materials and LKPD Using AI Tools. Next, export the device in several outputs, namely html5 and offline-based, into an application file that can be extracted in a computer device or mobile device. At this stage, research instruments were also developed in the form of a practicality questionnaire. Then at this stage, a review of the feasibility of the product was carried out by conducting a validity test which was assessed by 5 lecturers and 2 teachers. Furthermore, this feasibility test will be revised according to the input from the lecturers and teachers. To find out the practicality of the product, a small-scale test was carried out on 10 students who were the object of the research. The results of the validity and practicality test are then used as input for improvement and development of products to be of higher quality.

Implementation Stage, after the product is developed, the next stage is to carry out product implementation, namely large-scale trials. Where the trial will be carried out on grade VII students of SMPN 27 Medan. This test is to see the effectiveness of the product in the form of AI-based

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differentiated learning tools.

Evaluation Stage, after the implementation stage, the results of all instrument implementation activities are obtained. The results obtained are the basis for the evaluation stage of the product. The source of evaluation can be obtained from the results of interviews with students, student response questionnaires, or notes while in the field during the implementation. On the basis of all these results, a final revision was made to the assessment instrument. Products that have been revised according to the results of the evaluation are called products that have met the feasibility aspects.

Result and Discussion

This research produces an AI-based learning media by utilizing an AI application, namely Curipod. This learning media is interactive, so there is 2-way communication, this can happen because in this media there are feature features that researchers can use to make the media more interactive, the choice of feature features includes Poll, Word Cloud, drawings, open question, and AI feedback. With this feature, students can use their devices or gadgets to provide answers or responses from the instructions given. This interactive media can foster students' interest so that learning activities increase [22].

Figure 1. Cover display of learning media

This AI-based learning media received input from media experts and material experts, namely:

1. The lack of color consistency on each slide, should just choose one or 2 of the same color themes for each slide.
2. The background slide does not show the characteristics of the material being taught, it is better to provide illustrations of images related to the mathematics material.

The following is the feasibility score of Curipod's AI-based learning media.

Table 1. Qualification Value

Ahli Materi	Ahli Media	Katagri
3,0	3,1	Layak
3,1	3,3	Layak
3,02	3,1	Layak

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After all learning tools get good feasibility scores and good readability tests, these learning tools are used in the learning process. The learning outcomes achieved by using AI-based differentiated learning tools are as follows.

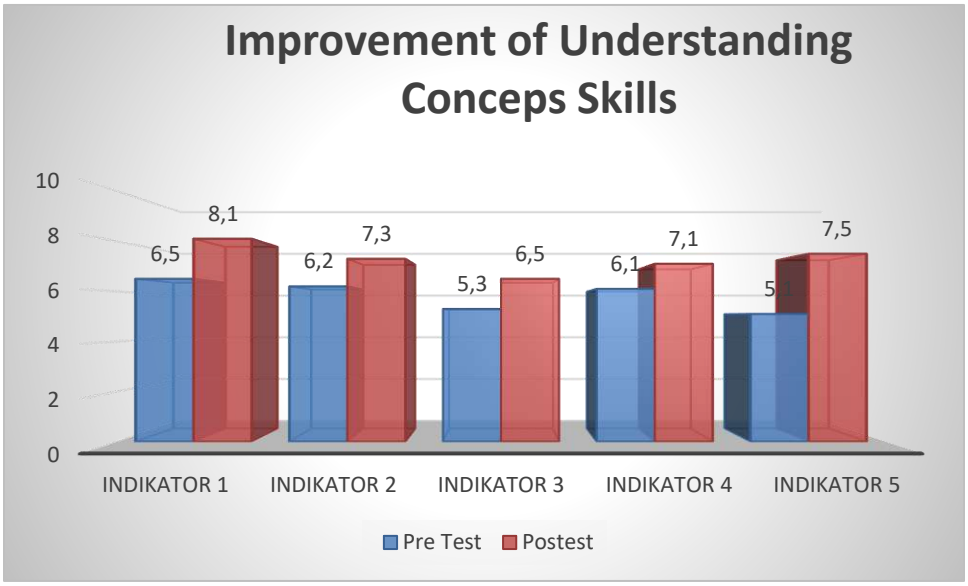

Figure 4. Improving Concept Comprehension Skills

This research is included in the type of development research that follows the ADDIE development model consisting of five stages, namely analysis, design, development, implementation, and evaluation [23] The following is an explanation of the data from media development using the ADDIE model.

The initial stage of this research is to analyze the needs of the learning process. Needs analysis is an effective way to identify problems that arise in a learning organization [24], This analysis was carried out on the initial abilities and characteristics of students. This is important to do before developing a learning tool because an initial characteristic analysis result is needed in developing a media [25]. Initial ability was analyzed based on the results of initial observations in grade VIII students of SMP Negeri 27 Medan. There are 100% of students who have facilities that support the digital and network-based learning process. This facility is in the form of gadget ownership. Based on the survey, data was obtained that 25 students had high abilities in utilizing features in gadgets, 8 students had moderate abilities while only 2 students were in the low category in utilizing features in their gadgets. These initial characteristics and abilities greatly support researchers in developing digital-based learning tools.

Then analyze the curriculum that is being implemented in the school. The curriculum that is being implemented at SMP Negeri 27 Medan is an independent curriculum, this curriculum facilitates a differentiated learning process. Students will have the opportunity to learn independently and creatively. This allows every student in Indonesia, who come from various tribes and cultures, to have diverse learning approaches according to their respective characteristics. Learning differentiation is an effort to accommodate the diversity of learners based

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on their differences in characteristics [26]. When students are in the school environment, they bring various kinds of differences. These differences can be in the form of abilities, experiences, talents, interests, languages, cultures, learning styles, and many more. The diversity of students is a reality in schools. Each student has different abilities, experiences, talents, interests, languages, cultures, and learning styles. Therefore, it is unfair if teachers only deliver the subject matter and assess students in the same way. Teachers need to pay attention to this diversity and provide services that suit the needs of each individual[26]. Based on the needs of the curriculum that is being implemented in schools, researchers develop a teaching medium that will facilitate the learning process. In the media there is a video that will facilitate students who have an audio-visual learning style, for visual students the media facilitates with material infographics, while for kinesthetic students there is a drawing service.

The next stage is Design, At this stage the researcher conducts 1) Designing a teaching mat consisting of 3 sub-subjects about phytagoras, 2) Designing an AI-Based video, 3) Designing a Curipod AI-based storyboard, 5) Designing an assessment instrument in the form of a student questionnaire, a practicality questionnaire, a readability questionnaire, and a feasibility questionnaire, so that at this stage a draft 1 is produced which will be displayed in the form of a flowchart.

The next stage is the development stage, the results of the flowchart in the previous stage were developed into an AI-Based Video product, AI-Based Teaching Media. Then conducted product trials to 3 lecturers who are subject matter experts and 2 media experts. The results of the validation given by the experts as shown in table 1 that the product developed is suitable for use based on the aspect of assessing the material experts in terms of content and construction, as well as media experts stating that the product is feasible in terms of presentation and ease of use of the features in the product. The validity of draft 1 products that have been assessed by these experts also received input from experts as seen in table 1. The result of the revision of draft 1 became a draft 2 product. This validation is to ensure that the product, in this case the learning media, is in accordance with the requirements and meets the expected learning objectives[27]. The next stage is the product implementation stage, this stage is divided into 2 parts, namely small-scale and large-scale implementation. The small-scale test is the implementation of the product on 10 grade IX students.

Table 2. Question item readability value

Students	Criteria		
	I	II	III
1	Good	Good	Good
2	Good	Good	Good
3	Good	Good	Good
4	Good	Good	Good
5	Good	Good	Good
6	Good	Good	Good
7	Good	Good	Good
8	Good	Good	Good
9	Good	Good	Good
10	Good	Good	Good

This test was carried out to obtain the readability score of the learning device product. Based on table 2, it shows that it is well readable. This adds to the quality of the products developed. The second stage of implementation is large-scale testing. All learning tools are implemented i, before

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the implementation of the implementation, students are given pretest questions, the average score of the student postest is 5.84, after the learning process the posttest data is taken with the average score of the student postest is 7.3, it can be seen that there is an increase in students' ability to understand mathematical concepts, as well as an increase in per indicator of students' ability to understand concepts. The learning media developed facilitates the learning needs of students, so that students with visual learning styles can take advantage of PPTs in curipods, as well as students with audio visual learning, they can see the videos listed in the media. The learning process that facilitates the learning needs of students will have a positive effect, namely increasing student activities and achieving learning goals[28][29]. The media developed meets the needs of students based on the results of the initial analysis, students have plurality in learning styles so that this media is present in facilitating it.

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Dynamics analysis of seir models on the spread of tuberculosis with vaccine effects in medan

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Abstract. *This research aims to analyze the spread of Tuberculosis (TB) disease using the SEIR (Susceptible-Exposed-Infectious-Recovered) model which is modified to include the effect of vaccination as a mitigation effort. This SEIR model separates populations into four compartments: susceptible, exposed, infectious, and recovered. Vaccine effectiveness is calculated to see its impact on the rate of decline in the number of infected individuals. Based on the fixed point stability analysis, it was found that vaccination can significantly reduce the basic reproduction rate (R_0), which is the main indicator in determining the rate of infection spread. Numerical simulations were conducted to observe population dynamics in various vaccination coverage scenarios. The simulation results show that increasing vaccination coverage contributes to reducing the number of new TB cases and accelerating population recovery. Thus, widespread vaccination is indicated as an effective step to control the spread of TB.*

Introduction

Tuberculosis (TB) remains a serious global health problem to date. This infectious disease caused by the bacteria Mycobacterium tuberculosis mainly attacks the lungs and can spread through droplets when the sufferer coughs or sneezes. According to the World Health Organization (WHO), in 2022 there are an estimated 10.6 million new cases of TB worldwide, with 1.3 million deaths [1]. In Indonesia, TB remains a significant public health challenge. Based on data from the Indonesian Ministry of Health in 2023, Indonesia ranks second in the world with the highest TB burden after India. There are 824,000 new TB

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cases recorded with a death rate of 93,000 people per year. In Medan City, as the third largest city in Indonesia and the capital of North Sumatra Province, TB cases also show a worrying trend. Based on data from the Medan City Health Office in 2022, there were 7,823 new TB cases recorded with a Case Notification Rate (CNR) of 335 per 100,000 population, far above the national average of 271 per 100,000 population.

In developing countries, TB is often closely related to socio-economic conditions, such as poverty, population density, and limited access to health services. Various TB control efforts have been made, ranging from active case finding, treatment with the DOTS (Directly Observed Treatment Short-course) strategy, to the BCG (Bacillus Calmette-Guérin) vaccination program. Vaccination as one of the primary prevention measures plays an important role in reducing the risk of TB transmission. The BCG vaccination provides significant protection against pulmonary TB, with an effectiveness rate reaching 70-80% in children. However, the effectiveness of vaccines in adults is still a subject of ongoing research [2]

Mathematical modeling often involves simplifying complexity by identifying important variables, developing equations or systems of equations, and using mathematical analysis techniques to gain insights or predictions [3]. Mathematical modeling has become a powerful tool in analyzing and predicting the spread of infectious diseases [4][5] developed a mathematical model to analyze the impact of various interventions on TB dynamics, including treatment and isolation. A number of researchers focus on modeling the influence of social and behavioral factors on TB transmission. These studies provide an important foundation in understanding the dynamics of TB transmission, but have not specifically examined the impact of vaccination programs using the SEIR model approach [6].

The SEIR (Susceptible-Exposed-Infectious-Recovered) mathematical model has been widely used to analyze the dynamics of the spread of infectious diseases, including TB. This model divides the population into four compartments that describe the status of individuals with the disease. used the SEIR model to analyze an urban TB outbreak [7], applied a similar model to study the transmission of drug-resistant TB. However, both studies have not explicitly considered the effects of vaccination in their models [8].

Given the importance of vaccination programs in controlling TB, a more comprehensive analysis of their impact at the population level is needed. Mathematical modeling approaches can provide valuable insights into how different levels of vaccination coverage affect the dynamics of disease spread. that modifying epidemiological models to include vaccination factors can aid in the evaluation and optimization of disease control strategies [9].

This study aims to examine the dynamics of TB spread using a modified SEIR model that takes into account the effects of vaccination. Unlike previous studies, this study will focus on analyzing the impact of different levels of vaccination coverage on the basic reproduction rate (R0) and population dynamics. Fixed-point stability analysis will be conducted to understand the long-term behavior of the system, while numerical simulations will help evaluate the effectiveness of different vaccination scenarios in TB control efforts.

Through this approach, it is hoped that a better understanding of the role of vaccination in TB control can be obtained, as well as providing a scientific basis for decision-making in future TB control programs. The results of this study can contribute to the development of more effective and efficient vaccination strategies in global efforts to control the spread of TB.

Mathematic model

In the SEIR model for the spread of tuberculosis in Medan, the human population is divided into the following sub-populations:

- Susceptible (S): Represents the number of individuals who are susceptible to tuberculosis.
- Exposed (E): Represents individuals who have been infected with tuberculosis but cannot yet

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transmit the disease.

- Infected (I): Represents the number of individuals who are infected and capable of transmitting tuberculosis.
- Recovered (R): Represents individuals who have recovered from tuberculosis and are immune to reinfection.

The formulation of the model in this study introduces a parameter that accounts for the recovery and immunity of susceptible individuals through vaccine effects (σ).

The steps undertaken in this study to formulate the model are as follows:

a. Establish a system of differential equations based on the growth rate per unit of time for each sub-population (S, E, I, R) by incorporating the parameter σ (vaccine effect), which also involves the total population (N).
b. Determine the general form of the basic reproduction number (R_0).

After determining the model formulation, numerical simulations were performed using the fourth-order Runge-Kutta method to analyze how the distribution affects the developed model and to evaluate the stability of the model. The SEIR transmission scheme for tuberculosis in Medan can be seen in Figure 1 below:

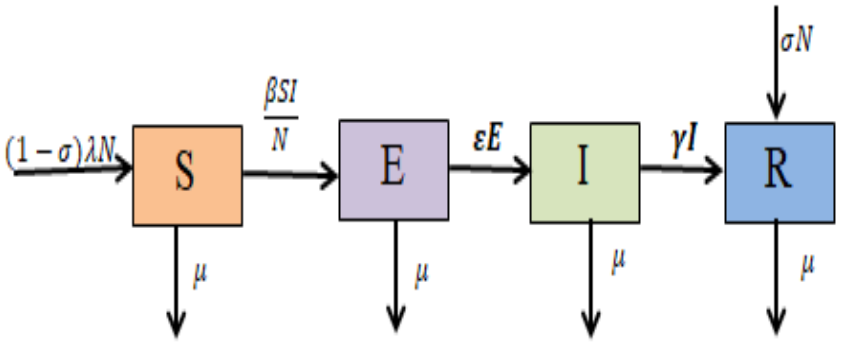

Figure 1. Scheme of Transmission Model for TB in Medan

Based on the model diagram, the SEIR model for the spread of tuberculosis in Medan is formulated by incorporating vaccination as a model parameter. This model consists of a system of nonlinear ordinary differential equations involving four dependent variables (S, E,I, and R) and one independent variable (t) as follows:

$$\begin{aligned}
\frac{dS}{dt} &= (1-\sigma)\lambda N - \frac{\beta SI}{N} - \mu S \\
\frac{dE}{dt} &= \frac{\beta SI}{N} - (\varepsilon + \mu)E \\
\frac{dI}{dt} &= \varepsilon E - (\gamma + \mu)I \qquad (1) \\
\frac{dR}{dt} &= \gamma I + \sigma N - \mu R \\
N(t) &= S(t) + E(t) + I(t) + R(t)
\end{aligned}$$

In this model:

- $(1-\sigma)\lambda N$: Represents the rate at which new individuals enter the susceptible (S)class due to birth or migration, with a proportion $(1-\sigma)$ of these individuals not receiving vaccination.
- $\frac{\beta SI}{N}$: Represents the infection rate, where individuals in the susceptible (S) class move to the

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exposed (E) class after contact with infected (I) individuals.

- ε : Represents the rate at which individuals transition from the exposed (E) class to the infected (I) class.
- γ : Represents the recovery rate of infected (I)individuals moving into the recovered (R) class.
- σ : Represents the proportion of vaccinated individuals who directly enter the recovered (R) class.
- μ : Represents the natural death rate affecting all sub-populations.

This model enables the analysis of the effectiveness of vaccination in influencing the dynamics of tuberculosis transmission in Medan.

Next, the system (4.1) is nondimensionalized to reduce the components in the system. Let $s, e, i,$ and r represent proportions with values $s + e + i + r = 1$. Thus, the domain of the function $D = \{(s, e, i, r): e \geq 0, i \geq 0, r \geq 0, e + i + r < 1\}$ is invariant for System (1).

Where: $s = \frac{S}{N}; e = \frac{E}{N}; i = \frac{I}{N}; r = \frac{R}{N}$, the System (1) can then be rewritten as follows:

$$\begin{aligned} \frac{ds}{dt} &= (1-\sigma)\lambda - (\beta i + \mu)s \\ \frac{de}{dt} &= \beta si - (\varepsilon + \mu)e \\ \frac{di}{dt} &= \varepsilon e - (\gamma + \mu)i \\ \frac{dr}{dt} &= \gamma i + \sigma - \mu r \\ N(t) &= s + e + i + r \end{aligned} \qquad (2)$$

From System (2), the equilibrium points can be determined by setting the right-hand side to zero. Thus, System (3) is obtained as follows:

$$\begin{aligned} (1-\sigma)\lambda - (\beta i + \mu)s &= 0 \\ \beta si - (\varepsilon + \mu)e &= 0 \\ \varepsilon e - (\gamma + \mu)i &= 0 \\ \gamma i + \sigma - \mu r &= 0 \end{aligned} \qquad (3)$$

A. *Disease-free Equilibrium Point and Its Stability*

The disease-free equilibrium point is a steady-state solution where tuberculosis (TB) is absent in the population. At this point, no individuals are in the exposed (eee) or infected (iii) classes, meaning $e = i = 0$. By solving Equations (1) and (4) at System (3), the TB disease-free equilibrium point is obtained as follows:

$$E_0 = (s, e, i, r) = \left(\frac{(1-\sigma)\lambda}{\mu}, 0, 0, \frac{\sigma}{\mu}\right) \qquad (4)$$

B. *Endemic Equilibrium Point*

The endemic equilibrium point $E^* = (s^*, e^*, i^*, r^*)$ represents a steady-state solution where the disease persists in the population. At this equilibrium, all subpopulations $S \neq 0, E \neq 0, I \neq 0$, and $R \neq 0$. From Equations (1)–(4) at System (3), the endemic equilibrium point is calculated as follows :

$E^* = (s^*, e^*, i^*, r^*)$

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$$= \left(\frac{(\gamma+\mu)(\varepsilon+\mu)}{\beta\varepsilon}, \frac{\beta\varepsilon(1-\sigma)\lambda - \mu(\gamma+\mu)}{\beta\varepsilon}, \frac{(1-\sigma)\varepsilon\lambda}{(\gamma+\mu)(\varepsilon+\mu)} - \frac{\mu}{\beta}, \frac{\sigma}{\mu} + \frac{\gamma}{\mu}\left(\frac{(1-\sigma)\varepsilon\lambda}{(\gamma+\mu)(\varepsilon+\mu)} - \frac{\mu}{\beta} \right) \right)$$

C. *Basic Reproduction Number*

Based Reproduction Number (R_0) is as the number of secondary cases or the second case produced by one infected person who can transmit the disease.

By analisis model, we find :

$$R_0 = \frac{\beta\varepsilon\lambda(1-\sigma)}{\mu(\gamma+\mu)(\varepsilon+\mu)} \quad (5)$$

If $R_0 < 1$, the virus will become extinc and

If $R_0 > 1$, the virus in endemic

D. *Runge-Kutta 4th Order Method*

This method leverages information from multiple points within a time interval to estimate the solution and maintain computational stability, ensuring that calculation errors do not grow exponentially.

$k_1 = f(t_n, y_n)$

$k_2 = f\left(t_n + \frac{h}{2}, y_n + \frac{h}{2}k_1\right)$

$k_3 = f\left(t_n + \frac{h}{2}, y_n + \frac{h}{2}k_2\right)$

$k_4 = f(t_n + h, y_n + hk_3)$

$y_{n+1} = y_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4)$

Tabel 1. Description of Variables, Parameters, Condition and Value

Variable/ Parameters	Description	Condition	Value
s	A population of individuals susceptible to infection with a virus over time.	$s \geq 0$	0,906146[1]
e	Populations of individuals infected with the virus without symptoms over time	$e \geq 0$	0,0557465[1]
i	A population of individuals infected with a virus with symptoms over time	$i \geq 0$	0,0374613[1]
r	Population of individuals who recover over time	$r \geq 0$	0,0006472[1]
λ	Natural birth rate	$\lambda \geq 0$	0,0255
σ	Rate of people being vaccinated	$\sigma \geq 0$	0,7
β	Rate of Exposed individuals to Infected	$\beta \geq 0$	0,47
ε	Rate of latent TB to active TB	$\varepsilon \geq 0$	0,135
γ	Rate of Infected individuals to recovered.	$\gamma \geq 0$	0,065
μ	Natural death rate	$\mu \geq 0$	0,0255

[1)] The parameter values used were obtained from the Medan City Health Department data in 2023 and from BPS Sumatera Utara

Result and simulation

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In this case, the R_0 value indicates that each infected individual can transmit the disease to an average of 1.031652 other individuals in a fully susceptible population, suggesting that the disease will persist for a long time. An R_0 value greater than 1 indicates the potential for an endemic, as the infection can spread exponentially. In this simulation, the high R_0 initially leads to a rapid increase in the proportion of the population in the *Infected* (I) and *Exposed* (E) compartments. However, with interventions (vaccination effects) and other factors, the spread of the infection is eventually controlled, as reflected by the stabilization of the proportion of each compartment at the end of the simulation.

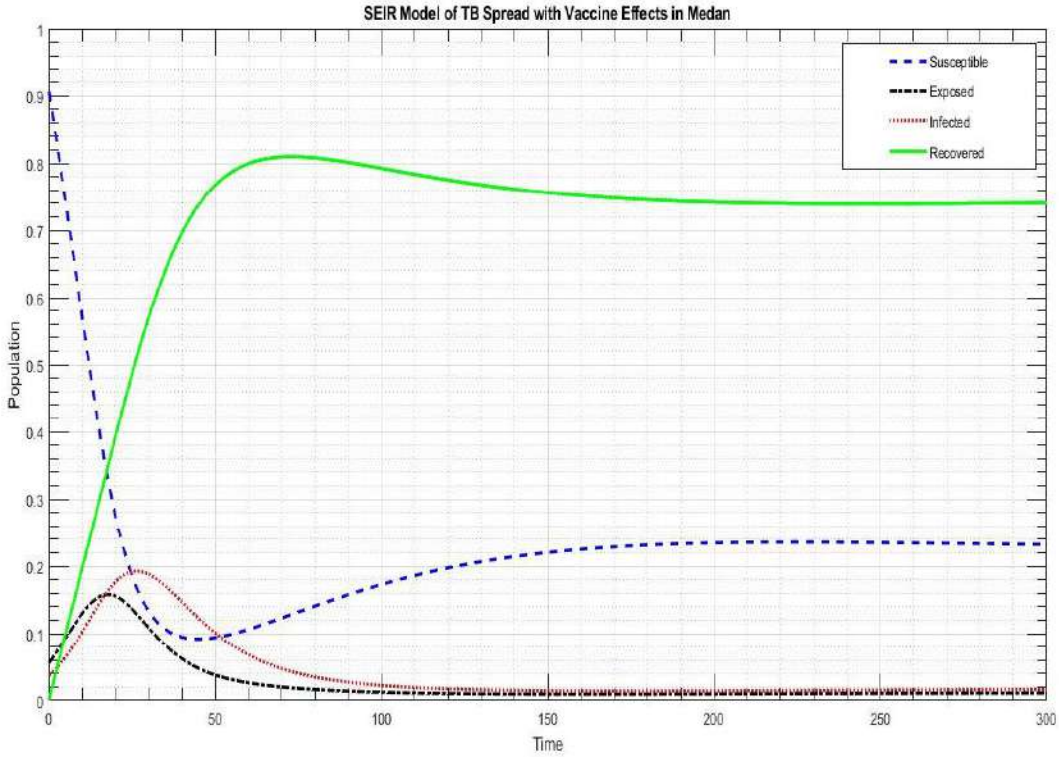

Figure 2. The simulation graph of TB transmission in Medan City at present**.**

The proportion of *Susceptible* individuals is represented by the blue dashed line. It illustrates the proportion of the population that is vulnerable or not yet infected with TB. Initially, the proportion of susceptible individuals is very high, nearly 90%. However, over time, this number decreases rapidly as many individuals become exposed or infected. Afterward, the number stabilizes at a very low level ($\sim 10\%$), indicating that most individuals in this group have transitioned to other categories.

The proportion of *Exposed* individuals is represented by the black dotted line. It represents individuals who have been exposed to TB but have not yet shown symptoms or transmitted the disease. The graph shows a rapid increase at the beginning, peaking around $t \approx 20 - 30$, and then gradually declining. This decline indicates that individuals in this group are transitioning to the Infected or Recovered categories.

The proportion of *Infected* individuals is represented by the red dashed line. It represents individuals who are infected and capable of transmitting the disease. The proportion rises after the Exposed group reaches its peak, indicating the transition from exposed to actively infected. However, after peaking around $t \approx 50$, the number of infected individuals decreases significantly, suggesting that prevention measures, treatment, or vaccination have begun to control the spread of TB.

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The proportion of *Recovered* individuals is represented by the thick green line. It represents the population that has recovered from TB. The graph shows a significant increase after the initial period, reflecting successful treatment or natural recovery. In the long term, the majority of the population belongs to this group (~70%), indicating the formation of community immunity.

To assess the impact of vaccination effects on the spread of tuberculosis among active individuals, variations were applied to the rate parameter σ. After calculations, it was found that the R_0 value reached a maximum of less than 1 when σ was at a certain level. In the scenario where $R_0 < 1$ the disease will naturally disappear from the population as each infected individual transmits the disease to less than one person. In this situation, σ is still required to accelerate the recovery process and minimize the number of infected individuals before the disease completely vanishes.

Below are the variations in :

Tabel.2 TheV ariation of Parameter σ Values

σ	R_0
0	3.438839
0.25	2,579129
0.50	1,71942
0.75	0,85971

After analyzing the changes in the value of σ, the results obtained are presented in Figure 3

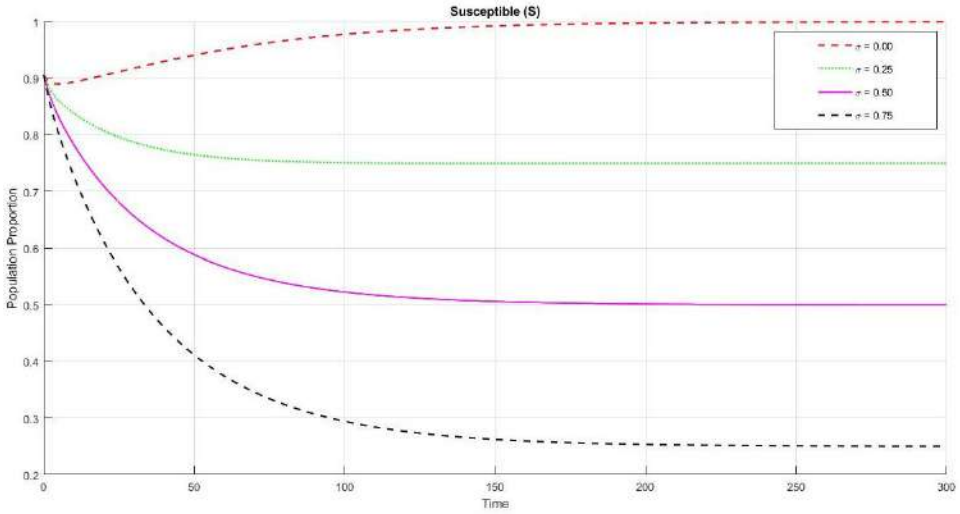

Figure 3. The graph of the S class over time (t) for $\sigma = 0.0, 0.25, 0.50, 0.75$

Upon reviewing the graph, it shows that the proportion of the **Susceptible** population decreases at different rates depending on the value of vaccine effect (σ) :

- For $\sigma = 0.75$ (black dashed line), the population decreases rapidly to ~30% within 50 years and stabilizes at a low level.
- For $\sigma = 0.50$ (magenta solid line), the decline is slower, stabilizing at $\sim 50 - 60\%$.
- For $\sigma = 0.25$ (green dotted line), the decline is gradual, stabilizing around 80%.
- For $\sigma = 0.0$ (red dashed line), there is minimal decline, with the proportion remaining high (~90%).

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Overall, higher σ values result in a faster reduction of the susceptible population and a lower stable level, while lower σ values lead to slower decline and higher stabilization.

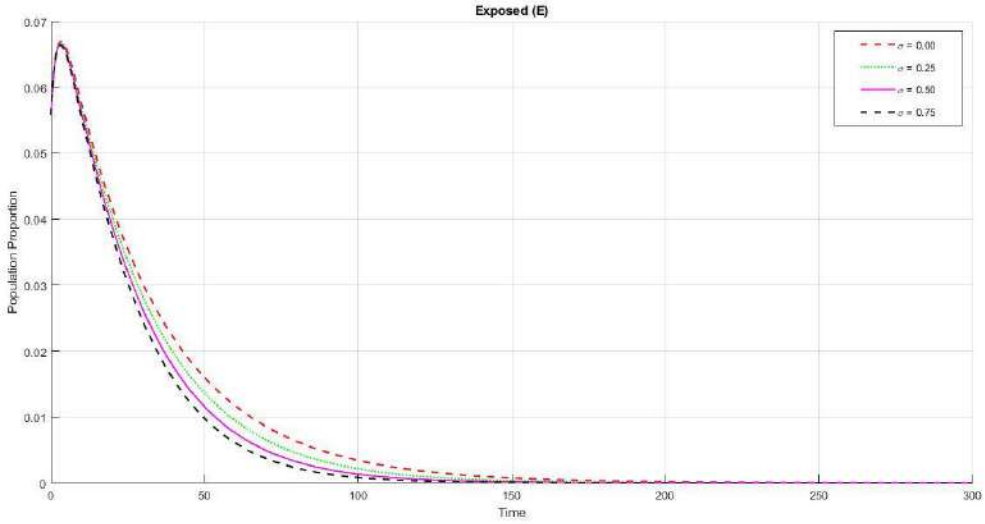

Figure 4 The graph of the E class over time (t) for $\sigma = 0.0, 0.25, 0.50, 0.75$

Based on the Exposed compartment graph and its relation to the effect of vaccination on TB transmission in Medan, it can be analyzed as follows:

- For $\sigma = 0.75$ (black dashed line), indicates very high vaccine effectiveness, where the TB-exposed population decreases dramatically in the first 50 periods. This illustrates an ideal scenario if the TB vaccination (BCG) program in Medan runs very effectively with broad coverage and high success rates.
- For $\sigma = 0.50$ (magenta solid line), represents good vaccine effectiveness but not as optimal as $\sigma = 0.75$. This may reflect the current state of TB vaccination in Medan, where the program is running well but still faces some constraints such as limited access or suboptimal public awareness.
- For $\sigma = 0.25$ (green dotted line), shows moderate vaccine effectiveness. This situation could occur in suburban areas of Medan with limited health access, where the BCG vaccination program has not reached the entire population or is constrained by distribution problems.
- For $\sigma = 0.00$ (red dashed line), reflects conditions without vaccine intervention or very low vaccine effectiveness. This could depict situations in slum areas or regions with low health awareness in Medan, where TB vaccination programs are not running well.

The vaccine effectiveness depicted by different σ values demonstrates the importance of optimizing TB vaccination programs in Medan to achieve significant case reductions as shown in curves with high σ. A comprehensive strategy including increased vaccination coverage, improved access, and public education is needed to achieve TB control targets in Medan.

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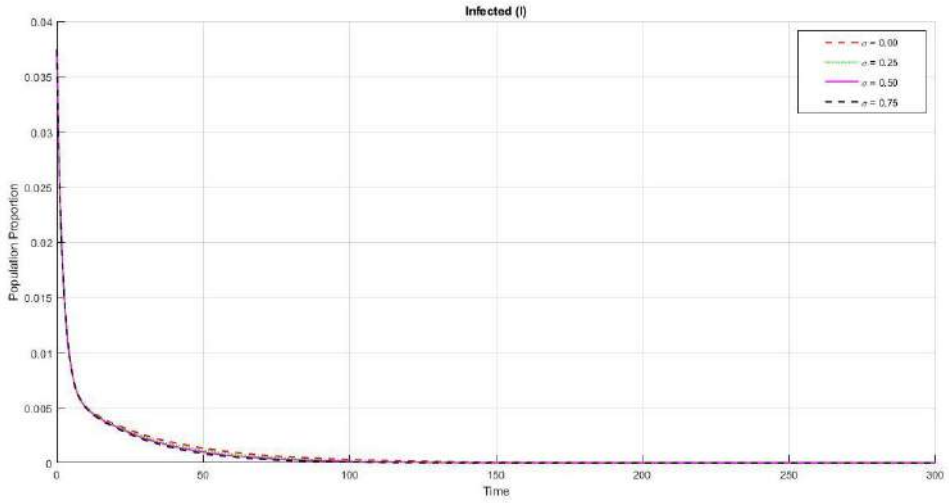

Figure 5. The graph of the I class over time (t) for $\sigma = 0.0, 0.25, 0.50, 0.75$

After analyzing the graph, it shows that the proportion of the **Infected** (I) population decreases with a similar pattern for all σ values, but with subtle differences:

- For σ = 0.75 (black dashed line), the infected population:
  Starts at around 0.035, drops sharply in the first 25 periods, reaches the lowest level compared to other σ values, and shows the most effective vaccination in reducing active TB cases
- For σ = 0.50 (magenta solid line):
  Decline pattern almost identical to σ = 0.75, Slightly higher in its stable level, Depicts still very good vaccine effectiveness
- For σ = 0.25 (green dotted line):
  Similar decline but with slightly higher stable level and shows effective but not optimal TB control
- For σ = 0.00 (red dashed line):
  Has the highest stable level and represents situation without vaccine intervention

The effect of some individuals being vaccinated results in a decline in the graph, indicating that the spread of the disease will stabilize at a certain point in time.

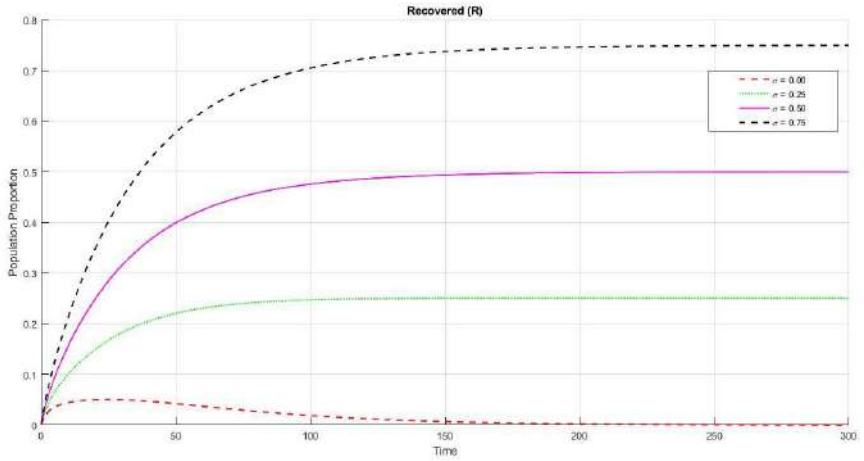

Figure 6. The graph of the R class over time (t) for $\sigma = 0.0, 0.25, 0.50, 0.75$

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After analyzing the graph, it shows that the proportion of the **Recovered** (R) population demonstrates different increases based on σ values:

- For σ = 0.75 (black dashed line):
  Shows fastest and highest increase, reaches stable level around 0.75 (75% population), indicates best vaccine effectiveness in recovery, Reflects optimal vaccination program success
- For σ = 0.50 (magenta solid line):
  Moderate but significant increase, stabilizes at around 0.50 (50% population), shows fairly effective vaccination program, Represents good program implementation conditions
- For σ = 0.25 (green dotted line):
  Slower increase, Reaches stable level around 0.25 (25% population), Depicts limited vaccine effectiveness, May reflect program implementation constraints
- For σ = 0.00 (red dashed line):
  Almost no increase\Stabilizes at very low level (< 5% population)
  Shows situation without vaccine intervention
  Picture of conditions without TB control program

The Recovered graph demonstrates the importance of an effective vaccination program in TB control in Medan. Achieving high σ values through optimal program implementation can significantly increase the recovered population and contribute to better TB control.

Conclusion

We considered the SEIR transmission model, categorized into *Susceptible* (S), *Exposed* (E), *Infected* (I), and *Recovered* (R) individuals, while incorporating the parameter of vaccination effects.There are two possible equilibrium points in this system:

1. Infection-free equilibrium, which always exists and is locally consistent.
2. Endemic equilibrium, which exists and is locally and asymptotically stable if the basic reproduction number is greater than one.

This phenomenon occurs because vaccination reduces the flow of individuals from the *Susceptible* (S) category to the *Exposed* (E) and *Infected* (I) categories while increasing the probability of individuals directly transitioning to the *Recovered* (R) category. Additionally, all flows along the S, E, I, and R axes tend to converge toward the infection-free equilibrium. The flow along the infected (I) axis specifically depends on the value of (R_0) which is influenced by vaccine coverage and effectiveness. It is observed that if $R_0 < 1$, the flow along the infected axis is attracted toward the infection-free equilibrium. However, when R_0 surpasses one, oscillations become so significant that the flow along the infected axis moves away from the equilibrium point (s, e, i, e) and is redirected toward (s^*, e^*, i^*, r^*) which remains achievable with adequate vaccination. The addition of vaccination can also shift the transcritical bifurcation at $R_0 = 1$, making the system more inclined toward an infection-free state. Furthermore, under the globally and asymptotically stable condition of (s, e, i, r) the infection can permanently disappear from the system, especially with the contribution of vaccination. Conversely, if the endemic equilibrium exists, it remains locally and globally stable; however, extensive vaccination can weaken this stability, driving the system toward an infection-free state.

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Analysis of factors that influence the human development index of north sumatra province using regression models

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Abstract. *A prosperous society is the main goal of implementing development in a country. One tool for measuring the level of community welfare is the Human Development Index (HDI). What factors influence HDI in a country is a study worth carrying out as a source of information for subsequent development plans. This research aims to obtain a regression model that explains the relationship between HDI and eight independent variables which include X_1 as life expectancy, X_2 as the average length of schooling, X_3 as the open unemployment rate, X_4 as percentage of the poor population, X_5 as the population's morbidity rate, X_6 as a percentage of the population in possession of health insurance (BPJS), X_7 as a percentage of the population receiving the Family Hope Program (PKH) during the last year, X_8 as a percentage of the population aged 5 years and over who own/control a cellular/wireless telephone in the last 3 months. The method used in this research is the OLS Regression method. The data used in this research is secondary data from the Central Statistics Agency (BPS). The research results show that the regression model using the OLS regression method is analysis of factors that influence the Human Development Index of North Sumatra Province Using Regression Models:* $\hat{Y} = 7{,}659 + 0{,}637X_1 + 0{,}235\,X_3 - 0{,}083\,X_4 - 0{,}149X_5 + 0{,}031X_6 - 0{,}083\,X_7 + 0{,}303X_8 + \varepsilon$

Keywords: *Human Development Index, the rate of economic growth, Regression Models, morbidity rate, percentage of the poor population*

Introduction

A prosperous life is the hope of all citizens, as are development programs implemented by the government that lead to one goal, namely the welfare of citizens both economically and socially. The opposite of prosperity is poverty, which is the condition of economic inability to meet the average standard of living of the people in an area [1]. Poverty is a problem that wants to be eliminated through development programs.

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Indicators of the success or failure of development can be seen from the level of welfare of its citizens. The higher the level of welfare of citizens in a region indicates that the government in the area has succeeded in carrying out its functions and duties. The achievement of community welfare is inseparable from various factors, including sources of income (employment), access to education, health, security, public facilities, the environment, security, culture, technology, and public policy. A study of the factors that are significant to the level of community welfare in a region can provide important information for consideration in the development plan for that region.

One of the measuring tools to see the welfare of the people in a region is to know the value of the human development index (HDI) achieved by the area. HDI shows the growth rate of human development, which is viewed from the economy and includes all aspects that support a prosperous human life [2]. Studies to analyze what factors affect the HDI can help to make public policies to improve community welfare. The relationship between HDI and the factors that influence it can be represented mathematically using inferential statistics. *Multiple Linear Regression (MLR),* commonly known as multiple linear regression, is one method that is often used to analyze the relationship between response variables and several independent variables [3].

Research methods

The data in this study are secondary data from BPS North Sumatra Province, namely the Human Development Index Publication of North Sumatra Province 2023, People's Welfare Statistics Publication of North Sumatra Province 2023, and Publication of North Sumatra Province in Figures. The research variable consists of a response variable, Y is the HDI value, and eight independent variables that are assumed to influence the response variable, namely: X_1 is Life Expectancy, X_2 is Average years of schooling, X_3 is Open unemployment rate, X_4 is Percentage of poor population X_5 is Population morbidity, X_6 is Percentage of health insurance ownership, X_7 is Percentage of population receiving the family hope program in the last year, X_8 is Percentage of the population aged 5 years and over who owned/were in possession of a cellular phone (HP)/wireless in the last 3 months

Results and discussion

Human development index (HDI)

The Human Development Index (HDI) is an indicator used to measure a country's development level and human welfare. The United Nations developed the HDI through the UNDP Institute, where this index tries to cover broader aspects of human welfare than just economic growth.

HDI includes three main dimensions, namely: Health is measured by life expectancy; Education is measured by average years of schooling attended by the adult population and years of schooling expectancy for children; and The standard of living is measured by real income per capita, reflecting the population's purchasing power.

HDI presents these indicators with a range of values between 0 and 1, where a higher score On the other hand, the factors that are thought to influence the level of welfare include the following: 1) Income: the level of income of an individual or household can affect the ability to fulfill basic needs and improve welfare; 2) Employment and job opportunities: The employment opportunities, unemployment, and the type of work available can affect a person's welfare; 3) Education: fair access to better education can improve skills, employment opportunities, and health awareness; 4) Health: good access to health facilities and affordable health services can improve welfare; 5) Social environment: Good social relationships and support from family, friends, and the community can influence mental and emotional well-being; 6) Security and stability: a safe and

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stable environment provides the basis for well-being; 7) Culture and values: Cultural values and community value systems can shape perceptions of well-being and create social norms; 8) Access to technology and information: Good access to technology and information can open new opportunities and improve social and economic connections; 9) Public policies: Government policies on the economy, education, health, and social protection can impact people's well-being.

Multiple linier regression (MLR)

Multiple linear regression (*MLR*) is a statistical method that describes the relationship between the response (dependent) variable and several independent variables. Based on empirical data obtained from the sample, a regression model that can represent the characteristics of the data will be estimated so that conclusions can be drawn about the effect of the independent variables on the response variable [4]. Estimating regression parameters can be done with several methods, such as maximum likelihood and *Ordinary Least Square (OLS).*

The *Ordinary Least Square* method, also known as the least squares method, estimates regression coefficients by minimizing the sum of squared errors, $\sum_{i=1}^{n} \varepsilon_i^2$ such that unbiased regression coefficients are obtained. The *OLS* estimator gives good results when all classical regression assumptions are met, namely the assumptions of normality, homoscedasticity, no multicollinearity, and autocorrelation between the independent variables [5].

This method aims to minimize the sum of squared *errors* so that the regression equation can be simplified into

$$Y = \mathbf{X}\beta + \varepsilon \tag{1}$$

Where $\boldsymbol{Y}$ and ε are matrix with sequence $n \times 1$, while $\boldsymbol{X}$ is matrix with sequence $n \times (k + 1)$. The estimated regression equation is :

$$\hat{Y} = \mathbf{X}\hat{\beta} + \varepsilon \tag{2}$$

Suppose. Sample Y is given, then the rule that allows the use of sample Y is to obtain an estimate by making $varepsilon = \hat{Y} - X\hat{\beta}$ as small as possible. The objective of the least squares method is to determine the estimator of the β_0 and β_1 which will minimize the sum of squared errors. Based on this, it is necessary to keep the parameters β as small as possible (minimal).

$$S = \varepsilon'\varepsilon = \left(Y - X\beta\right)'\left(Y - X\beta\right) \tag{3}$$

Where equation (1) is a scalar, its components are also scalar. As a result, scalar transpose cannot change the value of the scalar. To minimize can be obtained by doing a partial derivative of S against β' is as follows:

$$\frac{\partial S}{\partial \beta'} = -2YX' + 2X'X\beta \tag{4}$$

By equating equation (2) to zero, we obtain $X'Y = X'X\beta$, which is called the normal equation, and $\hat{\beta}_{OLS} = \left(X'X\right)^{-1} X'Y$, is referred to as the parameter estimate β by least squares [6].

Descriptive analysis

Descriptive analysis is essential to provide an initial overview of the distribution of observation data so that data characteristics can be obtained for further study. Data descriptions can be presented in the form of

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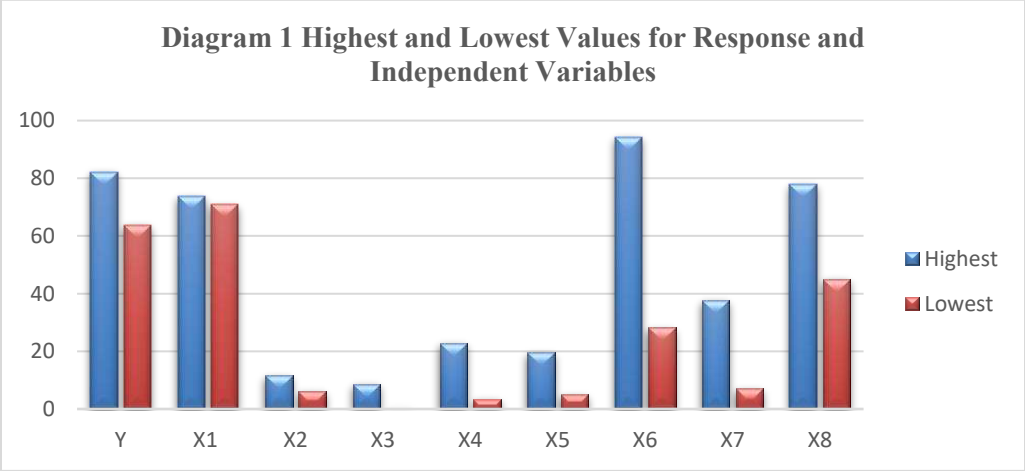
statistical measures or visual images through tables, diagrams, graphs, or images. Statistical measures often used as an initial description of a set of data include minimum, maximum, average, standard deviation, and variance [7].

Table 1. Descriptive statistics for cost-of-living response variable (Y) and independent variables (X)

	N	Minimum	Maximum	Mean	Standard Deviation
Y	33	63,70	82,19	72,4127	4,33862
X_1	33	70,88	73,81	72,4809	1,01414
X_2	33	6,14	11,62	9,3867	1,34188
X_3	33	0,45	8,67	4,5530	2,55136
X_4	33	3,44	22,81	9,9255	4,19192
X_5	33	4,98	19,62	10,3564	3,47037
X_6	33	28,21	94,26	64,2497	14,02408
X_7	33	7,05	37,63	17,7118	7,38104
X_8	33	45,11	77,85	63,8933	7,94812

Based on Table 1 above, some prominent characteristics of the response variable data and the independent variables that are the focus of observation in this study can be obtained. For the range or range of each variable, several variables have a reasonably wide range between the minimum datum and the maximum datum, such as in the independent variable X6 regarding the percentage of the population with health insurance ownership, where the average is at a value of 64.249 while the variance value is at a value of 196.675. Meanwhile, the minimum value of the percentage of health insurance ownership is at a value of 28.21, and the maximum is 94.26. This shows a considerable range between the most minor and most prominent datums, with a data spread based on the average value. More clearly, the comparison of the highest and lowest datum for each response variable and independent variable is presented in Diagram 1 below:



On the other hand, the distribution of districts/cities that occupy the highest and lowest positions for the HDI response variable is presented in Table 2.

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Table 2 Five districts/cities with the Highest and Lowest HDI

5 Districts/Cities with Highest HDI		5 Districts/Cities with Lowest HDI	
Districts/Cities	Value	Districts/Cities	Value
Medan	82,19	Nias Barat	63.70
Pematangsiantar	80,46	Nias Selatan	64.12
Binjai	77,60	Nias	64.56
Tebing Tinggi	76,98	Nias Utara	64.64
Deli Serdang	76,52	Mandailing Natal	68.56

Table 2 shows that Medan City is the city with the highest score on HDI with a score of 82.19. The HDI score obtained by Medan City shows that in terms of the quality of human development, Medan City is already good.

Inferesial analysis

The data analysis was conducted to form a regression model between the response and independent variables using the multiple linear regression method [8]. In this case, *OLS regression* was used. For each response variable and independent variable set, the initial regression model is obtained according to Table 3 below: Y is Human Development Index (HDI); X_1 is Life Expectancy, X_2 is Average years of schooling, X_3 is Open unemployment rate, X_4 is Percentage of poor population X_5 is Population morbidity, X_6 is Percentage of health insurance ownership, X_7 is Percentage of population receiving the family hope program in the last year, X_8 is Percentage of the population aged 5 years and over who owned/were in possession of a cellular phone (HP)/wireless in the last 3 months

Tabel 3 *Output* SPSS untuk Model Regresi *(OLS Regression)* Variabel Respon Y

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.476	20.166		.073	.942
	X1	.507	.311	.119	1.633	.116
	X2	2.092	.489	.647	4.278	.000
	X3	.119	.092	.070	1.292	.209
	X4	.133	.105	.129	1.275	.214
	X5	.093	.081	.074	1.148	.262
	X6	-.054	.028	-.175	-1.923	.066
	X7	.005	.060	.009	.085	.933
	X8	.236	.065	.432	3.644	.001

a. Dependent Variable: Y

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Based on the values in Table 3, the regression model is as follows:

$$\hat{Y} = 1{,}476 + 0{,}507X_1 + 2{,}092X_2 + 0{,}119\,X_3 + 0{,}133\,X_4 + 0{,}093X_5 - 0{,}054X_6 + 0{,}005\,X_7 + 0{,}236X_8 + \varepsilon \quad (5)$$

Classical assumption test

In regression analysis, several assumptions must be met, namely the assumption of normality in residuals, the assumption of heteroscedasticity, and the assumption of multicollinearity. The normality test can be done using the Kolmogorov-Smirnov method as shown in Table 4 below:

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		33
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	1.16807211
Most Extreme Differences	Absolute	.062
	Positive	.054
	Negative	-.062
Test Statistic		.062
Asymp. Sig. (2-tailed)		.200[c,d]

Table 4 Normal Distribution Test (*Residuals*)

Based on the results of the normality test, it is known that the significance value is 0.200> 0.05 so it can be concluded that the residuals are normally distributed.

Meanwhile, the heteroscedasticity test, which aims to see whether the variance of the residuals is constant or not, can be done using the Gletsjer test. Residual variances that are not constant indicate that heteroscedasticity occurs in the model, so the regression model obtained is potentially ineffective and biased. The Glejser test itself works by creating a new regression model based on the absolute value of the residuals and independent variables, as shown in Table 5 below:

Table 5 Glejser test for heteroscedasticity

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-6.083	13.926		-.437	.666
	X1	.126	.215	.189	.585	.564
	X3	.015	.064	.057	.235	.816
	X4	-.081	.072	-.503	-1.119	.274
	X5	-.091	.056	-.468	-1.627	.117
	X6	.007	.019	.137	.340	.737
	X7	.037	.041	.400	.886	.385
	X8	.028	.045	.330	.628	.536
	X2	-.348	.338	-.692	-1.030	.313

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Based on the results of the Glejser test, it appears that all significance values for each variable are greater than 0.05, therefore it can be concluded that there is no heteroscedasticity in the model.

The next classic assumption test is to check whether there is multicollinearity in the model, that is, the existence of a linear correlation between the independent variables studied [9]. The VIF value, the main diagonal element of the inverse correlation matrix, can indicate whether there are variables with multicollinearity. If the VIF value is more than 10, then there is multicollinearity in the model.

Table 6 VIF Value for Multicollinearity Test

Model	Collinearity Statistics	
	Tolerance	VIF
(Constant)		
X1	.325	3.080
X2	.075	13.353
X3	.579	1.726
X4	.168	5.970
X5	.408	2.449
X6	.207	4.833
X7	.166	6.031
X8	.122	8.208

Based on the TOL and VIF values, there is one variable whose value is above 10, namely X_2, therefore it can be concluded that there is a significant potential for multicollinearity between the independent variables in the model.

Final regression model

The presence of multicollinearity in a regression model can cause inaccurate interpretation, so action is needed to overcome this problem. One action is to eliminate the independent variables that indicate multicollinearity. In this case, the variable X2 will be removed from the model, so the regression coefficients for the final model are presented in Table 7.

Table 7 Regression Coefficients for the Final Model

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	7.659	26.163		.293	.772		
X1	.637	.402	.149	1.584	.126	.328	3.051
X3	.235	.115	.138	2.040	.052	.633	1.580
X4	-.083	.119	-.081	-.700	.490	.219	4.570
X5	-.149	.075	-.119	-1.978	.059	.798	1.254
X6	.031	.026	.100	1.194	.244	.413	2.421
X7	-.083	.073	-.141	-1.134	.268	.188	5.318

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X8	.303	.082	.554	3.702	.001	.129	7.733

a. Dependent Variable: Y

Based on the coefficient values listed in Table 7, the regression model formed can be stated as follows:

$$\hat{Y} = 7{,}659 + 0{,}637X_1 + 0{,}235\,X_3 - 0{,}083\,X_4 - 0{,}149X_5 + 0{,}031X_6 - 0{,}083\,X_7 + 0{,}303X_8 + \varepsilon \quad (6)$$

Model interpretation

The final model obtained is interpreted by looking at the coefficient of determination and conducting simultaneous and partial tests. The coefficient of determination can be seen in Table 8. From the table, the value R^2 is 0.928 and the *adjusted* R^2 value is also 0.907, this indicates that 90% of the variation in *HDI* can be explained by the independent variables *X*.

Table 8 The Value R^2 and the *adjusted* R^2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.963[a]	.928	.907	1.32152

a. Predictors: (Constant), X8, X6, X5, X3, X1, X4, X7

Meanwhile, the effect of the independent variables together, can be seen from the simultaneous test shown in Table 9 below:

Table 8 ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	558.696	7	79.814	45.701	.000[b]
	Residual	43.661	25	1.746		
	Total	602.357	32			

a. Dependent Variable: Y

b. Predictors: (Constant), X8, X6, X5, X3, X1, X4, X7

From the table, the calculated F value is 45.701> F table and sig. 0.000 < 0.05. Based on this fact, it can be concluded that together there is a significant influence of the independent variables (X_1 ,X_3 ,X_4 ,X_5 ,X_6 X_7 ,X_8 on *HDI*.

The significance value of each independent variable in the final model can partially interpret how each affects the response variable (Table 7). According to the table, only the independent variable X_8 has a significance value smaller than 0.05; therefore, only variable X_8 partially influences HDI.

Conclusion

Based on the data analysis that has been carried out on this research problem, several things can be concluded, namely: 1) the final regression model is $\hat{Y} = 7{,}659 + 0{,}637X_1 + 0{,}235\,X_3 - 0{,}083\,X_4 - 0{,}149X_5 + 0{,}031X_6 - 0{,}083\,X_7 + 0{,}303X_8 + \varepsilon$; 2) The value R^2 is 0.928 and the *adjusted* R^2 value is also 0.907, this indicates that 90% of the variation in *HDI* can be explained by the independent variables; According to partial test, the significance value that is smaller than 0.05 is only the independent variable

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X_8, therefore partially only variable X_8 has an influence on HDI; 3) The calculated F value is 45.701> F table and sig. 0.000 < 0.05. Based on this fact, it can be concluded that together there is a significant influence of the independent variables (X_1 ,X_3 ,X_4 ,X_5 ,X_6 X_7 ,X_8 on *HDI*. For future research, it is recommended to use other regression methods that can accommodate those related to location differences. In addition, it can also consider other factors or variables that have the potential to have a significant effect on the response variable.

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Optimization of stunting prediction in north sumatera province using machine learning algorithm

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Abstract. *In Indonesia, stunting is a significant health concern. North Sumatra Province, which was rated 19th in 2022, has a significant prevalence of stunting. According to the 2022 Indonesian Nutritional Status Study (SSGI), North Sumatra Province's stunting prevalence rate was 21.1 percent, which was still higher than the 18 percent objective for 2022. Additionally, North Sumatra Province's 21 districts and cities continue to have stunting prevalence rates higher than the 21.6 percent national average. Therefore, in an attempt to lower the stunting prevalence rate in North Sumatra Province, this study attempts to develop an appropriate model to predict stunting prevalence. Support vector regression (SVR) and the random forest machine learning technique are used in the prediction model that is constructed. The mean square error (MSE) and root mean squared error (RMSE) metrics are used to assess the model. The random forest technique yields an MSE value of 0.015737 with an RMSE of 0.125448. The support vector regression approach yields an MSE value of 0.046873 with an RMSE of 0.216502. In most places, Random Forest's forecasts are more accurate than SVR's when it comes to estimating the proportion of stunted babies in different districts and cities..*

Keywords: *Stunting, Random Forest Algorithm, Support Vector Regression Algorithm, North Sumatera*

Introduction

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The future of human resources (HR) will be reflected in the caliber of today's youth. A nation with a high-quality generation has a great chance to reap the benefits of a golden generation down the road. In order to prepare Indonesia's golden generation for 2045, the government has created a number of child-related laws [1]. One of the weights of issues with nutrition in growing is still present in Indonesia [2].

Stunting is a condition of growth failure in toddlers that is at risk of being permanent if not treated early. This phenomenon is caused by chronic malnutrition, repeated infections, and minimal psychosocial stimulation since the fetus is in the womb until the first 1,000 days of life [3]. In 2022, a survey in 33 provinces and 486 districts/cities throughout Indonesia found the prevalence rate fell to 21.6 percent. However, this figure has not reached the government's target of reaching 14 percent nationally [4]. Stunting in toddlers often occurs due to poor nutritional intake and diet and is indirectly related to poverty levels. In addition to parental care, infectious diseases due to inadequate sanitation, health services, and social, cultural, and environmental aspects are also major factors [5, 6]. Other conditions that are closely related to this phenomenon are children's energy intake, protein intake, gender, birth weight, number of household members, parents' education and occupation, and area of residence [7-9].

According to the findings of the 2021 SSGI Survey, the frequency of stunting in North Sumatra Province dropped to 25.8 percent from the year before. The percentage dropped by 4.7 percent to 21.1 percent in 2022, falling short of the 21.6 percent national prevalence average [10]. The provincial government of North Sumatra is still working to lower stunting rates through a number of initiatives. The goal of these initiatives is to reduce the prevalence of stunting as quickly as possible [10].

North Sumatra is ranked 19th in terms of stunting prevalence in Indonesia in 2022. The North Sumatra Provincial Government has prepared various cross-sector activities, ranging from sanitation, toilets, water quality, nutrition education, and opening up employment opportunities as widely as possible. In addition, nutritional interventions for pregnant women and toddlers are also carried out. Although the stunting prevalence rate in North Sumatra in 2022 is 0.5 points lower than the national figure, there are 21 districts/cities in North Sumatra that have a prevalence of stunting toddlers above the provincial average [11]. Therefore, it is necessary to conduct stunting handling modeling to predict the prevalence rate from year to year in the districts/cities of North Sumatra Province. So that the local government can carry out appropriate handling to prevent the high prevalence rate of stunting in North Sumatra Province.

For the stunting phenomena in North Sumatra to be promptly monitored and addressed, a thorough analysis is required. In order to create a model of the prevalence rate of stunting based on the factors that affect it, this study uses a machine learning method. Support vector regression (SVR) and the random forest algorithm are two machine learning methods used in modeling.

Research methodology

Data and data sources

The Central Statistics Agency (BPS) and the North Sumatra Provincial Health Office provided the data used in this study. The 2021–2023 data set was used. The following variables are included in this study:

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Table 1. Research variables and data sources

No	Variable (unit)	Data Source	Description
1	K1 (%)	North Sumatra Provincial Health Office	K1 (First Contact) is the first pregnancy check-up carried out by a pregnant woman, ideally in the first trimester of pregnancy (before 12 weeks). Pada tahap ini, ibu hamil akan mendapatkan pemeriksaan dasar, seperti pemeriksaan tekanan darah, berat badan, tinggi fundus uteri, serta pemeriksaan laboratorium dasar (seperti darah dan urine).
2	K4 (%)	North Sumatra Provincial Health Office	K4 (Fourth Contact) is the fourth pregnancy check-up that pregnant women are expected to undergo, usually in the third trimester. This visit is important to monitor the development of the pregnancy, the health of the mother and fetus, and preparation for childbirth.
3	K6 (%)	North Sumatra Provincial Health Office	K6 (Sixth Contact) is a health program that extends the scope of examinations to K6, which is the sixth pregnancy contact that is usually carried out before delivery. At this stage, the examination is more focused on preparing the mother to face delivery, including evaluating the position of the fetus and the condition of the placenta.
4	IDL (%)	North Sumatra Provincial Health Office	IDL (Complete Basic Immunization) coverage is an indicator in a health program that shows the percentage of infants or children who have received all basic immunizations recommended by the government or health institutions. This basic immunization aims to protect children from various dangerous infectious diseases.

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5	Number of Hospitals	North Sumatra Provincial Health Office	Number of hospitals available in a district/city
6	Infants Getting Breast Milk (%)	North Sumatra Provincial Health Office	Number of babies who receive breast milk in a district/city
7	LBW babies (%)	North Sumatra Provincial Health Office	Percentage of low birth weight babies
8	Toddlers get Vit A (%)	Dina North Sumatra Provincial Health Office	Percentage of babies under five years old getting vitamin A
9	Postpartum mothers get Vitamin A (%)	North Sumatra Provincial Health Office	Percentage of mothers who experienced postpartum receiving vitamin A
10	Pregnant women receive TTD (%)	North Sumatra Provincial Health Office	Percentage of pregnant women receiving DPT and Tetanus, Toxoid and Diphtheria vaccines
11	HDI	Central Statistics Agency (BPS)	Human Development Index
12	Poor Population (%)	Central Statistics Agency (BPS)	Percentage of Poor Population
13	Population Density (people)	Central Statistics Agency (BPS)	Number of residents in a city or district
14	Number of Toddlers with Diarrhea	North Sumatra Provincial Health Office	Total number of toddlers (children under 5 years of age) who experienced diarrhea in a certain time period
15	Number of BABS	North Sumatra Provincial Health Office	The number of individuals or households in a population that practice open defecation
16	Stunting (%)	North Sumatra Provincial Health Office	Comparison between the number of children experiencing stunting and the total number of children in a certain age group

Research stages

The stages of research and data analysis carried out are:

1. Data preprocessing.

The data used in this study has several problems, including the number of outliers, the data is not well distributed, and some variables have missing data. Therefore, it is necessary to handle several problems encountered in the data, including by taking the following actions:

a. Data description analysis
   Data description analysis is used to see the condition and distribution of data so that action can be taken on the data if there are problems with the data. Descriptive analysis is done by displaying a boxplot to see the distribution of data and detect outliers in the data. Descriptive analysis is also done by presenting several parameters to describe data, such as mean, min, max, and standard deviation parameters.
b. Winsorizing.
   Winsorizing is one of the actions to overcome outlier data. The winsorizing technique works by limiting extreme values (outliers) in a dataset to a certain value, usually close to the limit of non-extreme data [12]. Generally, winorizing uses the 5th percentile value of the data as the lower limit and the 95th percentile as the upper limit [13].
c. Min-max scaling
   Min-Max Scaling is a data normalization technique that transforms the original data values into a new scale while maintaining the proportional relationship between the data. This

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method is useful when we want to equalize the scale of all features in the data so that the model does not prioritize certain features simply because they have a larger range of values [14]. Min-Max scaling in data preprocessing has a number of important influences, especially in improving the performance of machine learning models and ensuring more accurate and stable results. The formulation of min-mas scaling is [15]:

$$Xscale = \frac{X - X_{min}}{X_{max} - X_{min}} \quad \text{.....(1)}$$

d. Grid search cross-validation

Grid Search Cross-Validation is a technique for finding the best combination of parameters for a machine learning model by performing a grid-based search on the given parameters while using cross-validation to measure its performance [16]. The stages of grid search cross-validation [17] are:

1) Determining Parameters and Search Space (Parameter Grid).
2) Defining Random Forest and SVM models.
3) Determine the parameters to be optimized along with their candidate values, such as the number of trees (n_estimators), tree depth (max_depth), or regularization level. Create a parameter search space (parameter grid), which is the set of all possible parameter combinations.
4) Determine the number of folds in the cross-validation. In k-fold cross-validation, the dataset is divided into several subsets called folds. Run a grid search. Grid Search will try all parameter combinations in the specified parameter grid. For each parameter combination, the model is trained using k-1 folds and evaluated using the remaining folds.
5) This process is repeated k times for each parameter combination, and the results are averaged to produce a performance metric (e.g. accuracy, F1-score, or RMSE) for that combination.
6) Training the final model with optimal parameters.
7) Final Evaluation on Test Data.

2. Random Forest Algorithm

The random forest algorithm is one of the popular machine learning algorithms based on ensemble trees and can be used for both classification and regression tasks. Each decision tree is randomly constructed from the training dataset by bootstrap sampling (sampling with replacement) [18]. The stages of the random forest algorithm according to [19] are:

a) Creating Multiple Data Subsets (Bootstrap Sampling). The algorithm will take several random samples from the training data to create subsets of the data. Each subset of the data is then used to build a decision tree.
b) Building a Decision Tree for Each Data Subset. The decision tree will be built using a portion of the existing features (usually chosen randomly). This helps reduce the correlation between the trees and makes the model more stable. This process of randomly selecting features is also called feature bagging. The decision tree is built to a maximum depth or until certain conditions are met, such as a minimum number of samples at each node.
c) Voting or Averaging Process. After the decision tree is formed, each tree will produce a prediction. The algorithm takes the average of all predictions given by each tree.
d) Producing the final prediction. The final prediction is obtained by calculating the average of all predictions. In addition, the Random Forest algorithm also provides

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information about feature importance, namely the level of influence of each feature in forming a prediction.

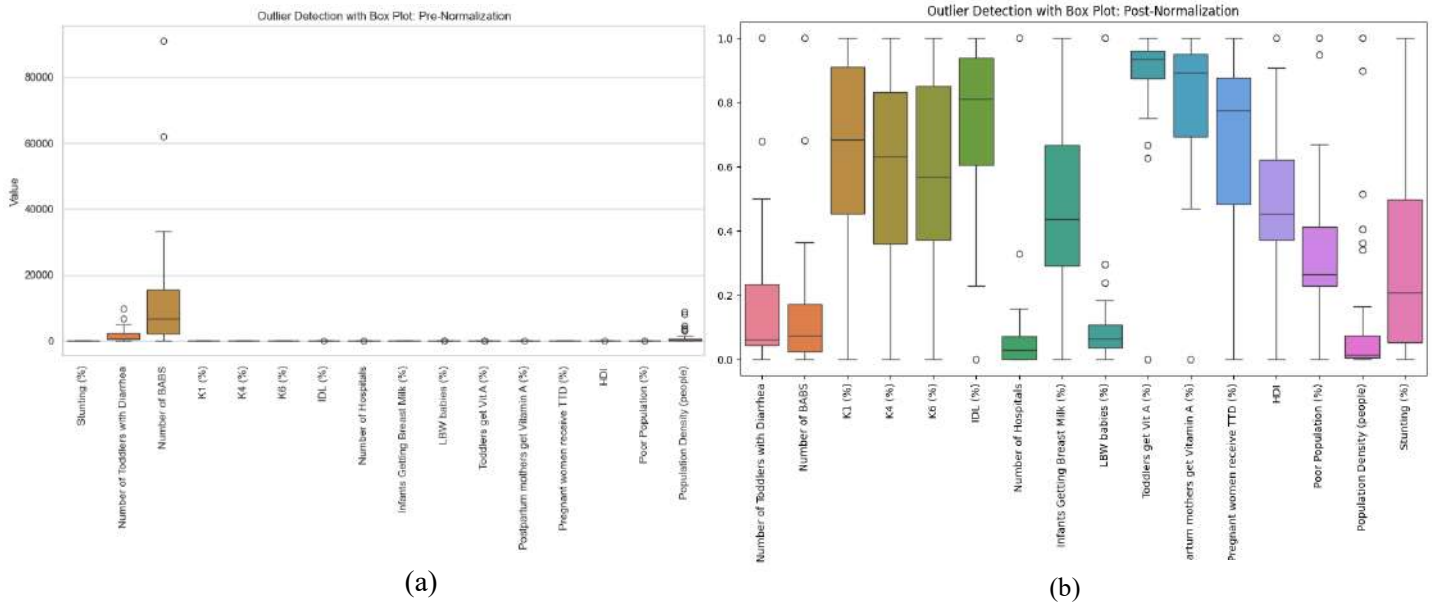
3. Support Vector Regression Algorithm

The Support Vector Regression (SVR) algorithm is a method in machine learning that uses a concept similar to the Support Vector Machine (SVM) but is applied to regression tasks [20]. The main stages in the Support Vector Regression (SVR) algorithm [21] are as follows:

a) Select the Function Kernel
b) Determine SVR parameters.There are two main parameters in SVR that need to be determined: 1) C: A regularization parameter that controls the balance between minimizing errors and avoiding overfitting; 2) Epsilon (ε): Sets a margin around the prediction line where errors will not be counted. In other words, only errors exceeding the epsilon value will be counted in the training process.
c) Mapping Data to High Dimensional Space
d) Input Data
e) Building a Hyperplane with Optimal Margin
f) Calculating Support Vectors
g) Constructing Prediction Function
h) Model Evaluation

Results and discussion

This study began by collecting demographic data, health data, and health facility data collected in sixteen variables. The data was then analyzed using descriptive analysis on the sixteen variables to see the distribution of data using a box plot.



(a) (b)

Figure 1. Box plot of data distribution a) data before normalization; b) data after normalization

The vertical line on the box plot shows the range of data outside the quartiles (Q1-Q3), which is considered to be reasonable data. The small circle on the box plot is the value that is outside the

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vertical line, which is an outlier, which is an extreme value that is very far from most of the data. These outliers are points that need to be studied further because they can indicate measurement errors or cases that are indeed very different from other data. Figure 1.a shows the imbalance in the variable scale, where some variables, such as Number of BABS, have a much larger value scale compared to other variables. Overall, this figure shows how the raw data has significant variability and outliers before normalization, and this is the first step to clean and prepare the data for further analysis.

Therefore, it is necessary to normalize the data of all variables. The normalization carried out in this study uses the min-max method; by normalizing using min-max, better prediction results are obtained. The results of this study are relevant to the results of the study [22], which states that normalization, especially using the z score and min-max methods, is able to reduce errors and produce better performance than not normalizing using z score and min-max normalization. Figure 1b shows that normalization makes data from variables that initially had very different scales more comparable. From Figure 1b, it can be seen that the comparison of variables such as the number of toddlers with diarrhea and population density is already in the same range. The box plot in Figure 1b shows that data normalization has succeeded in balancing variables that initially had different scales and facilitating comparative analysis between variables. Although outliers still exist, their influence is not as dominant as before normalization, so that the data distribution becomes clearer and more regular.

The correlation matrix plays an important role in the development and evaluation of predictive models, especially in exploratory data analysis (EDA) to understand the relationship between features. The correlation matrix obtained in this study is shown in Figure 2 below.

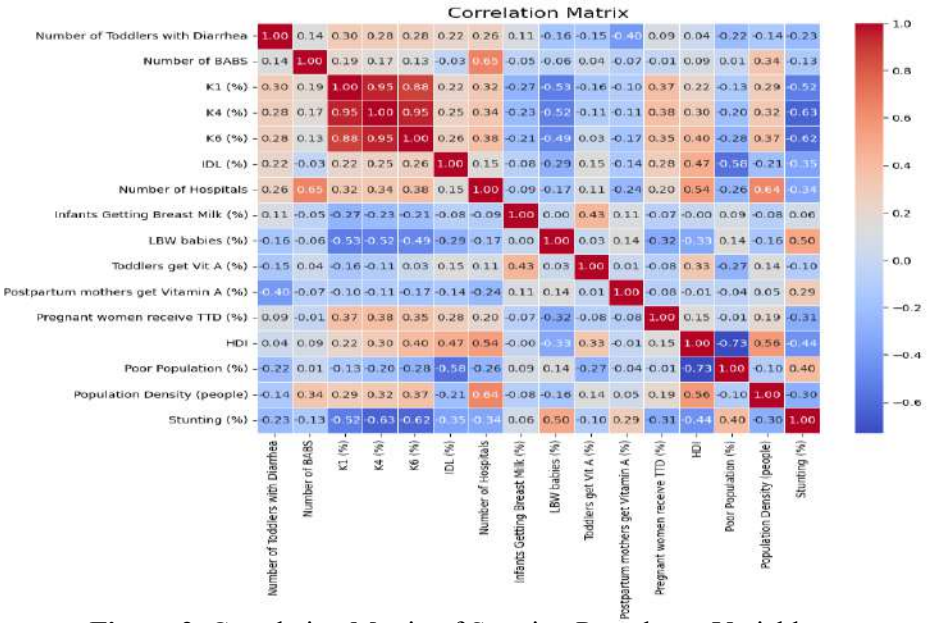

Figure 2. Correlation Matrix of Stunting Prevalence Variables

Some important points that can be seen from the matrix are that the strongest correlation (positive) to the% stunting variable is the% LBW baby variable (0.50). This shows that the higher the percentage of babies with low birth weight (LBW), the higher the possibility of stunting. A fairly strong negative correlation to % stunting is the IPM variable (-0.44) and % poor population (-0.30). This means that areas with a higher human development index (HDI) and a lower

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percentage of poor people tend to have a lower percentage of stunted babies. There is a very strong correlation between several features that may indicate multicollinearity: %K1 and %K4 have a correlation of 0.95. %K4 and %K6 have a correlation of 0.95.

The number of BABS and the number of hospitals have a correlation of 0.65. The very high correlation between these features can be a consideration to reduce similar features because highly correlated features tend to convey similar information. The HDI variable has a negative correlation with % of poor population (-0.73), which is expected because an increase in the HDI is usually accompanied by a decrease in poverty rates. % of pregnant women who can take TTD has a positive correlation with %K4 (0.38) and %K6 (0.38), which indicates that maternal health services are related to infant health services. Therefore, it is a consideration to remove several features that have high correlations with each other to reduce multicollinearity.

After conducting descriptive analysis to find out how the data is distributed and handling problematic data, the next stage is to conduct simulations in building prediction models using the Random Forest and Support Vector Regression (SVR) algorithms. From the simulations carried out, the best parameter combination was obtained for each algorithm as presented in Table 2.

Table 2. Simulation parameters of Random Forest Algorithm and Support Vector Regression Algorithm

Random Forest Algorithm			Support Vector Regression Algorithm		
Parameter	**Value**	**RFR Best Feature**	**Parameter**	**Value**	**SVR Best Feature**
n_estimators	[50, 100, 200],	%K4	kernel	[linear, poly, rbf, sigmoid],	Number of Toddlers with Diarrhea
max_depth	[10, 20, 30],	%LBW babies	C	[0.1, 1, 10],	Number of BABS
min_samples_split	[2, 5, 10],	Number of Hospitals	epsilon	[0.01, 0.1, 0.2]	%K1
min_samples_leaf	[1, 2, 4]	%K6			%K4
		HDI			%K6

By experimenting with different parameter combinations to find the optimum features and ideal parameters, Table 2 displays the simulation results of the Random Forest Regression and SVR models. The optimal parameters for the random forest algorithm are max_depth: 10, min_samples_leaf: 2, min_samples_split: 5, and n_estimators: 200, according to the simulation findings. In contrast, the optimal SVR algorithm settings are kernel: linear, epsilon: 0.01 and C: 0.1.

Table 3. Model evaluation based on model goodness-of-fit metrics

Evaluation metrics	RFR Algorithm	SVR Algorithm
Mean Squared Error	0.015737	0.046873
Root Mean Squared Error	0.125448	0.216502

The Random Forest algorithm model yields the most ideal parameters, according to the comparison of the Random Forest algorithm's simulation results with those of the SVR algorithm displayed in Table 3. The Random Forest algorithm's MSE and RMSE model goodness metrics are smaller than those of the SVR approach, which explains this. Furthermore, when the errors generated are less than 10%, the Random Forest algorithm's model goodness measures yield optimal model goodness (MSE = 1.57% and RMSE = 4.7%).

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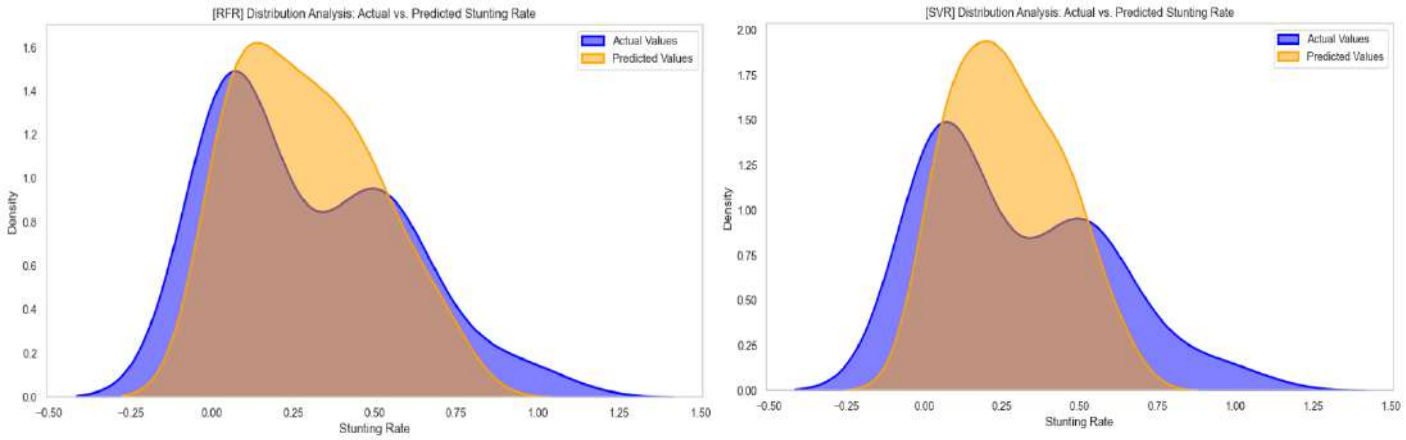

(a) (b)

Figure 3. Graph of Density Function of Actual and Predicted Value Distribution (a) Random Forest Algorithm; (b) Support Vector Regression Algorithm

This figure shows the comparison distribution between actual and predicted values of stunting rates (%Stunting) predicted using the Random Forest algorithm (Figure a) and Support Vector Regression (SVR) (Figure b). The predicted distribution (orange) and the actual value distribution (blue) in the Random Forest algorithm are very similar, with the predictions almost following the actual distribution pattern. Most of the predicted areas are within or very close to the actual distribution area, indicating that Random Forest has successfully predicted with good accuracy. Small differences in some areas indicate that the predictions are not very perfect, but overall, Random Forest is quite good at approximating the actual values.

In certain places, particularly in the distribution's tails, the Support Vector Regression (SVR) algorithm's projected distribution (orange) differs slightly from the actual distribution (blue). Although it is still fairly close, SVR does not seem to be as accurate as Random Forest in tracking the true value pattern. The observed discrepancies imply that SVR might not be as effective in capturing data variation, particularly at high values (outliers).

Random Forest appears to produce more accurate predictions than SVR, with the distribution of predictions more closely following the distribution of actual values. This suggests that Random Forest may be more suitable for predicting stunting rates (%Stunting) in this data. The differences in the peaks and spreads of the curves suggest that the model predictions do not fully align with the actual distribution of stunting rates. This plot is useful for understanding the performance of the random forest and SVR models, especially to determine the accuracy of the model in capturing the actual distribution.

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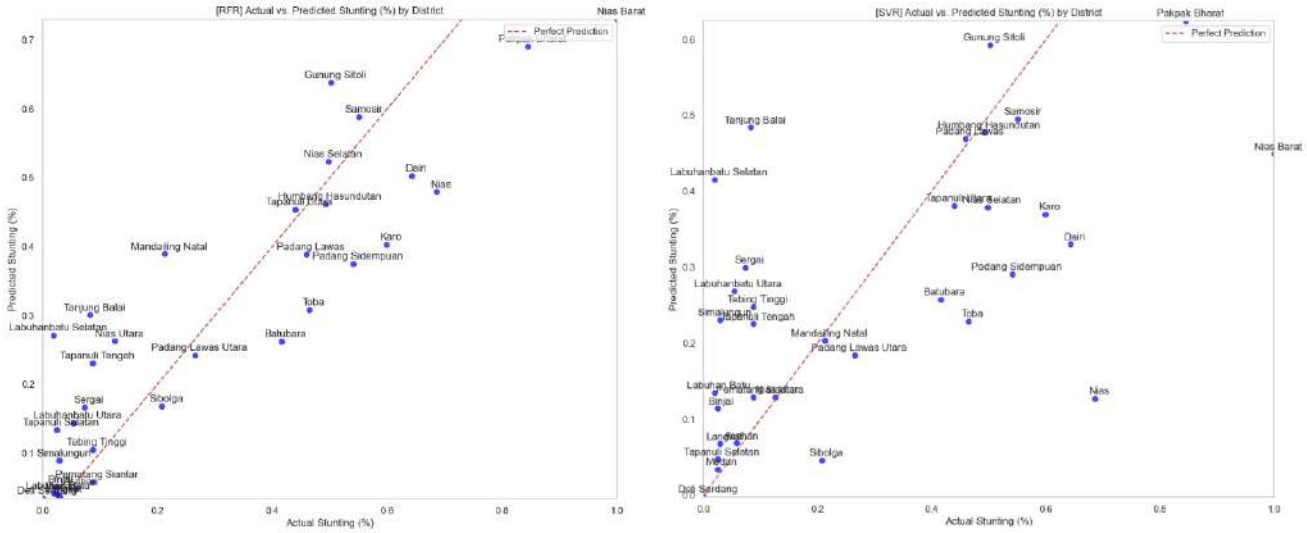

(a) (b)

Figure 4. Biplot of Actual Values and Predictions of Data Distribution by Regency/City. a) Random Forest Algorithm; b) Support vector regression algorithm

Figure 4 shows a biplot comparing the actual and predicted values of the percentage of stunted infants in 33 regencies/cities in North Sumatra Province based on the Random Forest and Support Vector Regression (SVR) algorithms. In Figure 4a, most of the data points are close to the prediction line, indicating that the Random Forest model is able to predict values quite accurately for most gions/cities. There are some points that are slightly away from the line, but the difference between the predicted and actual values is generally small, indicating good performance. This indicates that the Random Forest model as a whole is quite reliable in predicting stunting rates, although there are slight deviations in some regions or cities.

Meanwhile, in Figure 4b, most of the prediction points are further from the perfect prediction line compared to Random Forest, indicating that predictions by SVR are more often off from the actual value. Data points that are far from the line indicate that the SVR model is less accurate in predicting values in several regencies/cities. Certain regencies/cities, such as West Nias, have significant differences in predictions. This indicates that SVR may have difficulty capturing complex data patterns or outliers. From Figure 4, it can be concluded that the Random Forest algorithm is better than SVR in predicting the percentage of stunted babies in various regions/cities.

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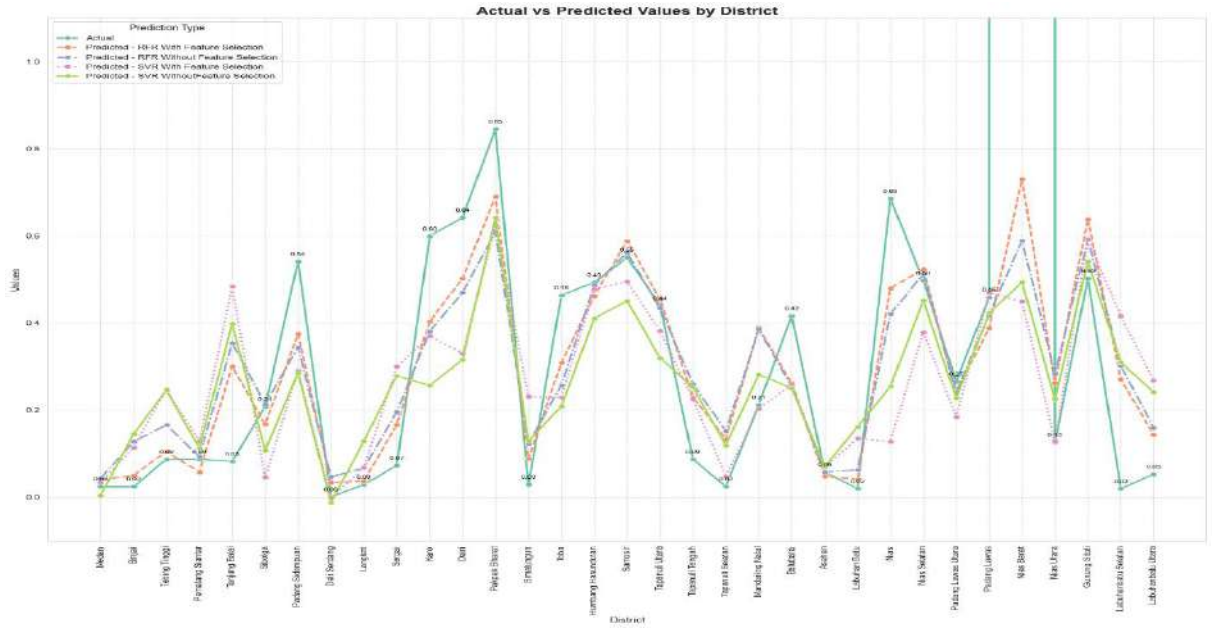

Figure 5. Comparison Plot of Actual Values and Values from Various Prediction Models

A graph comparing real values and anticipated values from many prediction models across 33 regencies/cities is presented in Figure 5. Actual values (blue and dotted lines), predictions made with the Random Forest Regressor (RFR) model with feature selection (shown in orange), predictions made with the Random Forest Regressor (RFR) model without feature selection (shown in purple), predictions made with the Support Vector Regressor (SVR) model with feature selection (shown in green), and predictions made with the Support Vector Regressor (SVR) model without feature selection (shown in pink) are the various prediction model types that are compared in this graph. The line patterns for each model vary per regency/city, indicating the accuracy of the predictions made by the different models. It is evident from this graph that each regency/city has a wide range of suitability.

Conclusion

This study used 16 variables to assess health, demographic, and health facility data from 33 districts/cities. Descriptive analysis of the data distribution using box plots leads to the conclusion that the data scale is unbalanced and contains outliers. Therefore, the min-max approach is used to normalize the data in order to overcome the imbalance in the data scale. This makes the data more uniform and makes it easier to compare variables. The percentage of babies with low birth weight (LBW), which was positively correlated with the prevalence of stunting, and the human development index (HDI), which was negatively correlated with stunting, were among the strongly correlated variables (multicollinear) in the data, according to the correlation matrix results. As a result, it was necessary to eliminate and segment a number of features that were part of the model. With reduced mean squared error (MSE) and root mean squared error (RMSE) values, the simulation results demonstrated that the Random Forest algorithm outperformed SVR. The prediction distribution graph indicates that SVR tends to be less accurate, particularly at extreme values, but Random Forest is better at tracking the true actual distribution pattern. In general,

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Random Forest predicts the percentage of stunted babies in different districts and cities more accurately than SVR, with forecasts in most places being closer to the actual numbers.

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Detection of emotional disorders in new undergraduate students using fuzzy logic

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Abstract. *Emotional disorders are psychological conditions characterized by emotional instability, difficulty in managing emotions, and have a significant impact on daily life. Based on the report of the results of the Basic Health Research in 2018, the prevalence of emotional disorders in the Indonesian population aged 15-24 years was 10%. Therefore, students are a group that is vulnerable to emotional disorders. Emotional disorders in students are influenced by internal factors such as high personal expectations and ineffective time management, as well as external factors such as financial difficulties, social interactions and living arrangements. This study aims to detect emotional disorders in students based on the specified factors. Data comes from 100 new FMIPA students obtained through questionnaires. The fuzzy system uses five input variables and one output variable. Input variables include gender (male and female), place of residence (boarding house, living with parents, living with family), time management skills (low and high), financial problems (high and low), and number of friends (few and many). The output variable is a fuzzy detection (None, Little, and Lot). Fuzzy rules use 48 rules and relationships between input and output variables based on the data patterns obtained. To determine the accuracy of the system, the fuzzy detection output results are compared with the SRQ-20 score results as actual detection. Based on the test results, the accuracy of the new student emotional disturbance detection system is 91%.*

Keywords: detection, emosional disorders, fuzzy, gender, residence, time management, financial problems, number of friends, SRQ-20

Introduction

Mathematics is a science that underpins every aspect of human life, from simple calculations to serving as the foundation for cutting-edge technological innovations. It is not merely the study of numbers and computations but also a tool capable of solving various human problems.

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Mathematics possesses the ability to recognize and process patterns. Based on these patterns, mathematics aids in the formation of mathematical models that represent real-world problems. These models can then be analyzed and utilized in decision-making processes. The health sector is one such real-world domain characterized by identifiable patterns.

Emotional disorders are psychological conditions characterized by emotional instability, difficulties in managing emotions, and significant impacts on daily life. These disorders can manifest as anxiety, depression, or post-traumatic stress disorder (PTSD) [1]. According to the 2018 Basic Health Research report, the prevalence of emotional disorders among Indonesians aged 15–24 years was 10% [2]. This age group often experiences significant physical, emotional, and social changes, making them more susceptible to such disorders.

In Indonesia, undergraduate students typically range from 17 to 25 years old, placing them in a vulnerable group for emotional disturbances. The initial phase of college, particularly during the first and second semesters, serves as a transition from high school to higher education. During this period, new students face more complex academic demands and various other life aspects.

Challenges such as cultural background differences, the necessity to live away from home, lack of time management skills amidst busy campus activities, and the pressure to excel academically can lead to stress among new students [3]. Those who are shy and lack confidence in social interactions often struggle to form new friendships. Students who feel lonely or lack companionship tend to experience greater emotional pressure, including feelings of isolation, lack of social support, and even risks of emotional disorders like depression, anxiety, stress, and somatic disorders [4]. Stress among students is influenced by internal factors such as high personal expectations and ineffective time management, as well as external factors like financial difficulties, social interactions, and living arrangements [5]

A study by Peltzer in 2018 revealed that 14.2% of 4,354 respondents in higher education in Indonesia experienced moderate depression, and 5% suffered from severe depression [6]. Additionally, more than 50% of new students were found to have emotional mental disorders [7]. Emotional disturbances in students tend to result in declining academic performance and can even affect dropout rates 8]. Therefore, detecting emotional disorders in higher education institutions is essential.

A Decision Support System (DSS) is a computer-based system that assists in semi-structured or unstructured decision-making processes, where subjectivity and data analysis play crucial roles. Fuzzy logic can be utilized in decision-making involving uncertainty in received data or data processing results [9]. Assessing emotional disorders often encounters uncertainties due to the subjective nature of symptoms and individual response variability. To address this, fuzzy logic can be applied in emotional disorder detection systems.

Methodology

This study aims to detect the level of emotional disorders among students based on factors such as gender, residence, time management skills, financial issues, and number of friends. The research procedures include: 1) Development of research instruments; 2) Data collection; 3) Data processing and analysis; 4) System development and implementation; 5) System testing; and 6) Conclusion drawing

Primary data were collected through online questionnaires distributed to new students of FMIPA. The questionnaire was designed to gather personal data such as gender and residence during studies, assessments on a scale of 1–10 for factors like time management skills, financial

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issues, and number of friends, as well as scores of emotional disorders using SRQ-20.

The decision support system design utilizes fuzzy logic with the Mamdani method. The implementation of the Mamdani method involves four stages: 1) Defining input and output variables and converting them into fuzzy sets; 2) Creating fuzzy rules; 3) Rule composition; and 4) Defuzzification.

To facilitate the implementation and testing process, all calculations are performed using Matlab. To measure the system's accuracy, the following equation is used:

$$\text{Accuracy} = \left(\frac{\text{Number of Correct Predictions}}{\text{Total Number of Cases}}\right) \cdot 100\% \quad (1)$$

Mamdani Method

The Mamdani method, introduced by Ebrahim Mamdani in 1975, is a widely used approach in fuzzy logic systems. This method is highly flexible and exhibits a high tolerance for human-derived input data, making it particularly suitable for processing such information [9]. In the Mamdani method, the minimum (Min) function is employed as the implication function, while the maximum (Max) function is utilized for rule composition.

Self-Reported Questionnaire (SRQ-20)

Self-Reported Questionnaire (SRQ) is a questionnaire developed by WHO for the detection (screening) of emotional disorders for research purposes and has been used in various countries [10]. SRQ consists of 20 questions and has been tested as a valid and reliable questionnaire [11]. SRQ-20 is used as an initial screening tool to identify potential emotional disorders in individuals that may require further evaluation by a psychologist or psychiatrist. Respondents fill out the SRQ-20 instrument themselves by answering 20 questions referring to their own experiences and circumstances over the past 30 days [12]. Each "Yes" answer gets a score of 1 and a score of 0 for the answer "No". The higher the score obtained indicates an increase in the number of symptoms experienced. If the score is at least 6, it is considered to have an emotional mental disorder and if further examined by a psychiatrist, it has the potential for a mental disorder [13].

Result and discussion

Data collection

The population in this study was 1367 firsts semester FMIPA students. Based on the Slovin equation by taking a margin of error of 10%, the number of samples used was 100 people. The results of the validity and reliability tests in this study were carried out on the answers of 20 respondents.

Table 1. Validity Test Results

No	Question	Validity Results		Validity
		r table	r count	
1	Your ability to manage time	0,444	0,727	Valid
2	The financial problems you are facing	0,444	0,605	Valid
3	Many friends you have	0,444	0,701	Valid

Based on Table 1, r count on each question shows a value that is more than r table. Therefore, the questionnaire used is Valid.

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Table 2. Reliability Test Results

No	Question	Cronbach's Alpha if Item Deleted
1	Your ability to manage time	0,508
2	The financial problems you are facing	0,550
3	Many friends you have	0,499

Based on Table 2, the Cronbach Alpha value for each question is more than 0.444. So the questionnaire is declared reliable.

Data obtained from 100 respondents on the criteria of gender, place of residence during college and SRQ-20 scores can be seen in Table 3 below.

Table 3. Respondent data

Gender	%	Residence	%	SRQ-20 Score	%
Male	37	Boarding House	16	1 - 5	15
		With Parents	19	6 - 12	19
		At the Family home	2	13 - 20	3
Female	63	Boarding House	31	1 - 5	9
		With Parents	27	6 - 12	39
		At the Family home	5	13 - 20	15

From Table 3 it can be seen that the majority of respondents are women at 63%. Based on residence, the majority of male students live with their parents at 51.25%, while the majority of female students rent boarding houses at 49.2%. Based on the SRQ-20 score, male students who have a minimum score of 6 are 59.46%, while female students are 85.71%.

Fuzzy System

In forming a fuzzy system, researchers based on the data patterns obtained.

Fuzzyfication

In this study, researchers took five input variables and one output variable. Input variables are gender, place of residence, ability in time management, financial problems faced, and many friends owned. Input variables are Diagnosis. Representation of membership degree functions using triangle curves and trapezoid curves.

(1) The gender variable is divided into two fuzzy sets, namely MALE and FEMALE. The MALE fuzzy set has the domain in the interval [1,1] and FEMALE has the domain in the interval [2,2]. The representation curves in both sets use triangular curves.

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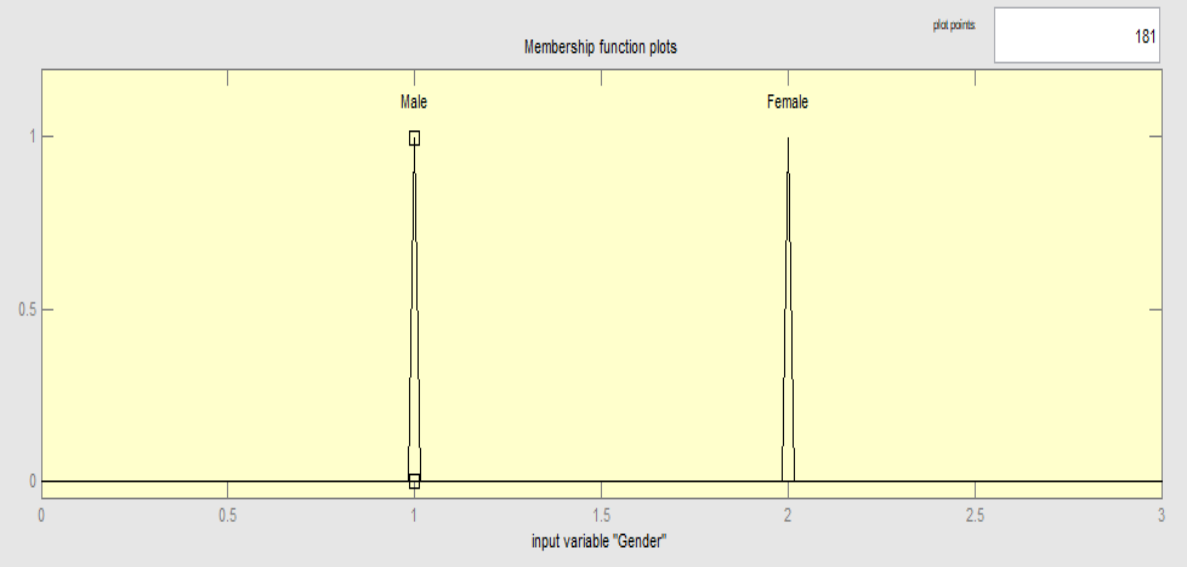

Figure 1. Display of membership function representation of gender variable.

(2) The Residence variable is divided into three fuzzy sets, namely Boarding House, With Parents, and at the Family Home. The Boarding House set has the domain in the interval [1,1], With Parents has the domain in the interval [2,2], and at the family home has the domain in the interval [3,3]. The representation curves in the three sets use triangular curves.

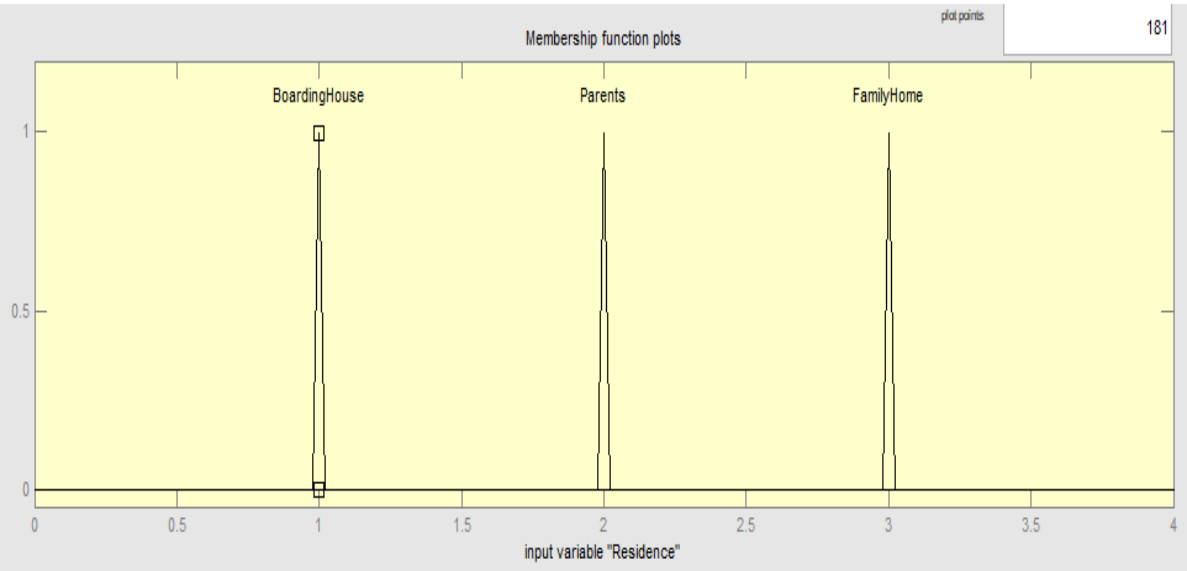

Figure 2. Display of membership function representation of residence variable

(3) Time Management variables are divided into two fuzzy sets, namely Low and High. The Low set has the domain in the interval [1,6] and High has the domain in the interval [4,10]. The representation curves in both sets use trapezoidal curves.

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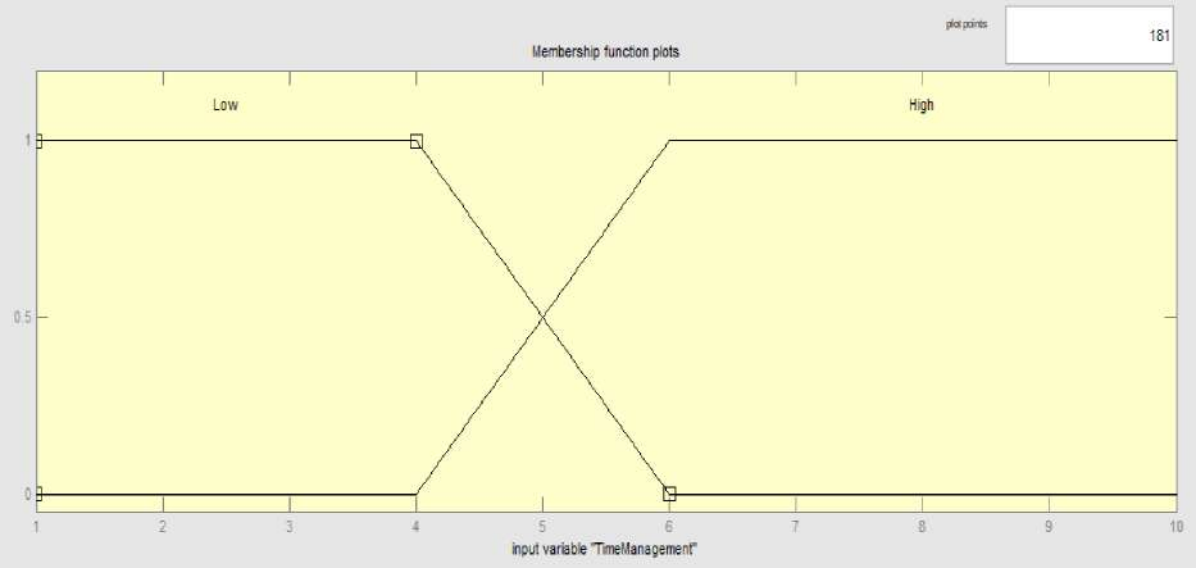

Figure 3. Display of membership function representation of the time management variable.

(4) The Financial Problems variables are divided into two fuzzy sets, namely High and Low. The High set has the domain in the interval [1,6] and Low has the domain in the interval [4,10]. The representation curves in both sets use trapezoidal curves.

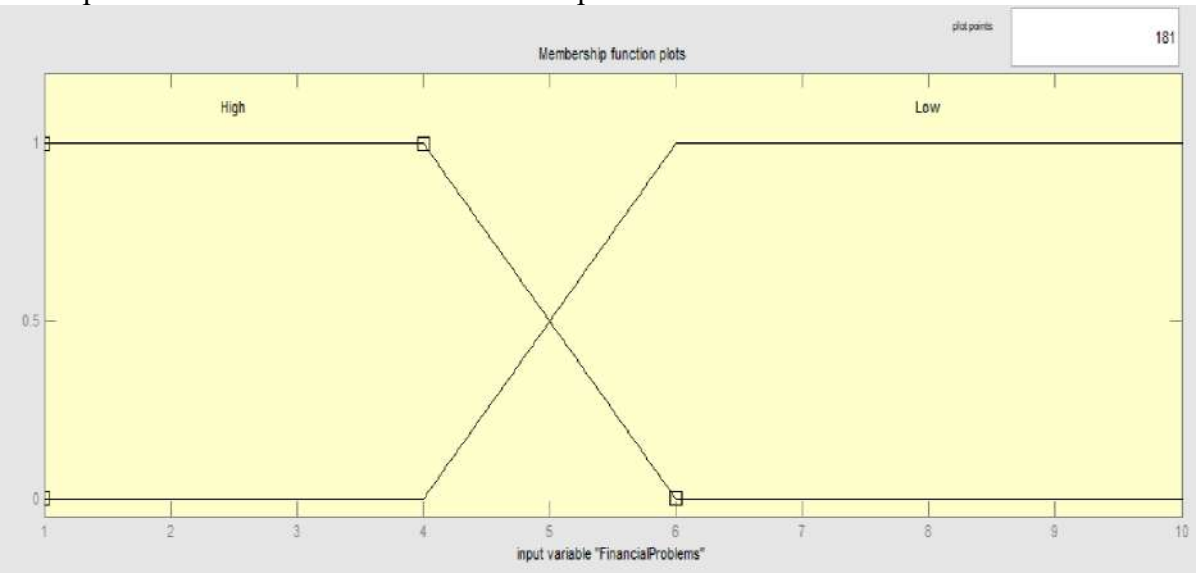

Figure 4. Display of membership function representation of financial problems variables

(5) The Number of Friends variable is divided into two fuzzy sets, namely Little and Lot. The Little set has the domain in the interval [1,6] and Lot has the domain in the interval [4,10]. The representation curves in both sets use trapezoidal curves.

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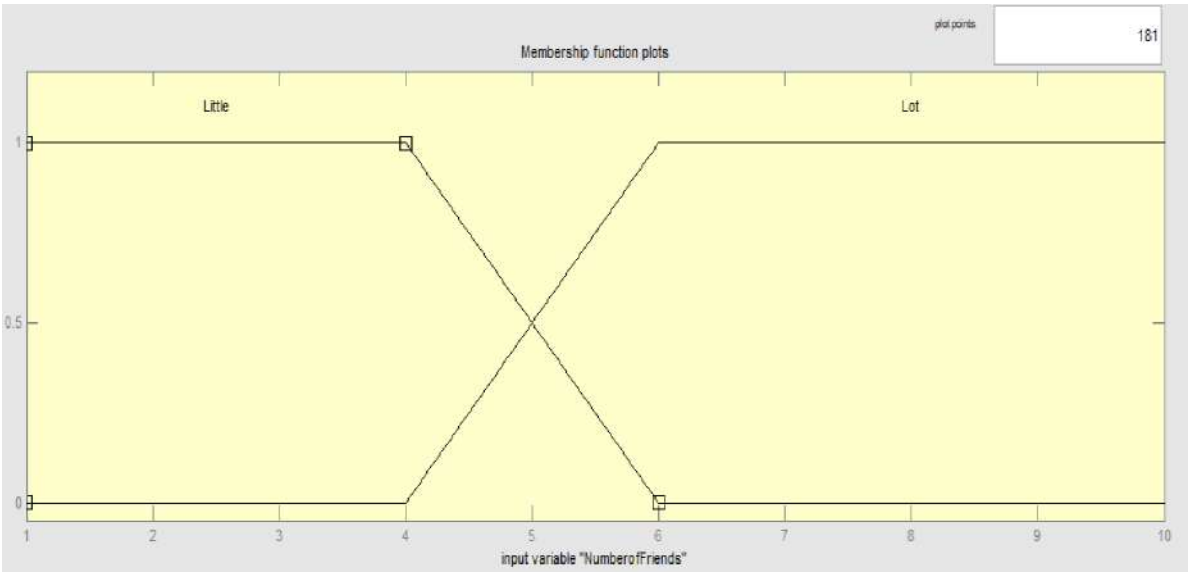

Figure 5. Display of membership function representation of the number of friends variable

(6) Fuzzy Detection Variables are divided into three fuzzy sets, namely No, Small and Big. The None set has the domain in the interval [0,5], small has the domain in the interval [6,12] and Big has the domain in the interval [13,20]. The representation curves in both sets use trapezoidal curves.

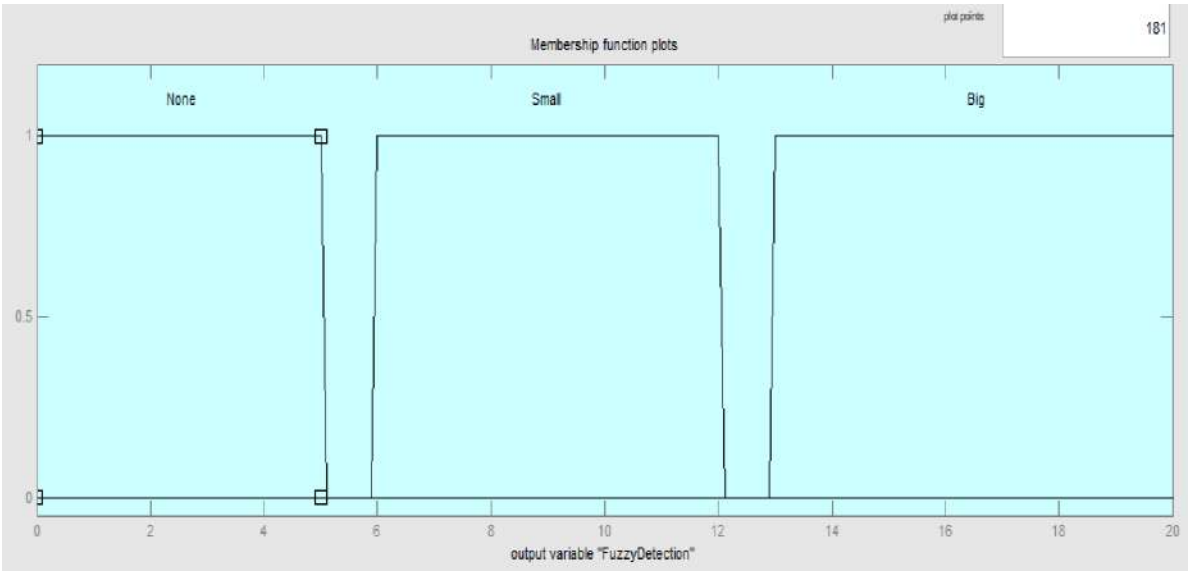

Figure 6. Display of membership function representation of fuzzy detection variable

Fuzzy Rules

In this study, the determination of fuzzy rules adjusts the data that has been obtained. To obtain accurate output, the relationship between input variables is associated with the actual output variables obtained from the SRQ-20 questionnaire. The number of fuzzy rules adjusts the number of fuzzy sets in the input variables that have been defined. Therefore, the fuzzy system uses 48 fuzzy rules.

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(1) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Little) then (FuzzyDetection is Big)
(2) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Lot) then (FuzzyDetection is Small)
(3) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Little) then (FuzzyDetection is None)
(4) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Lot) then (FuzzyDetection is None)
(5) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is High) and (NumberofFriends is Little) then (FuzzyDetection is Small)
(6) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is High) and (NumberofFriends is Lot) then (FuzzyDetection is None)
(7) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Little) then (FuzzyDetection is Small)
(8) If (Gender is Male) and (Residence is BoardingHouse) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Lot) then (FuzzyDetection is None)
(9) If (Gender is Male) and (Residence is Parents) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Little) then (FuzzyDetection is Big)
(10) If (Gender is Male) and (Residence is Parents) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Lot) then (FuzzyDetection is Small)

⋮

(23) If (Gender is Male) and (Residence is FamilyHome) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Little) then (FuzzyDetection is Big)
(24) If (Gender is Male) and (Residence is FamilyHome) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Lot) then (FuzzyDetection is Small)
(25) If (Gender is Female) and (Residence is BoardingHouse) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Little) then (FuzzyDetection is Small)
(26) If (Gender is Female) and (Residence is BoardingHouse) and (TimeManagement is High) and (FinancialProblems is High) and (NumberofFriends is Lot) then (FuzzyDetection is Small)

⋮

(47) If (Gender is Female) and (Residence is FamilyHome) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Little) then (FuzzyDetection is No)
(48) If (Gender is Male) and (Residence is FamilyHome) and (TimeManagement is Low) and (FinancialProblems is Low) and (NumberofFriends is Lot) then (FuzzyDetection is No)

System Testing

To test the emotional disturbance detection model in new FMIPA students, researchers conducted a fuzzy system test using Matlab. The values of each input variable use data obtained from the questionnaire.

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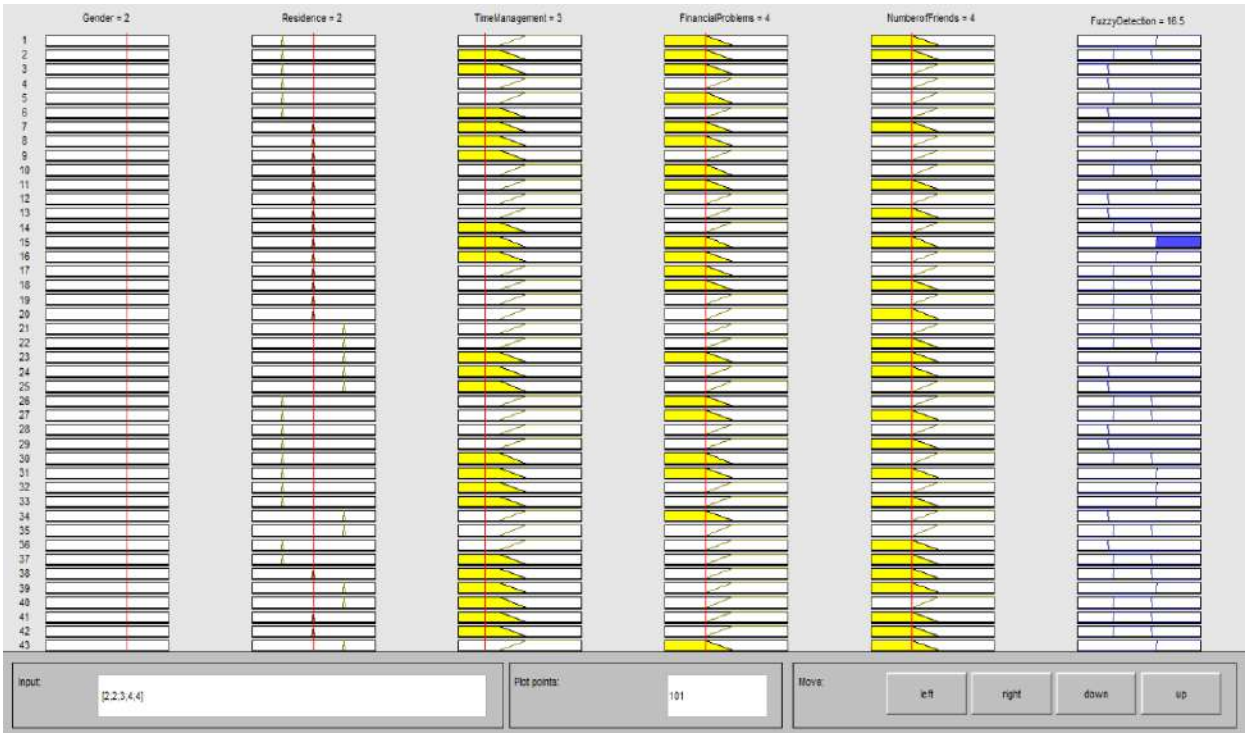

Figure 6. System testing with Matlab

Figure 6 is a test for data with input variables: Gender 2 (female), Residence 2 (Parents), Time management 3 (low), Financial Problems 4 (high), and Number of Friends 4 (low). Based on fuzzy rule number 37, the Fuzzy Detection output is 16.5 (big).

Table 4. System Testing on 100 Respondens

No	Gender	Residence	Time Management	Financial Problems	Number of Friends	Actual Detection	Fuzzy Detection
1.	1	2	4	3	3	Small	Small
2.	1	2	4	7	10	Big	Big
3.	1	2	6	3	8	Small	Small
4.	1	2	7	2	8	None	Small
5.	1	2	7	6	2	None	None
6.	1	2	9	7	8	None	None
7.	1	2	9	10	10	Small	No
8.	1	2	10	1	6	Small	Small
9.	1	2	10	3	3	Big	Big
10.	1	3	9	1	9	None	None
11.	1	3	8	8	6	Small	Small
12.	1	1	7	5	8	Small	Small
13.	1	1	7	5	10	Small	Small
14.	1	1	7	4	1	Big	Big
15.	1	1	8	6	8	None	None
16.	1	1	8	6	8	None	None
17.	1	1	4	1	2	Small	Small
18.	1	1	5	4	5	Small	Small
19.	1	1	6	2	6	Small	Small
20.	1	1	7	8	8	None	None
⋮							

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No	Gender	Residence	Time Management	Financial Problems	Number of Friends	Actual Detection	Fuzzy Detection
81.	2	2	3	4	4	Big	Big
82.	2	2	4	10	7	Small	Small
83.	2	2	5	9	8	None	Big
84.	2	2	6	4	7	Small	Small
85.	2	2	7	5	7	None	Small
86.	2	2	7	7	8	Small	Small
87.	2	2	8	9	6	None	Small
88.	2	2	8	6	6	Small	Small
89.	2	2	8	4	10	Big	Small
90.	2	2	9	5	6	Small	Small
91.	2	2	9	1	1	Small	Small
92.	2	2	9	4	4	Big	Small
93.	2	3	4	8	5	None	None
94.	2	3	5	5	8	Small	Small
95.	2	1	5	3	4	Big	Big
96.	2	1	5	3	7	Big	Small
97.	2	1	5	2	5	Big	Big
98.	2	1	8	5	5	Small	Small
99.	2	1	8	2	7	Big	Small
100.	2	1	9	6	10	None	None

Table 4 shows the results of emotional disturbance detection in 100 respondents based on the results of system testing with the help of matlab. Actual detection data is obtained based on the SRQ-20 value. The SRQ-20 score is grouped into 3 parts according to the output variable of the fuzzy system. The test results show that there are 9 fuzzy detection results that do not match the actual detection. So that the accuracy of the system based on equation (1) is obtained at 91%.

Conclusion

The SRQ-20 instrument is a tool that can be used to detect emotional disorders in students based on their own experiences and circumstances. This means that the SRQ-20 detects based on internal factors. Emotional disorders are also influenced by external factors. This study was conducted to detect emotional disorders based on internal factors such as gender and time management skills, as well as external factors such as financial problems, number of friends and place of residence. To obtain good system accuracy, it is necessary to recognize and analyze patterns in the questionnaire answers. The answer pattern is the basis for forming a fuzzy set on the input and output variables and the appropriate relationship between the two variables. In general, high financial problem factors can cause symptoms of emotional disorders. There are 11 rules with fuzzy detection: none, 25 rules with fuzzy detection: little, and 12 rules with fuzzy detection: big. The output of the system shows fuzzy detection of emotional disorders in students. Fuzzy detection is compared to detection using the SRQ-20 instrument. The accuracy of the student emotional disorder detection system is 91%

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Construct validity using principal component analysis in the development of instruments for coronary table patients

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Abstract. *Coronary heart disease (CHD) is a leading cause of global mortality, highlighting the need for a valid assessment tool to manage risk effectively. Construct validity is a key element in developing such instruments, measuring their accuracy in assessing CHD -related aspects. Principal Component Analysis (PCA) is a statistical method used to evaluate construct validity by identifying data structures and grouping variables into principal components. This study aims to assess the application of PCA in validating the construct of a CHD assessment instrument, focusing on three main aspects: the effectiveness of the PCA process, identification of principal components, and its impact on instrument accuracy. The research design is cross-sectional with a random sample of 100 CHD-risk individuals.*

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Data were collected through surveys on risk variables such as age, gender, hypercholesterolemia, smoking, hypertension, diabetes mellitus, and alcohol consumption. Data analysis included descriptive statistics, Pearson correlation, logistic regression, chi-square tests, and PCA. PCA results revealed three principal components: demographic factors, lifestyle habits, and clinical health, explaining 71.13% of data variability. These findings support the construct validity of the instrument and demonstrate its effectiveness in identifying key CHD risk factors. The study provides recommendations for improving the assessment tool to enhance CHD diagnosis and management.

Keywords: Statistical Method, Risk Variables, Coronary Heart Disease, Principal Component Analysis, Construct Validity

Introduction

Coronary heart disease (CHD) remains one of the leading causes of death worldwide, threatening the health and quality of life of millions of people each year [1]. The high prevalence and serious impact of this disease emphasize the importance of using valid assessment instruments to accurately detect and manage the risk of CHD. Construct validity is a key component in the development of these instruments, referring to the extent to which the instrument can accurately measure the intended construct or concept [2]. Construct validity ensures that the instrument not only measures the intended variable but also reflects the relevant dimensions of coronary heart disease. In this context, Principal Component Analysis (PCA) offers a robust statistical method for evaluating the construct validity of assessment instruments. PCA is used to identify the data structure by grouping variables into principal components that can explain the maximum variability of the data [3]. This process is important because it helps researchers understand the relationships between variables in the instrument and determine whether these variables cluster according to the relevant dimensions of CHD [4] . PCA also allows researchers to simplify complex data models by reducing dimensions without losing significant information, thereby facilitating the interpretation of results [5].

However, the application of PCA in construct validation faces several challenges and important questions. First, how can the process of construct validation using PCA be performed effectively? Although PCA is a useful tool, it requires a deep understanding of statistical techniques and result interpretation. Researchers must be able to determine the optimal number of components and ensure that the identified components are relevant to the construct being measured [6]. Errors in selecting the number of components or interpreting the results can lead to inaccurate conclusions about the validity of the instrument.

Second, what are the main components identified in the coronary heart disease instrument through PCA? Identifying the main components is a crucial step in determining whether the instrument measures relevant variables. Researchers must evaluate the resulting components to confirm that they reflect the important dimensions of coronary heart disease, such as clinical symptoms, risk factors, and diagnostic parameters [7]. These components must be considered in the context of theory and clinical knowledge about coronary heart disease. Third, to what extent can PCA support the accuracy and relevance of the instrument in measuring important aspects of coronary heart disease? This evaluation is essential to ensure that the developed assessment instrument is truly effective in supporting the diagnosis and management of coronary heart disease. PCA should be used to assess whether the developed instrument can accurately and reliably measure aspects relevant to CHD in clinical practice and research. This research aims to address these issues and provide recommendations to improve the quality of assessment instruments.

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This study focuses on several important aspects of using Principal Component Analysis (PCA) for construct validation of coronary heart disease instruments. First, how can the PCA process be effectively applied to assess the construct validity of coronary heart disease assessment instruments? This process includes technical steps such as selecting the appropriate number of components, interpreting factors, and analyzing results to ensure that the instrument accurately measures the intended construct. Precision in this process is crucial, as errors in selection or interpretation can lead to invalid results. Second, what are the main components identified in the coronary heart disease instrument through PCA? Identifying these principal components is crucial for determining whether the variables in the instrument cluster according to the relevant dimensions of coronary heart disease, such as clinical symptoms, risk factors, and diagnostic parameters. Accurate components will ensure that the instrument truly measures the important aspects of the disease. Third, to what extent can PCA support the accuracy and relevance of the instrument in measuring important aspects of coronary heart disease? This evaluation is essential for determining the instrument's effectiveness in clinical practice and research, and for providing a basis for recommendations to improve the reliability and validity of the assessment instrument.

The aim of this research is to thoroughly analyze the application of PCA in the construct validation of coronary heart disease assessment instruments. This includes understanding the technical steps involved in PCA, such as the optimal method for determining the number of components and interpreting results, to ensure that the construct validation process is conducted effectively. Additionally, this study aims to identify and analyze the principal components detected in the coronary heart disease instrument through PCA. By understanding these principal components, researchers can ensure that the variables in the instrument cluster according to the relevant dimensions of the disease and that the instrument accurately measures important variables. The final goal is to assess the extent to which PCA can support the accuracy and relevance of the instrument in measuring important aspects of coronary heart disease. This research aims to provide recommendations for improvement based on PCA findings, so that the assessment instrument can be more effectively used in the diagnosis and management of coronary heart disease, thereby enhancing clinical practice and research in this field.

Literatur Review

Construct validity is a fundamental element in the development of assessment instruments, especially in measuring complex medical conditions such as coronary heart disease (CHD). Construct validity refers to the extent to which an instrument truly measures the intended construct or concept [1]. In the context of CHD, this construct includes various aspects related to the disease, such as clinical symptoms, risk factors, and diagnostic indicators. The importance of construct validity in the context of CHD cannot be understated, as a valid instrument is required to accurately measure the various dimensions of the disease that impact diagnosis and patient management. One of the main challenges in developing assessment instruments for CHD is ensuring that the instrument not only measures observable variables but also reflects the underlying theoretical structure [8]. For instance, clinical symptoms such as chest pain, shortness of breath, and fatigue must be measured accurately, and these measurements should be consistent with existing medical theories about CHD. This theoretical structure includes an understanding of how various symptoms and risk factors are interrelated and contribute to the development and diagnosis of the disease. Therefore, construct validity not only ensures that the instrument measures what it is supposed to measure but also that these measurements are based on a deep and holistic understanding of the disease.

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Construct validity requires demonstrating that the instrument used measures the intended construct reliably. This involves two main types of validity: convergent validity and discriminant validity [9]. Convergent validity assesses how well the instrument correlates with other variables that are expected to have a strong relationship. For example, an instrument designed to measure the severity of coronary artery disease (CAD) should show a high correlation with other validated diagnostic tests, such as electrocardiogram (EKG) or coronary angiography. If the instrument shows a significant correlation with other diagnostic methods, then the instrument's convergent validity can be considered high. Conversely, discriminant validity measures the instrument's ability to differentiate between distinct constructs. This means the instrument must demonstrate that the measurements are specific to CAD and do not overlap with other constructs, such as chronic obstructive pulmonary disease (COPD) or heart failure. Discriminant validity is crucial to ensure that the measurement truly reflects the CAD condition and is not influenced by variables or conditions that may be clinically similar but pathologically different.

The process of ensuring construct validity also involves empirical testing. The instrument must be tested on a representative sample of the target population to see how it performs in practice. Construct validity testing requires empirical data showing that the instrument functions as theoretically expected. For instance, if an instrument is designed to measure the severity of CAD, then the scores produced by the instrument should correlate with the severity diagnosed by a doctor using more conventional and proven methods. Additionally, it is important to remember that construct validity is an ongoing process. As medical knowledge and technology advance, our understanding of CAD also evolves. Therefore, the assessment instruments used must be evaluated and updated regularly to ensure they remain valid and relevant. This could involve adding or modifying items in the instrument, or developing new versions of the instrument that align better with the latest understanding of the disease.

Overall, construct validity is a key element in ensuring that assessment instruments for CAD are reliable and accurate in measuring various aspects of the disease. By employing a comprehensive approach based on theory and supported by empirical evidence, researchers can develop instruments that are not only valid but also highly useful in diagnosing and managing CAD. Principal Component Analysis (PCA) is a valuable statistical method in assessing construct validity due to its ability to reduce data dimensions and identify underlying variable structures [10]. PCA works by grouping highly correlated variables into principal components that can explain most of the data variability [6]. This technique not only helps in reducing data complexity but also provides insights into the relationships between variables and how they cluster into relevant dimensions of the measured disease [11]. In the context of developing instruments for CAD, PCA allows researchers to identify components that significantly impact disease measurement, thus providing a solid foundation for assessing construct validity.

Implementing PCA in construct validation involves several technical steps that need to be performed carefully to ensure accurate and reliable results. The first step is selecting the variables to be analyzed. These variables must be relevant and have the potential to describe various dimensions of coronary artery disease [3]. For example, in a study on CAD, selected variables might include clinical symptoms, diagnostic test results, and risk factors such as high blood pressure and cholesterol levels. Once variables are chosen, the next step is to determine the optimal number of principal components. This is done by analyzing eigenvalues and the scree plot [3]. Eigenvalues show the extent to which each component contributes to the total variability in the data. The scree plot helps in visualizing the point at which the variability decrease starts to slow down, indicating the optimal number of components. Generally, components with eigenvalues

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greater than one are considered significant, but the final decision often involves theoretical and practical considerations.

Next, the components identified through PCA must be interpreted. This requires a deep understanding of how these components relate to the variables in the instrument. This interpretation is crucial to ensure that the components reflect relevant dimensions of coronary artery disease [5]. For example, if a principal component includes variables related to clinical symptoms such as chest pain and shortness of breath, then this component can be interpreted as a dimension of clinical symptoms in CAD. Using PCA in the development of assessment instruments for CAD offers several benefits. One major advantage is PCA's ability to simplify complex data models by reducing the number of variables to analyze without losing important information [7]. This is crucial in clinical contexts where simplification and efficiency are key. By identifying the most relevant principal components, researchers and medical practitioners can focus on the most important variables in the diagnosis and management of CAD.

Moreover, PCA helps in ensuring that the assessment instrument has high construct validity. By grouping highly correlated variables into coherent components, PCA ensures that each component truly measures specific dimensions of coronary artery disease [11]. This helps in ensuring that the instrument is not measuring symptoms randomly but measuring symptoms relevant to the theoretical construct underlying CAD. PCA can also be used to identify potential areas for improvement in the assessment instrument. For example, if there are variables that do not strongly correlate with any of the principal components, this might indicate that these variables are either irrelevant or need to be reviewed. Thus, PCA not only assists in construct validation but also in the iterative process of developing and refining assessment instruments.

Evaluating the accuracy and relevance of the instrument based on PCA results is the final and crucial step in the validation process. PCA helps in identifying principal components that explain data variability and ensures that the instrument measures important aspects of coronary artery disease accurately. This technique also allows for the simplification of complex data models, making interpretation and practical application easier [7]. In the context of CAD, this means that the developed instrument should effectively measure relevant variables without losing critical information. This evaluation helps in ensuring that the instrument is reliable for diagnosing and managing coronary artery disease and makes a significant contribution to research and clinical practice in this field [4]. Thus, PCA not only serves as an analytical tool but also as a foundation for improving and developing better assessment instruments.

Research Methodology

This study uses a cross-sectional design to collect data at a single point in time from the studied population. This design was chosen because it allows for the evaluation of the prevalence of coronary heart disease (CHD) risk factors and the relationships between various variables within the same time period. Data were collected through surveys or medical records covering various variables considered as risk factors for CHD. The study population consists of individuals at risk of developing CHD. Inclusion criteria include being ≥ 18 years old and not having a prior diagnosis of CHD. From this population, a random sample of 100 individuals was selected. Random sampling aims to achieve better representation of the population and minimize bias in the research results.

The study involves several variables suspected to be related to the risk of CHD. These variables are age (x1), with age status 0 = < 40 years and 1 = ≥ 40 years; gender (x2), with gender status 0 = female and 1 = male; hypercholesterolemia (x3), with hypercholesterolemia status 0 = no and 1

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= yes; smoking (x4), with smoking status 0 = no and 1 = yes; hypertension (x5), with hypertension status 0 = no and 1 = yes; diabetes mellitus (x6), with diabetes mellitus status 0 = no and 1 = yes; and alcohol consumption (x7), with alcohol consumption history 0 = no and 1 = yes. Data were collected through surveys or medical record collection. Each participant was asked to provide information on the above variables through a prepared questionnaire. The questionnaire includes questions regarding age, gender, hypercholesterolemia status, smoking habits, hypertension status, diabetes mellitus diagnosis, and alcohol consumption history. The collected data were then input and processed using SPSS software for further analysis.

Data analysis was conducted in several steps. First, descriptive statistical analysis was performed to calculate the mean, standard deviation, minimum, and maximum of each variable, providing an overview of the data distribution and characteristics. Second, frequency tables were constructed for categorical variables to see the distribution of proportions within each category of the variable. Third, Pearson correlation analysis was conducted to assess the relationship between numeric variables to determine the extent of their interrelationship. Subsequently, logistic regression was used to assess the relationship between the binary dependent variable (diabetes mellitus) and several independent variables (hypercholesterolemia, smoking, and hypertension). This helps in determining the impact of each independent variable on the risk of diabetes mellitus. Additionally, cross-tabulation and chi-square tests were performed to assess the relationship between two categorical variables, providing information on the statistical significance of the relationship. The final part of the data analysis is Principal Component Analysis (PCA), which is used to identify the principal components that explain the variability in the data and group the variables related to major risk factors. Steps in PCA include determining the number of significant principal components based on eigenvalues (>1), performing component rotation (e.g., varimax rotation) to facilitate interpretation, and interpreting factors based on significant factor loadings (loading > 0.4). PCA results help in evaluating the construct validity of the instruments used in this study and identifying the main risk factors for coronary heart disease.

Result and Discussion

This study aims to evaluate the construct validity of the instrument developed to identify risk factors for coronary heart disease using Principal Component Analysis (PCA). The study employs a cross-sectional design, with data collected at a single point in time from a sample of 100 individuals. The sample was randomly selected from a population of individuals at risk for coronary heart disease, with inclusion criteria including being ≥ 18 years old and having no prior diagnosis of coronary heart disease. The variables examined in this study include age (x1), with age status 0 = < 40 years and 1 = ≥ 40 years; gender (x2), with gender status 0 = female and 1 = male; hypercholesterolemia (x3), with hypercholesterolemia status 0 = no and 1 = yes; smoking (x4), with smoking status 0 = no and 1 = yes; hypertension (x5), with hypertension status 0 = no and 1 = yes; diabetes mellitus (x6), with diabetes mellitus status 0 = no and 1 = yes; and alcohol consumption (x7), with alcohol consumption history 0 = no and 1 = yes. Data were collected through surveys or medical records, where each participant provided information on the above variables. The data were then input and processed using SPSS for further analysis.

Data analysis is done in several stages. First, a descriptive statistical analysis was carried out to calculate the mean, standard deviation, minimum, and maximum of each variable. The results of the description analysis showed that the distribution of data was quite variable, with the mean age being around the middle point (mean = 0.46, SD = 0.50), which showed an almost even distribution between age groups < 40 years and ≥ 40 years. Similarly, other variables showed a fairly uniform

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distribution among existing categories. Next, a Pearson correlation analysis is performed to assess the relationship between numerical variables. Correlation matrix results show that some variables have quite strong relationships. For example, hypercholesterol (x3) showed a significant positive correlation with smoking (x4) (r = 0.22) and hypertension (x5) (r=0.17). This suggests that individuals with hypercholestrol also tend to have smoke habits and a higher risk of high blood pressure.

To evaluate the relationship between the binary dependent variable (diabetes militus) and several independent variables, a logistic regression analysis was carried out. The logistical regression results showed that hypercholesterol (x3) and smoking (x4) had a considerable positive coefficient against the risk of diabetes militus, although not all results were significant at the level of 0.05. Hypercholesterol had B = 0.90, SE = 0.50, and p = 0.07, while smokers had B=0.80, SE=0.45, and p=0.08. Despite this, the results still provide indications that both of these factors may play a role in increased risk of militancy diabetes. In addition, cross-tabulation and chi-square tests are used to assess the relationship between two categorical variables. For example, the relationship between hypercholesterol and smoking shows a chi-square value of 12.34 with a p-value = 0.001, which means that the relationship is significant at a rate of 0.01. It suggests that there is a strong link between individuals who have hypercholesterol with smoking habits.

Table 1. KMO dan Barlett's Test

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.34	1	0.001
Continuity Correction	11.29	1	0.001
Likelihood Ratio	13.57	1	0.001
Linear-by-Linear Assoc	12.21	1	0.001
N of Valid Cases 100			

The primary analysis using PCA is carried out to identify the primary component that explains data variability and group the variables that are related to the major risk factors. The PCA results showed that there are three significant main components with eigenvalues > 1, which cumulatively describes 71.13% of the total data variability. The first component describes 36.54% of variability, the second component explains 18.55%, and the third component explained 16.04%. Screenshot plot from the PCA indicates that after the third part, the eigenvalue begins to horizontally, indicating that the three major components are sufficient to explain most of the variability of the data. After varimax rotation, the matrix component indicates that the age-variable (x1) and gender variables (x2) have a high load on the first component, the hypercholesterol variable (X3) and the smoking variable(x4) have high loads on the second component. Alcohol consumption (x7) has a relatively lower load but still significant on some components.

Interpretation of these PCA results suggests that the constructive validity of the developed instrument is quite good, with three main components identifiable and each component has closely related variables. The first component can be interpreted as a demographic factor (age and gender), the second component as a lifestyle factor (hypercholesterol and smoking), and the third as a clinical health factor. (hipertensi dan diabetes militus). The findings provide support for the use of this instrument to identify and group the major risk factors for coronary heart disease in the population studied. The study aims to evaluate the validity of the construction of the instrument developed for identifying the risk factors of coronar heart disease using Principal Component Analysis. (PCA). The design of the study used was cross-sectional, where data was collected from samples of as many as 100 people at risk of coronary heart disease. The inclusion criteria include

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age ≥ 18 years and have no history of previously diagnosed coronary heart disease. The variables studied included age (x1), gender (x2), hypercholesterol (x3), smoking (x4), hypertension (x5), militant diabetes (x6), and alcohol consumption. (x7). Data is collected through surveys or medical records and processed using SPSS.

Descriptive analysis shows a variable data distribution for each variable. The age of the respondents was divided almost evenly between the groups < 40 years and ≥ 40 years, with an average of 0.46 and a standard deviation of 0.50. The gender distribution is also balanced between men and women. The majority of the respondents did not have hypercholesterol, did not smoke, had no hypertension, didn't have militant diabetes, and had no history of alcohol consumption. This analysis provides a good initial picture of the characteristics of the sample being studied. Pearson's correlation analysis reveals some significant relationships between the variables studied. There is a significant positive correlation between hypercholesterol (x3) and smoking (x4) (r=0.22), as well as between hypercolesterol (x3) and hypertension (x5) (r = 0.17). These results indicate that individuals with hypercholestrol tend to have smoke habits and a higher risk of hypertensive disease. Logistic regression analysis performed to assess the influence of independent variables on milituous diabetes shows that hypercholesterol (x 3) and smoke (x 4) have quite large positive effects, although not significant at a rate of 0.05.

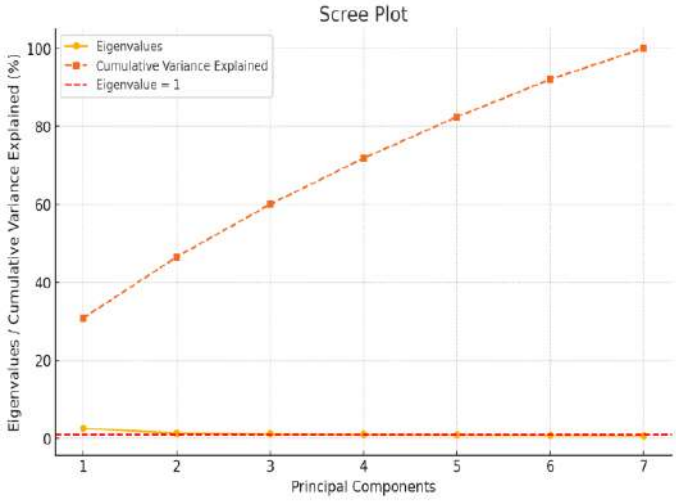

Figure 1. Scree Plot Analysis

The interpretation of the Scree Plot reveals several important pieces of information about the principal components in factor analysis. The line marked with 'o-' represents the eigenvalues for each component, with the first component having the highest eigenvalue, followed by the second and third components. Eigenvalues greater than 1 indicate that the component significantly contributes to the variance in the data. The line marked with 's--' shows the cumulative percentage of variance explained by the number of components. In this plot, the first three principal components explain approximately 71.13% of the total data variability, with each component contributing 36.54%, 18.55%, and 16.04% of the variance, respectively. The dashed red line at an eigenvalue of 1 marks the common threshold for determining the number of significant principal components. From the Scree Plot, it is clear that after the third component, the eigenvalues start to decline drastically and approach a value of 1. This indicates that three principal components are sufficient to explain most of the data variability, suggesting that additional components do not

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contribute significantly further.

The chi-square test results show several significant relationships between categorical variables. For example, the relationship between hypercholesterolemia and smoking has a chi-square value of 12.34 with a p-value of 0.001, indicating that the relationship is significant at the 0.01 level. This demonstrates a strong association between individuals with hypercholesterolemia and smoking habits. Principal component analysis (PCA) identified three principal components explaining 71.13% of the total data variability. The first component explains 36.54% of the variability, the second component explains 18.55%, and the third component explains 16.04%. The Scree Plot shows that after the third component, eigenvalues begin to level off, meaning that three principal components are sufficient to explain most of the data variability. After varimax rotation, variables were grouped with high loadings on the corresponding components: age (x1) and gender (x2) on the first component, hypercholesterolemia (x3) and smoking (x4) on the second component, and hypertension (x5) and diabetes mellitus (x6) on the third component. Alcohol consumption (x7) has a lower but still significant loading on several components.

The interpretation of the PCA results indicates that the construct validity of the developed instrument is quite good. The three identified principal components reflect the main dimensions of risk factors: demographic, lifestyle, and clinical health. Significant relationships between certain variables, such as hypercholesterolemia and smoking, and their impact on diabetes mellitus risk, suggest that these factors are important to consider in efforts to prevent and manage coronary heart disease. Overall, these analysis results support the use of the developed instrument to identify the main risk factors for coronary heart disease. Good construct validity ensures that the measurements are reliable and accurate in reflecting relevant risk factors. These findings provide a strong basis for further development and application of this instrument in various research and clinical practice contexts, and can aid in the identification and management of individuals at high risk of coronary heart disease.

Conclusion

This study examines the construct validity of a coronary heart disease (CHD) assessment instrument using Principal Component Analysis (PCA). In this context, construct validity is crucial to ensure that the developed instrument accurately measures the relevant dimensions of CHD. The PCA results indicate that three principal components can be identified: demographic factors (age and gender), lifestyle factors (hypercholesterolemia and smoking), and clinical health factors (hypertension and diabetes mellitus). These three components cumulatively explain 71.13% of the data variability, indicating that the instrument is valid in grouping variables related to CHD risk. Descriptive analysis reveals a fairly even distribution of variables, while correlation analysis shows significant relationships between some risk variables, such as hypercholesterolemia and smoking. Logistic regression results suggest that hypercholesterolemia and smoking may contribute to the risk of diabetes mellitus, although not all results are significant at the 0.05 level.

Overall, PCA has proven effective in assessing the construct validity of this assessment instrument by identifying relevant principal components for the diagnosis and management of CHD. These findings support the use of the instrument in clinical practice and research, with recommendations to improve or update the instrument based on the latest understanding of CHD.

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The scrambling index of two-colored hamilton digraph type I

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Abstract. *The scrambling index of two-colored digraph $D^{(2)}$, denoted by $k(D^{(2)})$ is the smallest positive integer $k+t$ over all pairs of non negative integers (k,t)such that for each distinct vertices u and v in $D^{(2)}$ there is a vertex w in $D^{(2)}$ such that there are walks from u to w and from v to w that consist of k red and t blue arcs. We discuss the scrambling index of two-colored Hamilton digraphs on n vertices consisting of two cycles of length n and $(n-2)$. For such two-colored digraphs we show that the scrambling index lies on the interval* $[(n^3-2n^2-3n+4)/4, (n^3-2n^2-n+10)/4)]$

Keywords: scrambling index, two colored digraph, smallest positive integer, blue arc, two cyles.

Introduction

Let D be a digraph. A walk of length t from u to v is a sequence of arcs of the form $u \to v_1, v_1 \to v_2, \cdots, v_{k-1} \to v$ .We use the notation $u \xrightarrow{t} v$ walk to represent a walk of length t from u to v. A $u \to v$ path is a walk with distinct vertices except possibly $u = v$. A cycle is a $u \to v$ path with $u = v$. A digraph D is strongly connected if for each pair of vertices u and v there is a $u \to v$ walk and a $v \to u$ walk. A strongly connected digraph D is primitive provided there is a positive integer k such that for each pair of vertices u and v there exists a $u \xrightarrow{k} v$ walk. The smallest of such positive integer k is called the exponent of D and is denoted by $\exp(D)$.

Research on scrambling index of a primitive digraph D is initiated by Akelbek and Kirkland [1]. The *scrambling index* of a primitive for each pair of vertices u and v in D one can find a vertex w in D such that there is a $u \xrightarrow{k} w$ walk and a $v \xrightarrow{k} w$ walk. The scrambling index of a primitive digraph is denoted by k(D). They show that, see [2], primitive digraph with largest scrambling index is obtainned by the Wielandt digraph W_n consisting of a Hamilton cycle $v_1 \to$

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$v_2 \to \cdots v_n \to v_1$ and the arc $v_{n-1} \to v_1$.

A two-colored digraph $D^{(2)}$ is a digraph each of whose arc is colored by red or blue. For nonnegative integers h and l, an (h, l)-walk in a two-colored digraph is a walk consisting of h red arcs and l blue arcs. An (h, l)-walk from u to v is denoted by $u \xrightarrow{(h,l)} v$. For a walk W in $D^{(2)}$, we respectively denote r(W) and b(W) to the number of red arcs and blue arcs of W.

The vector $\begin{bmatrix} r(W) \\ b(W) \end{bmatrix}$ is the compotition of W. A two-colored digraph $D^{(2)}$ is primitive provided that there are nonnegative integers h and l such that for each pair of vertices u and v in $D^{(2)}$ there is a $u \xrightarrow{(h,l)} v$ walk. Let $D^{(2)}$ be a two-colored digraph and let $C = \{C_1, C_2, \cdots C_q\}$ be the set of all cycles in $D^{(2)}$. We define the cycle matrix M of $D^{(2)}$ to be the matrix

$$M = \begin{bmatrix} r(C_1) & r(C_2) & \cdots & r(C_q) \\ b(C_1) & b(C_2) & \cdots & b(C_q) \end{bmatrix}.$$

That is M is the matrix such that the ith column of M is the composition of the cycle $C_i, i = 1,2, \cdots, q$. If the rank of M is 2, content of M is the greatest common divisor of the 2 by 2 minor of M , and the content of M is 0 otherwise. Fornasini and Valcher [3] show that a two-colored digraph $D^{(2)}$ is primitive if and only the content of M is 1.

In 2003, Shader and Suwilo [4] generalize the concept of exponent of a digraph to that of exponent of a two-colored digraph $D^{(2)}$.The exponent of a two-colored digraph $D^{(2)}$ is the smallest positive integer $h + l$ over all nonnegative integer h and l with the property that for each pair of vertices u and v in $D^{(2)}$ there is a $u \xrightarrow{(h,l)} v$. They show that if n is odd, then the largest exponentof a two-colored digraph on n vertices lies on the interval $[(n^3)/2, (3n^3 + 2n^2 - 2n)/2]$. The left end of the interval is obtained by a Hamiltonian two-colored digraph with the underlying digraph is the digraph L_n consisting of the Hamiltonian cyle $v_1 \to v_2 \to \cdots v_n \to v_1$ and the arc $v_{n-2} \to v_1$.

In this paper, we generalize the notion of a scrambling index of a primitive digraph to that of a scrambling index of a primitive two-colored digraph $D^{(2)}$. For a primitive two-colored digraph $D^{(2)}$ we define the scrambling indexof $D^{(2)}$ to be the smallest positive integer $h + l$ over all nonnegative integer h and l such that for each pair of vertices u and v in $D^{(2)}$ there is a vertex w with the properly that there is a a $u \xrightarrow{(h,l)} w$ walk and a a $v \xrightarrow{(h,l)} w$ walk. The scrambling index of $D^{(2)}$ is denoted by $k(D^{(2)})$. We discuss the scrambling index of the class of two-colored digraph $L^{(2)}$ type I on n vertices whose underlying digraph is the digraph L_n .

Some Preliminaries

In this section we discuss a way in setting up an upper bound and a lower bound for the scrambling index of a primitive two-colored digraph. We first note that every walk in a two-colored digraph can be decomposed into a path and some cycles. This implies for every $u \xrightarrow{(h,l)} v$ walk we have the following relationship

$$\begin{bmatrix} h \\ l \end{bmatrix} = \begin{bmatrix} r(p_{uv}) \\ b(p_{uv}) \end{bmatrix} + z_1 \begin{bmatrix} r(C_1) \\ b(C_1) \end{bmatrix} + z_2 \begin{bmatrix} r(C_2) \\ b(C_2) \end{bmatrix} + \cdots + z_q \begin{bmatrix} r(C_q) \\ b(C_q) \end{bmatrix}$$

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$$= \begin{bmatrix} r(p_{uv}) \\ b(p_{uv}) \end{bmatrix} + Mz$$

for some path p_{uv} from u to v and some nonnegative integer vector **z.**

The following proposition will be useful in order todeterminean upper bound for scrambling index.

Proposition 1. Let $D^{(2)}$ be a primitive two-colored consisting of two cycles C_1 and C_2. Suppose v is a vertex that belongs to both two cycles. If for some positive integers h and l, there is a path p_{uv} from u to v such that the system

$$Mz + \begin{bmatrix} r(p_{u,v}) \\ b(p_{u,v}) \end{bmatrix} = \begin{bmatrix} h \\ l \end{bmatrix} \quad (1)$$

has nonnegative integer solution, the there is an (h, l)-walk from u to v .

Proof: Assume that the solution to the system (1) is $\mathbf{z} = (z_1, z_2)^T$.

We consider four cases

If $z_1 > 0$ and $z_2 > 0$, then the walk that starts at u, moves to v along the $(r(p_{u,v}), b(p_{u,v}))$-path $p_{u,v}$ and finally moves z_1 and z_2 times around the cycles C_1 and C_2, respectively, and back at v is an (h, l)-walk from u to v.

If $z_1 = 0$ and $z_2 > 0$,then the walk that starts at u, moves to v along the $(r(p_{u,v}), b(p_{u,v}))$-path $p_{u,v}$ and finally moves z_2 times around the cycle C_2 and back at v is an (h, l)-walk from u to v .Similarly if $z_1 > 0$ and $z_2 = 0$,then the walk that starts at u ,moves to v along the $(r(p_{u,v}), b(p_{u,v}))$-path $p_{u,v}$ and finally moves z_1 times around the cycle C_1 and back at v is an (h, l)-walk from u to v .

Finally, if $z_1 = z_2 = 0$,then the $(r(p_{u,v}), b(p_{u,v}))$-path $p_{u,v}$ from u to v is is an (h, l)-walk.

We next discuss a way in setting up a lower bound for the scrambling index. Let u and v be two different vertices in a primitive two-colored digraph $D^{(2)}$. The *local scrambling index* of vertices u and v in $D^{(2)}$, denoted $k_{u,v}(D^{(2)})$, is

$$k_{u,v}(D^{(2)}) = min\left\{h + l : u \xrightarrow{(h,l)} w \text{ walk}, v \xrightarrow{(h,l)} w \text{ walk for some } w \in V(D^{(2)})\right\}.$$

From the definition of scrambling index we have

$$\max_{u,v \in V(D^{(2)})} \left\{k_{u,v}(D^{(2)})\right\} \leq k(D^{(2)}) \quad (2)$$

Let $D^{(2)}$ be a primitive two-colored digraph.The inner local exponent of a vertex u , denoted by $expin_{D^{(2)}}(u)$, is the smallest positive integer $h' + l'$ over all nonnegative integer h' and l' such that for each vertex v in $D^{(2)}$ there is an $v \xrightarrow{(h',l')} u$ waik in $D^{(2)}$. See similar definition [2]. The definition of the scrambling index and inner local exponent imply that any vertex u in $D^{(2)}$

$$k(D^{(2)}) \leq expin_{D^{(2)}}(u). \quad (3)$$

Combining (2) and (3)we have the following bounds of the scrambling index.

Proposition 2. Let $D^{(2)}$ be a primitive two-colored digraph. Then for any vertices u and v in $D^{(2)}$ we have

$$k_{u,v}(D^{(2)}) \leq k(D^{(2)} \leq expin_{D^{(2)}}(u).$$

Let u and v be any vertices in a primitive two-colored digraph $D^{(2)}$ with $u \neq v$. For a primitive two-colored digraph consisting of two cycles, we have the following lower bound for $k_{u,v}(D^{(2)})$.

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Lemma 3. Let $D^{(2)}$ be a primitive two-colored digraph consisting of two cyles C_1 and C_2 and let u and v be any two different vertices in $D^{(2)}$. Suppose there is a vertex w such that there is u $\xrightarrow{(h,k)}$ w and v $\xrightarrow{(h,k)}$ w. If q_1 and q_2 are integers such that $\begin{bmatrix} h \\ l \end{bmatrix} = M \begin{bmatrix} q_1 \\ q_2 \end{bmatrix}$, then $\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \geq M^{-1} \begin{bmatrix} r(p_{uw}) \\ b(p_{uw}) \end{bmatrix}$ and $\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \geq M^{-1} \begin{bmatrix} r(p_{vw}) \\ b(p_{vw}) \end{bmatrix}$ for some path p_{uw} and some path p_{vw}.

Proof: Since $D^{(2)}$ is primitive, then content of M is 1 which then implies $\det(M) = \pm 1$.Without loss of generality we assume that $\det(M) = 1$. Notice that

$$\begin{bmatrix} h \\ l \end{bmatrix} = \begin{bmatrix} r(p_{uw}) \\ b(p_{uw}) \end{bmatrix} + Mx$$

for some path p_{uw} from u to w and nonnegative integer vector **x**. Then

$$x = \begin{bmatrix} q_1 \\ q_2 \end{bmatrix} - M^{-1} \begin{bmatrix} r(p_{uw}) \\ b(p_{uw}) \end{bmatrix} \geq 0$$

Hence $\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \geq M^{-1} \begin{bmatrix} r(p_{uw}) \\ b(p_{uw}) \end{bmatrix}$ for some path p_{uw}. Similarly $\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \geq M^{-1} \begin{bmatrix} r(p_{vw}) \\ b(p_{vw}) \end{bmatrix}$ for some path p_{vw} ■

We note from Lemma 2.3 we have that

$$\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} = M^{-1} \begin{bmatrix} r(p_{uw}) \\ b(p_{uw}) \end{bmatrix} = \begin{bmatrix} b(C_2)r(p_{uw}) - r(C_2)b(p_{uw}) \\ b(C_1)b(p_{uw}) - b(C_1)r(p_{uw}) \end{bmatrix}$$

Hence we have

$$q_1 \geq b(C_2)r(p_{uw}) - r(C_2)b(p_{uw}) \quad (4)$$

for some path p_{uw} from u to w. Similarly, we have

$$q_2 \geq r(C_1)b(p_{uw}) - b(C_1)r(p_{uw}) \quad (5)$$

for some path p_{vw} from v to w.

Two-colored Digraph with Large Exponent

It is a well known result, see [4], that the largest exponent of a primitive two-colored digraph lies on the interval $[(n^3 - 2n^2 + 1)/2, (3n^3 + 2n^2 - 2n)/2]$ when n is odd. The left end of the first interval is obtained using two-colored digraph consisting of two cycles whose underlying digraph is the primitive Hamilton digraph L_n on n ≥ 5 vertices which consist of an n-cycle $v_1 \to v_2 \to v_3 \to \cdots \to v_{n-1} \to v_n \to v_1$ and the arc $v_{n-2} \to v_1$ as shown in Figure 1. Notice that the digraph L_n consist of exactly two-cycles, they are the n-cycle and (n − 2)-cycle $v_1 \to v_2 \to v_3 \to \cdots \to v_{n-3} \to v_{n-2} \to v_1$. Since L_n is primitive, it is necessary that n is odd. Let $L_n^{(2)}$ be a two-colored digraph with underlying digraph is L_n. Let M be the cycle matrix of $L_n^{(2)}$. The following lemma, see[4,5]for proof, gives necessary and sufficient condition for $L_n^{(2)}$ to be a primitive two-colored digraph.

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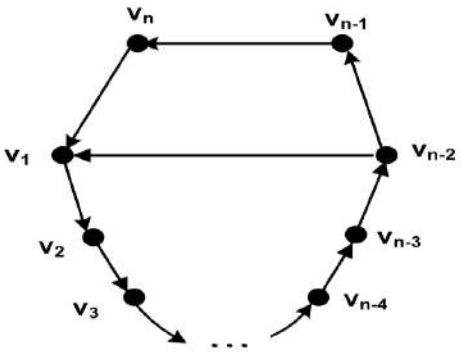

Figure 1. Digraph L_n

Lemma 4. Let $L_n^{(2)}$ be a two-colored digraph with underlying digraph L_n . The two-colored digraph $L_n^{(2)}$ is primitive if and only if $\mathrm{M} = \begin{bmatrix} (\mathrm{n}-1)/2 & (\mathrm{n}+1)/2 \\ (\mathrm{n}-3)/2 & (\mathrm{n}-1)/2 \end{bmatrix}$.

The following theorem,due to Suwilo [5], see also Shader and Suwilo [4], gives the lower and upper bound for exponent of class of two-colored digraphs whose underlying digraph L_n .

Theorem 5. Let $L_n^{(2)}$ be a two-colored digraph with underlying digraph L_n . Then $2\mathrm{n}^2 - 6\mathrm{n} + 2 \leq \exp(L_n^{(2)}) \leq (\mathrm{n}^3 - 2\mathrm{n}^2 + 1)/2$.

Furthermore Suwilo [5] characterize necessary and sufficient condition for two-colored digraph $L_n^{(2)}$ to have exponent exactly $(\mathrm{n}^3 - 2\mathrm{n}^2 + 1)/2$ and $2\mathrm{n}^3 - 6\mathrm{n} + 2$, respectively.

Corollary 6. Let $L_n^{(2)}$ be a two-colored digraph with underlying digraph L_n . The $\exp(L_n^{(2)}) = (\mathrm{n}^3 - 2\mathrm{n}^2 + 1)/2$ if and only if $L_n^{(2)}$ has a red path of length $(\mathrm{n}+1)/2$ and a blue path of length $(\mathrm{n}-1)/2$.

Corollary. 7 Let $L_n^{(2)}$ be a two-colored digraph with underlying digraph L_n .The $\exp(L_n^{(2)}) = 2\mathrm{n}^2 - 6\mathrm{n} + 2$ if and only if $L_n^{(2)}$ has a unique (2,0)-path and this path lies on both cycles.

Lemma 4 implies thatfor a two-colored digraph $L_n^{(2)}$ to be primitive, the n -cycle must contain exactly $(\mathrm{n}+1)/2$ red arc and the $(\mathrm{n}-2)$ -cycle must contain exactly $(\mathrm{n}-1)/2$ red arc. Corollary 6 implies that for the two-colored digraph $L_n^{(2)}$ to have exponent $(n^3 - 2n^2 + 1)/2$, the n -cycle must contain red path of length $(\mathrm{n}+1)/2$ and blue path of length $(\mathrm{n}-1)/2$. This implies there are four possible two-colored digraph $L_n^{(2)}$ with exponent $(n^3 - 2n^2 + 1)/2$. We characterize them as follows

1. The two-colored digraph $L_n^{(2)}$ is type I if the blue arcs of $L_n^{(2)}$ are the arcs that lies on the path $v_{\frac{(n+1)}{2}} \to v_{\frac{(n+3)}{2}} \to \cdots \to v_{n-1} \to v_n$ of length $\frac{(n-1)}{2}$ plus the arc $v_{n-2} \to v_1$.
2. The two-colored digraph $L_n^{(2)}$ is type II if the blue arcs of $L_n^{(2)}$ are the arcs that lies on the path $v_{\frac{(n-1)}{2}} \to v_{\frac{(n+1)}{2}} \to \cdots \to v_{n-2} \to v_{n-1}$ of the length $\frac{(n-1)}{2}$.
3. The two-colored digraph $L_n^{(2)}$ is type III if the blue arcs of $L_n^{(2)}$ are the arcs that lies on

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the path $v_n \to v_1 \to v_2 \to \cdots \to v_{\frac{(n-3)}{2}} \to v_{\frac{(n-1)}{2}}$ of the length $\frac{(n-1)}{2}$.

4. The two-colored digraph $L_n^{(2)}$ is type IV if the blue arcs of $L_n^{(2)}$ are the arcs that lies on the path $v_{n-1} \to v_n \to v_1 \to v_2 \cdots \to v_{\frac{(n-5)}{2}} \to v_{\frac{(n-3)}{2}}$ of the length $\frac{(n-1)}{2}$ plus the arc $v_{n-2} \to v_1$.

Considering Corollary 7 we say the two-colored digraph $L_n^{(2)}$ is type V if the (2,0) -path in $L_n^{(2)}$ is the path $a \to a+1 \to a+2$ for some $1 \le a \le n-4$.

The Results on Scrambling Index

The main result of the scrambling index type I is stated in the following theorem.

Theorem 8. Let $L_n^{(2)}$ be a two-colored digraph of type I whose underlying digraph is the digraph L_n. Then $k\left(L_n^{(2)}\right) = (n^3 - 2n^2 - 3n + 4)/4$.

Proof: We show that $k\left(L_n^{(2)}\right) \ge (n^3 - 2n^2 - 3n + 4)/4$. By Proposition 2 it suffices to show that $k_{v_n, v_{(n+1)/2}}\left(L_n^{(2)}\right) \ge (n^3 - 2n^2 - 3n + 4)/4$. Assume that there are $v_n \xrightarrow{(h,l)} w$ and $v_{(n+1)/2} \xrightarrow{(h,l)} w$ walks for some $w \in V(L_n^{(2)})$. We consider two cases depending on the position the vertex w.

Case 1. *The vertex w lies on $v_1 \to v_{(n+1)/2}$ path.*

There is a unique p_{v_n, v_t} from v_n to v_t which is a $(t, 0)$-path. Using this path and equation (4), we conclude that

$$\begin{aligned} q_1 &= b(C_2)r(p_{v_n,v_t}) - r(C_2)b(p_{v_n,v_t}) \\ &= \left(\frac{n-1}{2}\right)(t) - \left(\frac{n+1}{2}\right)(0) = \frac{t(n-1)}{2} \end{aligned}$$

There are two path $p_{v_{\left(\frac{n+1}{2}\right)}, v_t}$ from $v_{(n+1)/2}$ to v_t. They are a $(t-1, (n-3)/2)$-path and a $(t, (n-1)/2)$-path. Using the $(t-1, (n-3)/2)$-path and equation (5), we find that

$$\begin{aligned} q_2 &= r(C_1)b(p_{v_{(n+1)/2},v_t}) - b(C_1)r(p_{v_{(n+1)/2},v_t}) \\ &= \left(\frac{n-1}{2}\right)\left(\frac{n-3}{2}\right) - \left(\frac{n-3}{2}\right)(t-1) \\ &= \frac{n^2-2n-3}{4} - \frac{n-3}{2}t. \end{aligned}$$

Using the $(t, (n-1)/2)$-path and equation (5), we find that

$$\begin{aligned} q_2 &= r(C_1)b(p_{v_{(n+1)/2},v_t}) - b(C_1)r(p_{v_{(n+1)/2},v_t}) \\ &= \left(\frac{n-1}{2}\right)\left(\frac{n-1}{2}\right) - \left(\frac{n-3}{2}\right)(t) \\ &= \frac{n^2-2n+1}{4} - \frac{n-3}{2}t \end{aligned}$$

Hence we conclude that $q_2 = \frac{n^2-2n+1}{4} - \frac{n-3}{2}t$. By considering Lemma 5 we conclude that

$$\begin{bmatrix} h \\ l \end{bmatrix} \ge M \begin{bmatrix} \frac{t(n-1)}{2} \\ \frac{n^2-2n+1}{4} - \frac{n-3}{2}t \end{bmatrix} = \begin{bmatrix} (n^3 - n^2 - 5n - 3)/8 + t \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix}$$

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$$\geq \begin{bmatrix} (n^3 - n^2 - 5n + 5)/8 \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix} \quad (6)$$

since $t \geq 1$.

Case 2. The vertex w lies on the $v_{\frac{(n+3)}{2}} \rightarrow v_n$ path.

There is a unique path p_{v_n,v_t} from v_n to v_t which is a a $((n+1)/2, t-(n+1)/2)$-path. Using this path and equation (4) we find that

$$\begin{aligned} q_1 &= b(C_2)r(p_{v_n,v_t}) - r(C_2)b(p_{v_n,v_t}) \\ &= \left(\frac{n-1}{2}\right)\left(\frac{n+1}{2}\right) - \left(\frac{n+1}{2}\right)\left(t - \frac{n+1}{2}\right). \end{aligned}$$

There is a unique path $p_{v_{(n+1)/2},v_t}$ from $v_{(n+1)/2}$ to v_t which is a a $(0, t-(n+1)/2)$-path. Using this path and equation (5), we find that

$$\begin{aligned} q_2 &= r(C_1)b(p_{v_{(n+1)/2},v_t}) - b(C_1)r(p_{v_{(n+1)/2},v_t}) \\ &= \left(\frac{n-1}{2}\right)(t - \frac{n+1}{2}). \end{aligned}$$

By Lemma 3 we conclude that

$$\begin{aligned} \begin{bmatrix} h \\ l \end{bmatrix} &\geq M \begin{bmatrix} \left(\frac{n-1}{2}\right)\left(\frac{n+1}{2}\right) - \left(\frac{n+1}{2}\right)\left(t - \frac{n+1}{2}\right) \\ \left(\frac{n-1}{2}\right)(t - \frac{n+1}{2}) \end{bmatrix} \\ &= \begin{bmatrix} (n^3 - n^2 - n + 1)/8 \\ (n^3 - 3n^2 - 5n - 1)/8 + t \end{bmatrix} \\ &\geq \begin{bmatrix} (n^3 - n^2 - n + 1)/8 \\ (n^3 - 3n^2 - 5n + 11)/8 \end{bmatrix} \end{aligned} \quad (7)$$

Since $t \geq (n+3)/2$.

Now from (6) and (7) we conclude that

$$\begin{bmatrix} h \\ l \end{bmatrix} \geq \begin{bmatrix} (n^3 - n^2 - 5n + 5)/8 \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix}$$

This implies $k_{v_n,v_{(n+1)/2}}\left(L_n^{(2)}\right) \geq (n^3 - 2n^2 - 3n + 4)/4$ and hence $k\left(L_n^{(2)}\right) \geq (n^3 - 2n^2 - 3n + 4)/4$.

We next show that $k\left(L_n^{(2)}\right) \leq (n^3 - 2n^2 - 3n + 4)/4$. It suffices to show that for each vertex v_t, $t = 1,2,\cdots,n$, there is an (h,l)-walk from v_t to v_1 with

$$\begin{bmatrix} h \\ l \end{bmatrix} = \begin{bmatrix} (n^3 - n^2 - 5n + 5)/8 \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix}.$$

For this purpose we consider the system of equation

$$Mz + \begin{bmatrix} r(p_{t1}) \\ b(p_{t1}) \end{bmatrix} = \begin{bmatrix} (n^3 - n^2 - 5n + 5)/8 \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix} \quad (8)$$

And show that the system (8) has nonnegative integer solution for some path p_{t1} from v_t to v_1.

The solution to the system (8) is integer vector

$$z = \begin{bmatrix} (n-1)/2 + b(p_{t1})\frac{n+1}{2} - r(p_{t1})\frac{n-1}{2} \\ (\frac{n+1}{2})(\frac{n-3}{2}) - (\frac{n-3}{2}) + r(p_{t1})(\frac{n-3}{2}) - b(p_{t1})(\frac{n-1}{2}) \end{bmatrix}.$$

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If $1 \leq t \leq (n+1)/2$, then there is a $((n+1)/2 - t, (n-3)/2)$-path from v_t to v_1. Using this path we have $z_1 = (t-1)(n-1)/2$ and $z_2 = (\frac{n-3}{2})(\frac{2n+2}{2} - \frac{n-1}{2} - (t+1))$. Since $t \geq 1$ we have $z_1 \geq 0$ and since $t \leq (n+1)/2$ we have $z_2 \geq 0$.

If $(n+3)/2 \leq t \leq n-2$, then there is a $(0, n-1-t)$-path p_{t1} from v_t to v_1. Using this path we find $z_1 = (n-1)/2 + (n-1-t)(n+1)/2$ and $z_2 = (t-n+1+(n-3)/2)(n-1)/2$. Since $t \leq n-2$ we have $z_1 \geq n$, and since $t \geq (n+3)/2$, we have $z_2 \geq (n-1)/2$.

If $n-1 \leq t \leq n$, then there is a $(1, n-t)$-path from v_t to v_1. Using this path we find that $z_1 = (n-t)(n+1)/2$ and $z_2 = (t-n+(n+1)/2(n-1)/2$. Since $t \leq n$, we have $z_1 \geq 0$, and since $t \geq n-1$ we have $z_2 \geq (n-1)^2/4$.

Thus for each $t = 1,2,\cdots,n$ there is a path p_{t1} from v_t to v_1 such that the system (8) has nonnegative integer solution. Proposition 2.1 guarantee that for each $t = 1,2,\cdots,n$, there is a $v_t \xrightarrow{(h,l)} v_1$ walk with $h = (n^3 - n^2 - 5n + 5)/8$ and $l = (n^3 - 3n^2 - n + 3)/8$. This implies for each pair of distinct vertices v_i and v_j in $L_n^{(2)}$, there is a vertex v_1 with the property that there are $v_i \xrightarrow{(h,l)} v_1$ and $v_j \xrightarrow{(h,l)} v_1$ with

$$\begin{bmatrix} h \\ l \end{bmatrix} = \begin{bmatrix} (n^3 - n^2 - 5n + 5)/8 \\ (n^3 - 3n^2 - n + 3)/8 \end{bmatrix}s$$

This implies $k\left(L_n^{(2)}\right) \leq (n^3 - 2n^2 - 3n + 4)/4$. ■

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Bootstrap statistical inference on heteroscedastic linear regression model

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Abstract. The comparative performance of regression estimation techniques—including Ordinary Least Squares (OLS) and several bootstrap variants—is evaluated under varying data conditions using Monte Carlo simulations on synthetically generated datasets. The simulations examine the influence of sample size, number of predictors, and heteroscedasticity in the residual structure. Results indicate that the naive bootstrap method consistently underperforms, producing estimates with substantial bias, elevated variability, larger standard errors, lower coefficients of determination, and wider confidence intervals. While OLS remains unbiased in expectation, its standard errors increase notably under heteroscedasticity, limiting its inferential reliability. In contrast, wild bootstrap methods, particularly those employing Rademacher and Mammen weights, yield more accurate parameter estimates, reduced standard errors, and improved model fit as measured by R^2. Among these, the Mammen bootstrap demonstrates the most stable and efficient performance, generating consistently narrow confidence intervals across all sample sizes. These findings underscore the advantages of wild bootstrap techniques—especially Mammen's approach—for robust inference in regression models affected by heteroscedasticity, and highlight the importance of method selection in empirical settings where standard assumptions are violated.

Keywords: Ordinary Least Squares, Bootstrap Methods, Heteroscedasticity, Regression Estimation, Coefficient of Determination, Monte Carlo Simulations

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Introduction

Linear regression is a fundamental statistical method to explore relationships between dependent and independent variables. Ordinary Least Squares (OLS) is often employed for parameter estimation due to its efficiency and unbiased nature under classical assumptions, particularly homoscedasticity [1]. Homoscedasticity implies constant variance in residuals across observations. However, heteroscedasticity—non-constant variance in residuals—is frequently encountered, particularly in cross-sectional data with significant disparities between maximum and minimum observations [2].

Heteroscedasticity renders OLS inefficient, resulting in more significant standard errors and unreliable statistical inference, such as inaccurate hypothesis tests and wider confidence intervals. To overcome such limitations, bootstrap methods offer robust alternatives. The wild bootstrap, introduced by [3], has proven effective for heteroscedastic data by multiplying residuals with randomly chosen variables while preserving the original data's variance structure.

Mammen's distribution [4], and Rademacher's distribution are commonly used in wild bootstrap. Mammen's distribution approximates normality effectively, whereas Rademacher's distribution offers simplicity by limiting values to -1 and 1 [5]. Recent studies further validate wild bootstrap's utility. Wang [6] demonstrated its applicability for penalized quantile regression, while [7] highlighted its reliability in heteroscedastic data testing. Wu [8] explored its adaptability for high-dimensional data change-point inference, emphasizing its methodological flexibility. Simamora [9] explored strategies for constructing bootstrap-based confidence intervals tailored for heteroscedastic linear regression models. Their study aimed to enhance the precision of parameter estimates and the reliability of confidence intervals using the percentile bootstrap method. They also compared various bootstrap techniques, such as the paired bootstrap and residual bootstrap, assessing their effectiveness based on factors like coverage probability, estimation accuracy, and the impact of sample size and model characteristics.

The primary objective of the present study is to evaluate the effectiveness of the wild bootstrap technique in improving the accuracy of parameter estimation within heteroscedastic linear regression models. Specifically, the study aims to compare the performance of parameter estimation using two distinct bootstrap distributions: Mammen's and Rademacher's. In addition to assessing the precision of parameter estimates, the research also focuses on constructing confidence intervals derived from both distributions, analyzing how well these intervals reflect the actual population parameters. Furthermore, the study will explore the determination coefficients obtained from each distribution, providing a comprehensive comparison of their ability to explain the variance in the dependent variable. Such a multifaceted approach facilitates a more comprehensive understanding of the strengths and limitations inherent to each bootstrap method when applied to heteroscedastic regression models.

The remainder of the article will outline the methodology section, which explains the stages of the research process carried out. It also details the algorithm used to achieve the research objectives. The section is structured into several subsections, each addressing a specific aspect of the study. The initial part provides an overview of linear regression concepts and methods, outlining the fundamental assumptions for model implementation and the challenges posed by heteroscedasticity in the data. The second subsection presents the proposed algorithm, with emphasis on the application of the wild bootstrap technique within linear regression models to address heteroscedasticity. A step-by-step procedure for implementing the algorithm is also described in detail.

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The third section presents the results of simulations performed using two types of data: synthetic data generated through a computer experiment design, which allows us to control the variables and conditions of the experiment, and real-world data used to test the application of the proposed method in a practical scenario. The results of these simulations are analyzed to evaluate the effectiveness of the wild bootstrap approach in improving the accuracy of parameter estimation and statistical inference in heteroscedastic regression models.

The concluding section summarizes the simulation findings, highlights key insights, and outlines potential directions for further refinement of the proposed method. Conclusions are drawn based on the analysis, along with implications for future research and practical implementation.

Methodology

The implementation of the wild bootstrap approach is examined as a strategy to improve the accuracy of parameter estimation in linear regression models influenced by heteroscedastic error structures. The analysis specifically contrasts the performance of two well-established resampling distributions: Mammen and Rademacher. The comparative evaluation is centered on three fundamental components of statistical inference: the accuracy of estimated regression coefficients, the reliability of the resulting confidence intervals, and the explanatory capacity of the model. The latter is quantified through the coefficient of determination (R^2), which reflects the proportion of variance in the response variable that can be attributed to the variation in the predictors—serving as a standard indicator of model adequacy. The section begins with an overview of the theoretical foundations of linear regression, followed by a structured presentation of the algorithm designed to address the research objectives.

To address heteroscedasticity, the wild bootstrap method is employed as a resampling technique that retains the variance structure of the residuals. Instead of drawing resamples from raw data or residuals directly, this method multiplies the regression residuals by auxiliary random weights drawn from specific distributions. Two notable distributions frequently used for this purpose are the Rademacher and Mammen distributions. The Rademacher distribution employs symmetric binary values $\{-1, +1\}$, which are simple to implement and satisfy the requirement of mean zero and unit variance. In contrast, Mammen's distribution utilizes asymmetric two-point support values that better approximate higher-order moments and offer improved performance under certain non-normal conditions. These distributions are integrated into the bootstrap process to generate pseudo-responses, from which new estimates and confidence intervals are repeatedly computed.

The following subsection details the algorithmic procedure, including the generation of synthetic data, the implementation of wild bootstrap iterations, and the evaluation metrics used to assess the performance of each method.

Linear Regression

Linear regression is a statistical method used to model the relationship between a dependent variable (Y) and one or more independent variables (X). The goal is to estimate the parameters (coefficients) of the model that best fit the observed data. In matrix presentation, the linear regression model is represented as follows:

$$Y = X\beta + \epsilon, \tag{1}$$

where**:**

- ***Y*** is the vector of observed values for the dependent variable;

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- $\boldsymbol{X}$ is the matrix of independent variables (also called the design matrix), which includes the values of the predictors and a column of ones for the intercept term;
- $\boldsymbol{\beta}$ is the vector of coefficients (parameters) we aim to estimate;
- $\boldsymbol{\epsilon}$ represents the residuals or errors in the model.

The most common method for estimating parameters in linear regression is OLS, which minimizes the sum of squared residuals. The goal is to find the $\boldsymbol{\beta}$ coefficients that minimize:

$$\text{Minimize } \| Y - X\beta \|^2. \tag{2}$$

The normal equation is derived by minimizing the residual sum of squares with respect to β, which involves taking the derivative of the objective function and setting it equal to zero.

$$\hat{\beta} = (X^T X)^{-1} X^T Y, \tag{3}$$

where:

- $\hat{\beta}$ is the estimated vector of coefficients;
- X^T is the transpose of the design matrix X;
- $(X^T X)^{-1}$ is the inverse of $X^T X$, which must be invertible for a unique solution.

For the OLS estimators to be unbiased and efficient, several assumptions must be met, including linearity, independence, homoscedasticity, and normality of the errors. Once the parameters are estimated, model fit can be evaluated using metrics such as R^2, which indicate the proportion of variance explained by the model.

Simulation Algorithm

The algorithm is designed to implement the wild bootstrap technique in order to enhance the accuracy of parameter estimation in linear regression models subject to heteroscedasticity. The analysis compares the performance of two bootstrap distributions—Mammen and Rademacher—by evaluating parameter precision, the reliability of confidence intervals, and explanatory power as measured by the coefficient of determination.

- **Step 1: Data Preparation**
  Input Data:
  - Let Y be the vector of observed dependent variable values ($n \times 1$).
  - Let X be the matrix of independent variables ($n \times (p + 1)$), including a column of ones for the intercept.
  - The model assumes a relationship as in equation (1).

  Initial Parameter Estimation:
  - Use OLS to estimate the parameters $\hat{\beta}$, see equations (2) and (3).
  - Calculate the residuals: $\hat{\epsilon} = Y - X\hat{\beta}$.
- **Step 2: Wild Bootstrap Resampling**
  Resampling Process:
  - For each bootstrap iteration (repeat B times, e.g., 1000 iterations), perform the following:

    1. Generate Bootstrap Residuals:

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- Multiply the residuals $\hat{\epsilon}_i$ by random variables chosen from specific distributions, t_i^*:
  - Mammen (1993) replaced with sampling weight t_i^* which comes from a two-point distribution,

$$t_i^* = \begin{cases} -\frac{(\sqrt{5}-1)}{2}, & \text{with probability } p = (\sqrt{5}+1)/(2\sqrt{5}) \\ \frac{(\sqrt{5}+1)}{2}, & \text{with probability } p' = 1-p \end{cases}$$

  - We propose sampling weights t_i^* using the Rademacher Distribution,

$$t_i^* = \begin{cases} -1; & \text{with probability } 1/2 \\ 1; & \text{with probability } 1/2 \\ 0; & \text{untuk nilai yang lain} \end{cases}$$

2. Construct Bootstrap Sample:
   - Create the bootstrap response variable Y^* by adding the resampled residuals to the predicted values:

$$Y_i^* = X\hat{\beta} + \hat{\epsilon}_i \times t_i^*,$$

- **Step 3: Estimating Parameters from Bootstrap Samples**
  Re-estimate Parameters:
  - For each bootstrap sample Y^*, re-estimate the regression parameters $\hat{\beta}^{*b}$ using OLS:

$$\hat{\beta}^{*b} = (X^T X)^{-1} X^T Y^{*b}$$

    The procedure is repeated across all bootstrap samples to generate the empirical distribution of $\hat{\beta}^*$.

- **Step 4: Construct Confidence Intervals**
  Bootstrap Confidence Intervals:
  - Sort the bootstrap estimates $\hat{\beta}^*$ for each parameter in ascending order.
  - For a 95% confidence interval, use the 2.5-th and 97.5-th percentiles of the bootstrap distribution to form the interval:

$$\text{CI} = \left[\hat{\beta}^*_{2.5\%},\ \hat{\beta}^*_{97.5\%}\right].$$

- **Step 5: Evaluate Explanatory Power**

  Coefficient of Determination:
  - Compute R^2 for each bootstrap sample to measure the explanatory power of the model:

$$R^2 = 1 - \frac{\sum(Y^* - \hat{Y}^*)^2}{\sum(Y - \bar{Y})^2}.$$

  - Compare the R^2 values from different bootstrap samples to evaluate the consistency and explanatory ability of the model.

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Standard Error of Regression Coefficient Estimators

- Compute the Standard Error (SE) for each bootstrap sample to assess the variability of the estimated regression coefficients across resampled datasets.

$$\mathrm{SE}_{\beta_j} = \sqrt{\frac{1}{B-1}\sum_{b=1}^{B}\left(\hat{\beta}_j^{*b} - \bar{\beta}_j^{*}\right)^2},$$

where:

$\hat{\beta}_j^{*b}$ is the estimated regression coefficient for the j-th parameter in the b-th bootstrap sample.

$\bar{\beta}_j^{*}$ is the mean of the estimated coefficients from all BBB bootstrap samples.

B is the total number of bootstrap samples.

- **Step 6: Compare Bootstrap Distributions**
  Comparison of Distributions:
  - Analyze the results from both Mammen's and Rademacher's distributions:
    - Precision of Parameter Estimates: Evaluate how well each method estimates the parameters.
    - Confidence Interval Reliability: Compare the width and accuracy of confidence intervals.
    - Explanatory Power: Assess the R^2 values across bootstrap iterations to compare the performance of the two distributions.

We implement the simulation algorithm using artificial data, where the input matrix is designed based on a normal distribution. The residuals are modeled to exhibit heteroscedasticity, reflecting the increase in the index, and the response is adjusted to match a specific parameter value.

Results and Discussion

Results

A design matrix X is constructed to represent the independent variables in the regression model. The matrix comprises $n = 100$ rows (observations) and $p + 1 = 3$ columns, with the first column consisting of ones to represent the intercept term. The remaining $p = 2$ columns are filled with random values drawn from a standard normal distribution, $N(0,1)$, thereby introducing variability in the predictors while preserving a fixed intercept structure.Residuals are generated to mimic heteroscedastic behavior, where their variability increases with the observation index. Realistic heteroscedastic residuals are generated by scaling random values drawn from a standard normal distribution, $N(0,1)$, with a linearly increasing factor, defined as $N(0,1) \times (1 + 0.5 \times \mathrm{index})$. This procedure produces residuals with non-constant variance, reflecting a typical characteristic of real-world data. The response variable Y is then constructed based on the linear model $Y = X\beta_{true} + \epsilon$, where the true parameter vector is defined as $[2, 1, -1]^T$, and ϵ introduces heteroscedastic noise. Such a formulation ensures that Y is jointly determined by the predictors X and the structured variability introduced through the residuals.

A total of 1,000 Monte Carlo simulations were performed, each incorporating 1,000 bootstrap resamples, resulting in 1 million individual runs. Such a large-scale simulation design harnesses the strengths of Monte Carlo methods, which are widely used to model and analyze complex

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stochastic systems [10]. The integration of bootstrap resampling techniques [11] enables precise estimation of the variability associated with statistical estimators and the construction of reliable confidence intervals. The combined use of Monte Carlo and bootstrap approaches facilitates a comprehensive assessment of model reliability and performance, thereby enhancing the robustness of the results against sampling variability. The volume of simulations—amounting to one million runs—provides a strong empirical basis for hypothesis testing and contributes to the precision and credibility of the study's conclusions.

Figure 1 is the last Monte Carlo simulation with a bootstrap sample size of 1,000 using Rademacher's wild bootstrap. The bootstrap distribution of the estimate β_1 has a skewness of 0.04 and a kurtosis of 3.01. It means that it is almost symmetrical and very close to a normal distribution, which indicates that the parameter estimates are relatively stable and are not distorted by outliers or skewness. The bootstrap distribution of the parameter estimate β2\beta_2β2 exhibits negative skewness, indicating a slight leftward asymmetry characterized by a longer tail on the right side. However, the relatively small skewness value suggests that the deviation from symmetry is minimal. The kurtosis value is lower than the kurtosis constant of the normal distribution, indicating that the distribution is slightly more platykurtic, meaning it has lighter and flatter tails than the normal distribution. It suggests that the bootstrap estimates of β_2 tend to have fewer extreme values or outliers, which is a suitable property for inferential analysis. Overall, the distribution of β_2 is approximately normal, with few deviations related to skewness and kurtosis. Although the distribution of β_3 shows slightly higher than normal skewness and kurtosis, these characteristics are not too extreme and are still within the acceptable range for inferential analysis. It suggests that the estimates of β_3 can be considered relatively stable, although with a slight tendency to produce more extreme values or to be centered at higher values.

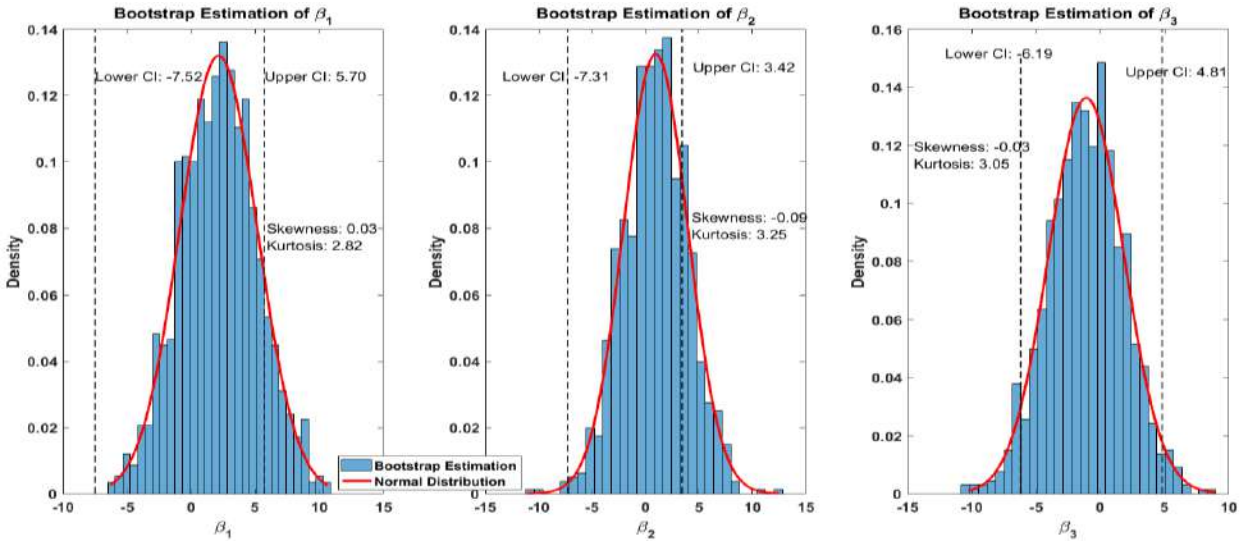

Figure 1. Bootstrap Density Distribution of the Last Monte Carlo Simulation Using Rademacher's Wild Bootstrap

Figure 2 is the last Monte Carlo simulation with a bootstrap sample size of 1,000 using Mammen's wild bootstrap. The skewness and kurtosis estimates are similar to the Rademacher distribution. The bootstrap distributions of the three-parameter estimates approach the normal distribution, although they have slightly different characteristics. In other words, these bootstrap results can be used confidently for statistical inference, especially since they approach the

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normality assumption often used in many statistical tests. The length of the bootstrap density distribution interval using the Mammen technique is shorter than the Rademacher technique. Another difference is that the characteristics of the Mammen interval do not always contain the largest bin frequency. Evidence of this pattern is observable in the distribution of β_2, where the confidence interval lies to the left of the distribution's peak.

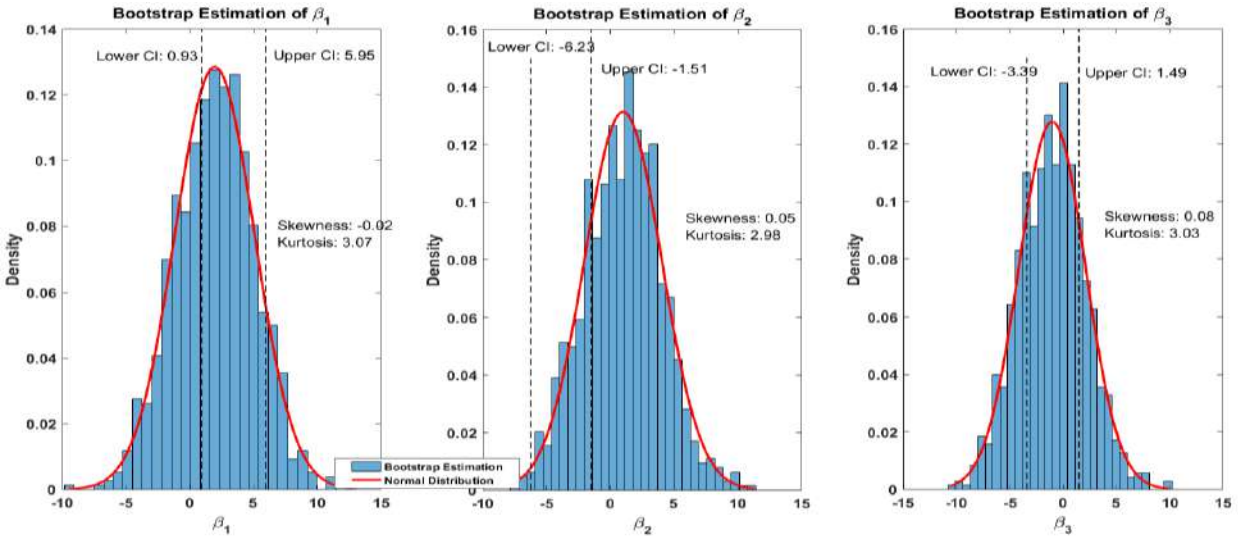

Figure 2. Bootstrap Density Distribution of the Last Monte Carlo Simulation Using Mammen's Wild Bootstrap

The following section compares the estimation results obtained using the Rademacher and Mammen wild bootstrap. Then, we include traditional methods such as OLS and the naive bootstrap. The comparison will involve various statistics, including estimates of standard errors, coefficient of determination (R^2), skewness, and kurtosis.

Discussion

The discussion section reviews the results of Monte Carlo simulations performed using artificially generated data, as detailed in the preceding section. The simulation design considered several key factors, including the number of observations (n), the number of predictors (p), and the heteroscedastic (non-homogeneous) structure of the residuals. Within this framework, regression parameters were estimated, and the performance of various estimation methods—such as OLS and several bootstrap variants—was evaluated. Results are presented in tables and figures, displaying the estimated coefficients, standard errors, R^2 values, and other relevant metrics. The sample size was systematically increased to enhance the reliability of the findings, thereby allowing clearer observation of method-specific behavior across varying conditions.

Table 1 demonstrates that the Naive bootstrap method consistently provides the least accurate regression coefficient estimates compared to other methods. For example, at $n = 20$, the Naive estimates for $\beta_2 = -0.0024$ and $\beta_3 = 0.0016$ deviate substantially from the true parameter values $\beta_{true} = [2, 1, -1]^T$, indicating high bias and considerable variability. The lack of effectiveness remains evident even as the sample size increases, indicating that the Naive bootstrap method is not robust when applied to heteroskedastic data. In contrast, the OLS approach produces relatively stable and nearly unbiased estimates, particularly for β_1, although it continues to exhibit limitations in handling non-constant residual variance.

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Wild Bootstrap methods like Rademacher and Mammen exhibit much better performance. Both methods produce coefficient estimates that are closer to the true parameter values and more stable under residual fluctuation. For instance, at $n = 100$, the Rademacher method yields estimates of $[1.9632, 1.1179, -0.9635]$, while the Mammen method produces $[1.9281, 1.1313, -1.0281]$, both of which closely approximate the true coefficients. Notably, the Mammen method tends to be more adaptive in dealing with asymmetric residuals or data containing outliers, as its asymmetric weight distribution provides higher-order moment matching suitable for heteroskedastic conditions. The asymmetry makes Mammen a highly reliable alternative, especially when the data exhibit irregular variance patterns and residual distributions deviating from normality.

Table 1. Regression Coefficient Estimation between Wild Bootstrap and Traditional Methods with Increasing Sample Size in Monte Carlo Simulation

Sample Size	Statistics	Traditional		Bootstrap	
		OLS	Naive	Rademacher	Mammen
$n = 20$	β_1	2.0155	2.0363	1.9800	2.0124
	β_2	0.9550	-0.0024	1.0227	0.9323
	β_3	-1.0427	0.0016	-1.0186	-1.0410
$n = 40$	β_1	2.0075	2.0194	1.9946	2.0669
	β_2	1.0097	-0.0037	1.0210	0.9872
	β_3	-0.9667	0.0013	-0.9586	-0.9563
$n = 60$	β_1	2.0957	2.0925	2.1013	1.9800
	β_2	0.8494	-0.0008	0.9901	1.0044
	β_3	-0.9056	0.0014	-0.9677	-1.0645
$n = 80$	β_1	1.9418	1.8787	2.1004	2.0496
	β_2	1.0112	0.0019	1.0268	0.9365
	β_3	-1.0966	0.0018	-0.9938	-0.9934
$n = 100$	β_1	1.9394	1.9372	1.9632	1.9281
	β_2	1.0952	-0.0009	1.1179	1.1313
	β_3	-0.8847	0.0010	-0.9635	-1.0281

Table 2 compares the Standard Errors (SE) of regression coefficient estimates β_1, β_2, and β_3 calculated using traditional methods (OLS and Naive bootstrap) and wild bootstrap methods (Rademacher and Mammen) at various sample sizes. The results indicate an increase in the SE as the sample size grows, a direct consequence of the data generation process that deliberately incorporates increasing heteroscedasticity, represented by residual variance scaling as $N(0,1) \times (1 + 0.5 \times \text{index})$. Such a configuration leads to increased residual variability, thereby elevating the standard errors in larger samples.

The Naive bootstrap consistently exhibits higher SE values than wild bootstrap methods, reflecting its inefficiency under heteroscedastic conditions. Although OLS is theoretically unbiased, it demonstrates instability, particularly evident at larger sample sizes (e.g., $n = 80$), where it occasionally produces higher average SE values than the Naive bootstrap, indicating reduced efficiency and consistency due to violated assumptions.

Among wild bootstrap methods, Mammen's distribution consistently produces the lowest SE across all sample sizes, confirming its superior precision and robustness against heteroscedasticity. The Rademacher method also outperforms the traditional approaches (OLS and Naive bootstrap), but still exhibits higher SE values than Mammen's distribution. Notably, the efficiency advantage

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of the Mammen method is most pronounced at small to medium sample sizes ($n = 20$ to $n = 60$), highlighting its suitability for handling heteroscedasticity effectively in regression modeling.

Table 2. Standard Error of Regression Coefficient Estimates between Wild Bootstrap and Traditional Methods with Increasing Sample Size in Monte Carlo Simulation

Sample Size	Statistics	Traditional		Wild Bootstrap	
		OLS	Naive	Rademacher	Mammen
$n = 20$	$SE(\beta_1)$	1.5611	1.5898	1.4637	0.6623
	$SE(\beta_2)$	1.6162	1.6654	1.3909	0.6421
	$SE(\beta_3)$	1.6169	1.6385	1.4464	0.6458
	Average	1.5981	1.6312	1.4337	0.6501
$n = 40$	$SE(\beta_1)$	2.0063	2.0147	1.9621	0.8697
	$SE(\beta_2)$	2.0512	2.0596	1.9157	0.8459
	$SE(\beta_3)$	2.0520	2.0538	1.9133	0.8540
	Average	2.0365	2.0427	1.9304	0.8565
$n = 60$	$SE(\beta_1)$	2.3878	2.3927	2.3141	1.0442
	$SE(\beta_2)$	2.4192	2.4115	2.2784	1.0316
	$SE(\beta_3)$	2.4132	2.4192	2.2552	1.0180
	Average	2.4067	2.4078	2.2826	1.0313
$n = 80$	$SE(\beta_1)$	2.7055	2.7003	2.6749	1.1935
	$SE(\beta_2)$	2.7319	2.7208	2.6468	1.1756
	$SE(\beta_3)$	2.7328	2.7414	2.6473	1.1800
	Average	2.7234	2.7208	2.6563	1.1830
$n = 100$	$SE(\beta_1)$	2.9976	3.0019	2.9676	1.3245
	$SE(\beta_2)$	3.0086	3.0340	2.9194	1.3085
	$SE(\beta_3)$	3.0282	3.0301	2.9091	1.3148
	Average	3.0115	3.0220	2.9320	1.3159

Table 3 presents the average values of the coefficient of determination (R^2) across different sample sizes for each estimation method. These results offer insights into the explanatory power of the models under varying degrees of heteroscedasticity. As shown, the wild bootstrap methods—particularly the Mammen distribution—consistently yield higher R^2 values, reflecting improved model fit compared to both the Naive bootstrap and Ordinary Least Squares. The R^2 values remain stable or increase slightly as the sample size grows, indicating improved stability and accuracy of parameter estimation with larger samples. The wild bootstrap methods, particularly Mammen's, consistently yield the highest R^2 across all sample sizes, suggesting superior robustness in handling heteroscedasticity. The Rademacher method also performs better than traditional methods but slightly below Mammen. Conventional methods (OLS and Naive bootstrap) consistently produce lower R^2 values compared to the wild bootstrap methods, with the Naive bootstrap performing the poorest. Although differences among methods narrow as sample size increases, wild bootstrap methods, especially Mammen's distribution, maintain a consistent advantage over traditional techniques.

Table 4 displays the average length of confidence intervals (LCI) for each regression coefficient estimate across all methods and sample sizes. The metric is crucial in evaluating the precision of inference. A shorter LCI indicates more efficient estimation. The results demonstrate that the Mammen wild bootstrap method consistently produces the narrowest intervals, suggesting superior inferential precision, especially in the presence of heteroscedasticity. Rademacher follows closely, while the traditional methods yield substantially wider intervals. The effect of sample size

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on the LCI increases with increasing sample size for all methods.

Table 3. Average of the Estimated Coefficient of Determination between the Wild Bootstrap Method and the Traditional Method with Increasing Sample Size in Monte Carlo Simulations

Sample Size	Statistics	Traditional		Wild Bootstrap	
		OLS	Naive	Rademacher	Mammen
$n = 20$	R^2	0.6578	0.6023	0.7012	0.7098
$n = 40$		0.6634	0.6117	0.7189	0.7254
$n = 60$		0.6662	0.6185	0.7247	0.7302
$n = 80$		0.6685	0.6230	0.7275	0.7335
$n = 100$		0.6698	0.6252	0.7292	0.7357

The increase in interval length due to the influence of the factor grows linearly with increasing sample size. The Mammen wild bootstrap method consistently produces the shortest LCI at all sample sizes, followed by Rademacher. The traditional method has a longer LCI, with OLS slightly larger than the Naive bootstrap. However, for a sample size of $n = 100$, the LCI of the OLS method is smaller than the Naive bootstrap. At $n = 20$, the Mammen bootstrap LCI averages only 2.5172, much shorter than OLS (6.6710) or Naive bootstrap (6.4200). Then, a more significant increase in sample size results in the three methods almost approaching the same value, but the Mammen method still excels with the shortest LCI. The Mammen bootstrap shows the best efficiency and stability, producing tighter intervals than the other.

Table 4. Length of Confidence Interval Estimation of Regression Model Parameters between Wild Bootstrap and Traditional Methods with Increasing Sample Size in Monte Carlo Simulation

Sample Size	Statistics	Traditional		Wild Bootstrap	
		OLS	Naive	Rademacher	Mammen
$n = 20$	LCI(β_1)	6.1662	6.2259	5.5991	2.5751
	LCI(β_2)	6.6723	6.5696	5.2460	2.4805
	LCI(β_3)	7.1746	6.4646	5.4364	2.4960
	Average	6.6710	6.4200	5.4272	2.5172
$n = 40$	LCI(β_1)	7.9646	7.8999	7.5976	3.3993
	LCI(β_2)	8.5655	8.1102	7.3081	3.2837
	LCI(β_3)	8.6248	8.0896	7.2975	3.3165
	Average	8.3850	8.0332	7.4011	3.3332
$n = 60$	LCI(β_1)	9.1898	9.3806	9.0068	4.0820
	LCI(β_2)	9.4632	9.4860	8.7508	4.0157
	LCI(β_3)	9.8275	9.5204	8.6808	3.9598
	Average	9.4935	9.4623	8.8128	4.0192
$n = 80$	LCI(β_1)	10.7628	10.5963	10.4040	4.6653
	LCI(β_2)	11.2663	10.7090	10.2055	4.5858
	LCI(β_3)	10.7580	10.7775	10.2140	4.6019
	Average	10.9290	10.6943	10.2745	4.6177
$n = 100$	LCI(β_1)	11.4265	11.7825	11.5813	5.1814
	LCI(β_2)	11.9856	11.9257	11.3129	5.1077
	LCI(β_3)	11.4009	11.8993	11.2712	5.1352
	Average	11.6043	11.8692	11.3885	5.1414

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Conclusion

Monte Carlo simulations offer crucial insights into the comparative performance of various regression estimation methods, OLS and several bootstrap techniques, under different data conditions. The simulations explore the influence of factors such as sample size, number of predictors, and residual heteroscedasticity. Consistently, the Naive bootstrap method performs poorly—its parameter estimates deviate markedly from the true values and display greater bias and variability than other approaches. Although OLS remains unbiased, its efficiency deteriorates under heteroscedasticity, as reflected by inflated standard errors.

Among the alternatives, Wild Bootstrap methods—particularly Rademacher and Mammen—demonstrate superior accuracy, lower standard errors, and higher R^2 values, especially in the presence of heteroscedastic and non-normal residuals. Notably, the Mammen method consistently yields the most precise estimates and the shortest confidence intervals across all sample sizes, underscoring its robustness and efficiency.

The analysis of standard errors reveals that the Naive bootstrap generates the largest errors across all sample sizes. OLS, while generally stable, shows erratic standard error behavior under heteroscedastic conditions, peaking notably at $n = 80$. In contrast, the Wild Bootstrap methods produce more consistent and efficient estimates, with Mammen exhibiting the lowest standard errors overall.

Further evidence of the superiority of Wild Bootstrap methods is seen in the coefficient of determination (R^2), where Rademacher often outperforms other methods at smaller sample sizes. Although differences diminish as nnn increases, Wild Bootstrap remains preferable to classical methods. Additionally, in terms of confidence interval length, the Mammen method again stands out, consistently producing the narrowest intervals.

In conclusion, while OLS remains a reliable baseline under ideal assumptions, the results highlight the significant advantages of Wild Bootstrap—especially Mammen—in providing accurate, efficient, and robust estimation under heteroscedasticity. These findings emphasize the importance of method selection based on the data's structural characteristics, particularly in real-world applications where heteroscedasticity and non-normality are prevalent.

Acknowledgments

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Analysis of the application of physics concepts of work, energy, and equilibrium in the traditional game of marjalengkat

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Abstract. *"Marjalengkat is a traditional game originating from Toba Samosir, North Sumatra. Marjalengkat is a folk game that involves physical activities such as jumping, running and maintaining balance. The purpose of this study was conducted to analyze physics concepts contained in the traditional game of Marjalengkat. This study explores several physics concepts involved in the movements and interactions between Marjalengkat players including the concepts of force, motion, energy and also equilibrium. The research method used in this study is descriptive qualitative. Data were collected through direct observation, interviews, documentation and literature analysis related to basic physics concepts. The results showed that in every movement of the traditional game Marjalengkat there is an application of physics principles such as work and energy and equilibrium. This finding is expected to provide a new perspective in learning physics that is contextual and relevant to local culture so as to increase students' interest in physics through an approach that is closer to everyday life."*

Keywords: *Analysis, Traditional Games, Marjalengkat, Work and Energy, Equilibrium*

Introduction

Local wisdom is basically the good values of local culture and has been recognized by the majority of society for its goodness. [1] These values often originate from ancestral traditions that continue to influence contemporary practices. One notable aspect of local wisdom that can be integrated into physics education is traditional games.

Traditional games are activities created using readily available materials and are widely played in specific regions. These games represent an essential aspect of local culture, often found throughout the Indonesian archipelago. Traditional games are not merely recreational; they also influence the development of character, psychological traits, and social life. This is due to their

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incorporation of elements such as sportsmanship, precision, honesty, agility, and team work.

One traditional game found in Toba Samosir, North Sumatra, is Marjalengkat. This game is recognized by different names in various regions; for instance, it is called "ingkau" in Bengkulu and "tengkak-tengkak" in West Sumatra. Marjalengkat has a history spanning over 50 years, establishing itself as a traditional game in Toba Samosir. Originally, Marjalengkat was frequently played as a contest of agility, serving to enhance running skills with the aid of two bamboo sticks. Today, Marjalengkat has evolved into a ceremonial activity during specific events; for example, it is a mandatory game during Indonesia's Independence Day celebrations to ensure its continued existence.

According to interviews conducted with the village head of Situngkir in Toba Samosir, Marjalengkat is believed to have originated during the Dutch colonial era. The term "Marjalengkat" translates to "growing youth," which reflects its popularity among the youth of Toba Samosir. The game is also commonly played as a means to navigate muddy terrain. Furthermore, traditional games like Marjalengkat contribute to enhancing children's motor skills.

Physics is a branch of natural science that explains observed phenomena based on rational thought, human experience, and experimentation. It is closely related to daily activities, as exemplified by the traditional game Marjalengkat, which incorporates numerous physics concepts that can be analyzed and aligned with graduate competency standards (SKL). Therefore, integrating these concepts into school physics education is essential. Key physics concepts present in this traditional game include work, energy, motion, and equilibrium. Based on the above description, the objective of this research is to analyze the physics concepts of work, energy, and equilibrium within the traditional game Marjalengkat.

Methodology

This study employs a qualitative descriptive research design with an ethnographic approach. The ethnographic approach aims to describe and analyze culture based on intensive field research. In this study, it is utilized to depict, explain, and analyze the physics concepts found in the traditional game Marjalengkat. Data collection methods include observation, interviews, documentation, and literature analysis regarding physics concepts in Situngkir Village, Toba Samosir. Research instruments consist of observation guidelines and interview protocols. The collected data will undergo analysis through the following steps: (1) reducing data from observations and interviews; (2) presenting data in descriptive text form; (3) drawing conclusions.

Result and Dicscussion

Traditional games are defined as a physical activity that is relatively simple and has developed in society from ancient times to the present generation with certain provisions and goals [2]. The traditional game Marjalengkat has existed for over 50 years, having been introduced to Toba Samosir during the Dutch colonial era, and subsequently spreading across various regions of Indonesia under different names.

Stilts in Sundanese are called "jajangkungan" which means high - high, a toy called main tinggi - tinggian. While in Central Sulawesi, stilts are called Tilako which means a tool used for stepping or walking [3]. This research aims to identify the physics concepts present in the traditional game Marjalengkat, specifically focusing on work, energy, and equilibrium. The findings indicate that the game incorporates concepts of work and energy, making it a valuable resource for physics education.

The equipment used in this game consists of a pair of bamboo poles shaped like stilts with foot

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supports. Each bamboo pole is approximately 2 meters long, with varying heights for the footrests (30 cm, 40 cm, and 50 cm). Based on the Fig (a), the ongoing game of Marjalengkat is closely related to the physics concepts of work, energy, and equilibrium.

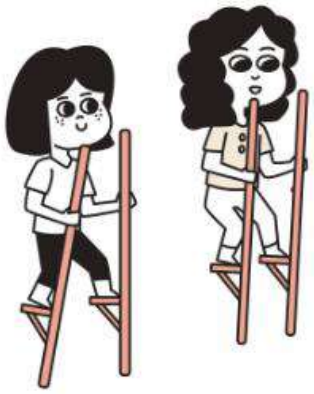

Figure 1. Illustration of Marjalengkat Game

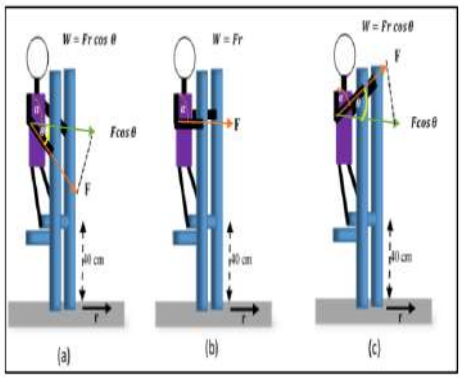

Figure 2. Player's arm position in each condition

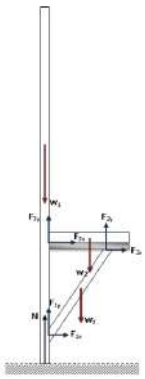

Figure 3. Description of the forces act on the marjalengkat stick

Work

Figure (a) illustrates an individual engaging in the traditional game of Marjalengkat. The work performed by the Marjalengkat player involves exerting effort to transition the Marjalengkat from its initial to final position. Notably, when the player ascends the bamboo, potential energy is present, whereas kinetic energy is observed during movement along the bamboo. When the player successfully balances atop the bamboo, a state of equilibrium is achieved. If the force exerted by the child while traversing a distance s with the bamboo stick is denoted as F, the work done can be expressed mathematically as follows:

$$W = F.s \quad (1)$$

When the player pushes with their legs to move forward, the force exerted must counteract gravity and perform work to elevate their body. The amount of work done depends on how forcefully the player pushes and how far they move. The ongoing game of Marjalengkat is closely related to the physics concepts of work and energy. Work refers to the effort exerted by the player to ascend onto the Egrang footrests and the effort required to move the Marjalengkat from its initial position to its final position. This energy constitutes mechanical energy, which is the sum of kinetic energy and potential energy.

Kinetic Energy

An object in motion possesses energy [5]. The motion of an object is caused by the forces acting upon it. The energy associated with a moving object is termed kinetic energy. The magnitude of kinetic energy is indicated by the force exerted by the Marjalengkat player, which can be interpreted in terms of the speed of the Marjalengkat. Observational interviews reveal that the proper arm position is perpendicular to the Marjalengkat arms. Conversely, if the player's arms are positioned too low or too high, it results in a reduced speed of the Marjalengkat. This demonstrates that the force applied by the Marjalengkat player significantly influences the object's kinetic energy.

Kinetic energy is also affected by the mass of the object and the speed of the Marjalengkat user.

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As either the mass of the object or the mass of the player increases, or as their speed increases, the kinetic energy will also increase. Any object in motion has the capacity to perform work, thus it is said to possess energy. This energy is referred to as motion energy or kinetic energy. For example, when a child runs, they have kinetic energy due to their exertion, enabling their movement. Therefore, as an object's mass increases, its kinetic energy increases; similarly, as its speed increases, so does its kinetic energy. It can be concluded that kinetic energy is directly proportional to both the mass and speed of the object. This relationship can be expressed in the following equation:

$$Ek = \frac{1}{2}mv^2 \quad (2)$$

Based on the figure above, Fig (b.a) depicts the position of the Marjalengkat player's arm inclined downward, forming an angle of approximately 115° between the upper and lower arms, resulting in a force component of F cos θ. In Fig (b.b), the player's arm is extended forward, creating a right angle (90°) with the stick, thereby maximizing the applied force F. Fig (b.c) shows the player's arm raised upward at an angle of approximately 45°, again yielding F cos θ. The greatest force exerted during this game occurs when the arm is extended forward, as illustrated in Fig (b.b).

The effect of object speed on kinetic energy can be seen in the difference in height of the stilt steps. The height of each stilt step has an effect on the comfort of the player and the speed produced [4]. A straight arm position facilitates wider strides, enabling quicker progression to the endpoint. Conversely, a downward arm position results in narrower steps, necessitating more strides to reach the finish line. When the arm is raised, the width of movement remains moderately expansive.

Potential Energy

Potential energy is the energy stored within an object due to its position or configuration [5]. In addition to being influenced by its position, potential energy is also affected by Earth's gravitational force. Any object elevated above the Earth's surface possesses potential energy. This form of energy is also present in materials such as rubber or springs when they are stretched.

Based on interviews regarding the game Marjalengkat, it was found that as the height of the footrests increases, the game becomes lighter and easier to play. However, if the footrests are positioned too high, it becomes more challenging for an individual to ascend onto the Marjalengkat. Thus, a higher footrest in the game facilitates easier and lighter gameplay.

This observation confirms that as the height of the Marjalengkat footrests increases, potential energy also increases due to the greater distance between the footrests and the Earth's surface. However, the magnitude of potential energy is also influenced by the mass of the object; thus, a greater mass results in higher potential energy. The value of potential energy aligns with the physics concept that it depends on the height of an object above the Earth's surface.

Potential energy arises from a force that depends on an object's relative position in its environment. Further states that as an object's position increases in height, its potential energy correspondingly increases.

Mathematically, potential energy can be expressed as follows:

$$Ep = mgh \quad (3)$$

Which is

Ep = potential energy (Joule)
m = mass (kg)
g = gravitational force (m/s^2)

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h = high (m)

Mechanical Energy

Mechanical energy is the sum of the kinetic and potential energy of an object that enables it to perform work. In the traditional game of Marjalengkat, it is evident that mechanical energy is present, as described above. This can be observed from the moment the player begins the game until its completion. Mathematically, mechanical energy can be expressed using the following equation:

$$EM = Ek + Ep = \frac{1}{2}mv^2 + mgh \quad (4)$$

The study of local knowledge related to the concept of mechanical energy in the traditional game of Marjalengkat has the potential to enhance understanding and preserve the values of local wisdom in Indonesia. From an educational perspective, identifying local knowledge related to physics concepts aligns with the 2013 curriculum and can be utilized by educators, parents, and the community as a resource for teaching physics in schools. Integrating local knowledge into modern scientific education can positively impact students by connecting physics concepts to everyday life.

An object is said to possess energy as a characteristic of its motion, referred to as kinetic energy. However, objects also have potential energy, which is the energy required by a force that depends on the object's position relative to its environment. The gravitational potential energy of an object is calculated as the product of its mass, gravitational acceleration, and its height above a specified reference level. For instance, an orange hanging on a tree possesses potential energy due to its height above ground level. Mechanical energy is defined as the total of potential and kinetic energy possessed by an object. Mathematically, it can be expressed as follows:

$$Em = Ep + Ek \quad (6)$$

Equilibrium

An object is considered a point mass in the definition of a particle system. All forces acting on an object are assumed to act on this point mass, resulting only in translational motion (linear motion). An object that does not experience a change in position when subjected to external forces is referred to as a rigid body. The equilibrium of a rigid body is a condition in which the momentum of the object or particle is zero. If an object is at rest, it will remain at rest. In this state of rest, the sum of the forces acting on the object is either zero or no forces are acting upon it. Mathematically, this can be expressed as $\Sigma F = 0$.

The equilibrium of a rigid body can be categorized into two types: static equilibrium and dynamic equilibrium. Based on motion, the equilibrium of a rigid body can also be divided into translational equilibrium and rotational equilibrium. Translational equilibrium occurs when there is no net force acting on the object; however, if the object was initially in motion with a certain velocity, it will tend to continue moving at that velocity.

On the other hand, rotational equilibrium occurs when the net torque acting on an object is zero. The translational equilibrium of a rigid body will change if an external force, whether a pulling or pushing force, is applied at the center of mass. If the force does not act at the center of mass, it will generate a torque, resulting in a change in its rotational equilibrium. Fundamentally, force can be described as a factor that can alter an object's translational motion, while torque can cause changes in an object's rotational motion.

The traditional game of Marjalengkat consists of several wooden or bamboo poles as its main

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components: the handle pole, footrest pole, and support pole. The equipment used in Marjalengkat can be classified as a rigid body within the context of physics. Rigid bodies differ from particles. The traditional game of Marjalengkat is closely associated with the concept of equilibrium in physics. An object is said to be in mechanical equilibrium relative to an inertial reference frame (observer) when the linear acceleration of its center of mass is zero ($a_m = 0$) and its angular acceleration around any fixed axis in the reference frame is also zero (a = 0). This condition does not require the object to be at rest, as the first condition allows the object to move with a constant velocity of its center of mass (v_{pm} = Constant).

Meanwhile, the second condition permits the object to rotate with a constant angular velocity as well (w = konstan). If the object is truly at rest (relative to a reference frame), it means that both the linear velocity of its center of mass and its angular velocity about any fixed axis are equal to zero ($v_{pm} = 0$ dan w = 0), then the rigid body is said to be in static equilibrium. If a rigid body is in a state of static equilibrium, then both of the above conditions will ensure that the object remains in static equilibrium.

The first condition is equivalent to the requirement that the total external force acting on the rigid body is equal to zero ($åF_{ekst} = 0$). This is a necessary condition, but not a sufficient one, to ensure that the object is in perfect mechanical equilibrium. The first condition represents the statement of translational equilibrium. Meanwhile, the second condition is equivalent to the requirement that the total external torque acting on the rigid body is equal to zero ($åt_{eskt} = 0$). This condition represents the statement of rotational equilibrium. The equilibrium of a rigid body is classified into two types: static equilibrium and dynamic equilibrium. The position of the Marjalengkat when standing upright and stationary is an example of static equilibrium. The forces in this system are illustrated in the accompanying figure (c).

Static balance analysis of bamboo stilt game shows that the force of gravity on the supporting leg will cause imbalance. The push or pressure of the hand holding the stilt pole is needed to maintain the balance of the person on the stilt [5].

Center of Gravity

The center of gravity of an object, also known as the equilibrium point or the point at which the object will balance without any tendency to rotate, is often identified as the location where the entire weight of the object is concentrated. The center of gravity is the point at which the weight of the object acts. The location of an object's center of gravity remains constant as long as its shape does not change. For a homogeneous solid object, the center of gravity is located at its geometric center; for example, the center of gravity of a sphere is at its center. However, if the density of the sphere varies, the center of gravity will not be at its geometric center but will shift towards the denser regions.

Similarly, in the traditional game of Marjalengkat, the center of gravity of a player changes depending on their position. When standing upright on the Marjalengkat, the player's center of gravity is aligned with their body's midpoint and directly above the support points provided by their feet. Once one foot steps forward to maintain balance between the body and Marjalengkat, the player's body leans slightly forward. This occurs because the center of gravity shifts forward due to changes in shape and support points. This understanding aligns with local knowledge in Toba Samosir, where players naturally bend slightly to maintain balance.

Conclusion

The analysis of the physical concepts in the traditional game of Marjalengkat reveals that it

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encompasses principles of work, energy, and equilibrium. It is essential to preserve the traditional game of Marjalengkat, advocating for its incorporation as a ceremonial activity during specific events and making it a requisite practice.

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Validity of augmented reality (ar)-based electronic teaching materials

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Abstract. *In the current digital era, the need for varied and innovative teaching materials in Basic Physics learning is increasingly growing. The use of technology in education has become an urgent necessity to improve the quality and effectiveness of the teaching and learning process. To address this challenge, an electronic teaching material based on Augmented Reality (AR) has been developed for the Basic Physics course on the topic of Mechanics. This teaching material was developed using the ADDIE research and development model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The validity of the developed teaching material has been evaluated by subject matter experts and media experts, showing that this material has good quality and is suitable*

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for use in learning. With positive validity results, this teaching material is ready to be implemented in the classroom to enhance students' understanding of Mechanics concepts.

Keywords: Augmented Reality (AR), Basic Physics, ADDIE model, Teaching materials, Mechanics

Introduction

Basic Physics is part of physics taught to students majoring in physics and a compulsory course for all FMIPA students in universitas Negeri Medan. This course is a course that examines physics topics that are the basis for all physics courses. This course underlies the development of engineering, planning design, technology and has an important role in various disciplines and is able to develop thinking power and thought processes.

Based on the conclusion of the results of the questionnaire given to students of the 2023 academic year 2023/2024 conducted online, it is stated that the Basic Physics course does not have a significant impact on subsequent courses even though specifically for the Chemistry Department itself there is a Physics Chemistry course and for the Biology Department there are Radiobiology and Biophysics courses. Basic Physics courses should be used as basic knowledge to understand advanced courses. But in reality, the material in the Basic Physics course stands alone and is not holistic. A total of 73.5% stated that the material concepts in the Basic Physics course are difficult to understand and most students have not been able to solve problems related to physics concepts because students are always required to memorize formulas without trying to interpret the meaning and function of the formula. Students use plug and chug and memory-based approaches in solving physics problems [1][2]. As a result, students' ability to build new concepts will be difficult to emerge. So that indirectly students consider physics material difficult [3][4]. One of the efforts that can be made by lecturers as learning facilitators is to develop teaching materials that can be a reference material for students, especially in blended learning. One of the applications of technology in learning. One of the applications of educational technology is the use of augmented reality-based media. Augmented Reality (AR) is a visual technology by projecting computer-generated information into the eye [5][6]. AR can also integrate virtual environments into real or 3D virtual objects [7]. AR technology has been applied in many fields, including tourism, archaeology, art, commerce, industrial manufacturing and restoration, education, emergency management, entertainment and leisure, and medical treatment [8][9].

The main advantage of AR is that it is able to create an immersive hybrid learning environment by combining the digital environment and the physical environment of objects, thus facilitating the development of processing skills, such as critical thinking skills, problem solving skills, and communication skills through interconnected collaborative exercises. AR as a system has three characteristics, namely the ability to combine real and virtual objects, interactive capabilities in real time, and the ability to be used on 3D objects.

The application of AR is expected to create a more interesting and meaningful learning process for students [10-12]. The use of AR media has the potential to be an alternative learning media in today's digital era. Learners need an update so that they are not only focused on conventional learning media. Media is one of the main factors in the success of a learning activity.

Based on the description of the problem above, the research team will design and develop Electronics teaching materials based on Augmented Reality as an alternative teaching material for

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Basic Physics courses in the Department of Physics FMIPA Unimed. Teaching materials that will be designed through basic development research, meaning that learning media will go through a construct validation process and limited trials in small classes before they can be used. It is hoped that the products of this research will be useful in improving the quality of learning and becoming a reference material for Basic Physics Courses.

Methodology

This type of research is a research and development that produces augmented reality-based basic physics teaching materials. The type of development research used is ADDIE research with five stages, namely analysis, design, development, implementation and evaluation [13]. AR-based basic physics teaching materials have been validated by material experts and media experts. Each indicator on the validation instrument is rated using a Likert scale ranging from 1 to 5 [14] and then analyzed with the average of each instrument. The results of the analysis were then assessed for suitability with the evaluation criteria described by Arikunto [15].

Result and Discussion

To ensure the feasibility of the developed information technology and data literacy teaching materials, the digital learning media first went through a validation process by experts in the field of materials and media. This validation aims to evaluate several important aspects, such as functionality, reliability, usability, and efficiency. This assessment is conducted to ensure that the learning media is not only materially relevant, but also effective and convenient to use in the teaching-learning process.

The results of the validation conducted by the material experts show that the teaching materials have met the eligibility standards on most of the evaluated indicators, although there are some minor improvement suggestions to further refine the presentation. The findings from this validation process are summarised in detail in Table 1, which serves as a reference for further development steps before implementation in the field.

Table 1. The Validity of Augmented Reality-Based Basic Physics Teaching Material

Indicator	Average	Criteria
Functionality	80	Valid
Reliability	80	Valid
Usability	82	Highly Valid
Efficiency	80	Valid

The validation results show that this AR-based teaching material obtained a validity value of 80.43%, which is included in the Good/Fair category. The validators comments stated that this teaching material was innovative, able to bridge abstract concepts to be more concrete, and attract students' attention. With validity in the Good/Fair category, this AR-based teaching material is suitable to be continued in small class trials and large class trials.

Conclusion

Basic physics teaching materials based on augmented reality have been designed and validated by material experts and media experts. The results of the validation indicate that the teaching materials developed are valid with decent aspect criteria. From the results of this validation, the

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teaching materials are eligible to enter the further trial stage to be suitable for use in basic physics learning activities.

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Implementation of digital student worksheets based on a scientific approach assisted by google sites

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Abstract. *The development of digital student worksheets has been carried out in high schools with the help of Google Sites. Digital student worksheet sites were developed to help students in the physics learning process that could be done without any limitations of space and time. Digital student worksheets can help students to be more active and increase motivation and interest in learning physics, especially in wave material. The purpose of the study was the implementation of the development of digital student worksheets that have been carried out previously. The research method was qualitative using a questionnaire. The research sample consisted of 60 students from class XI at SMAN 6 Medan. Based on the results of the questionnaire given, it was found that respondents stated the aspect of ease with an average of 4.2 with a decent category, for the aspect of clarity with an average of 4.2, for the aspect of suitability with an average of 4.5 with a very decent category, for the aspect of appearance with an average of 4.4 with a very decent category and the aspect of attractiveness with an average of 4.2 with a decent category. The implementation of digital student worksheets was categorized as very feasible so that it can be used in the physics learning process.*

Keywords: Digital Student Worksheets, Scientific Approach, Google Sites, Physics, Wave

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Introduction

Curriculum 2013 emphasizes the application of modern pedagogical dimensions in the learning process through a scientific approach. This approach has an important role in developing students' attitudes, skills, and knowledge. Currently, the scientific approach is considered effective in improving the teaching and learning process in schools. In physics learning applied in the 2013 curriculum, the focus is on the learner as the center of learning, no longer on the teacher as the source of knowledge. This policy is regulated in Ministerial Regulation No. 59 of 2013, which aims to create learning procedures and programs that put students in the main position and encourage innovative thinking. According to Permendikbud Number 103 of 2014, the scientific approach consists of observation, inquiry, information gathering/experimentation, reasoning/association, and communication. The learning process that uses scientific methodology is known as the scientific approach. The purpose of this approach is to direct learners that knowledge can be obtained from anywhere, not only from teachers who provide one-way knowledge [1-3].

The implementation of the 2013 curriculum requires the support of various learning tools that actively develop students. One of the tools that can be used is the student worksheets which serve as a guide for students to carry out structured activities. Student worksheets contain various activities that encourage active student involvement, such as observation, experimentation, and asking questions. Thus, student worksheets are closely related to the choice of learning approach that is integrated into the whole learning process. Through the use of student worksheets, students' activity and creativity in learning can be increased, and the delivery of subject matter becomes more effective. The function of student worksheets according to [4][5] states that the function of student worksheets is to learn further material given to students because in student worksheets there is a display that has been well designed to attract or motivate students. Along with the times, the presentation of student worksheets can be connected through electronic-based media called Digital Student Worksheets [6][7]. Digital student worksheets are teaching material that presents simulations by combining text, animation, video, and images and are supported by guidelines to make users more interactive [8][9].

The development of Digital Student Worksheets has previously been carried out in research conducted in 2024 with the name Digital Student Worksheets Based on the Scientific Approach using Google Sites. The development of student worksheets is the realization of the use of technology for effective or efficient learning by utilizing non-print devices based on websites or platforms, namely Google Sites. The advantage of using Google Sites is that learning can be done without having to be face-to-face between students and teachers. As for the advantages of using Google Sites, we can easily access information quickly with what we need such as attaching file files or adding slides, tables, and videos found on YouTube, Google Documents, and others [10][11]. Referring to Google Sites research also conducted [12] the use of Google Sites requires someone to be able to understand the use of e-learning media so that it can make someone's thinking power critical. Google Sites is also the easiest way to make information accessible to anyone who needs fast, up-to-date access. People can work together on the Site to add file attachments, information from other Google applications (such as Google Docs, Google Calendar, YouTube, and Picasa), and new free-form content [13]. The utilization of Google Sites together with digital LKPD based on the scientific approach will increase student involvement in the

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learning process, making it more interesting and motivating students to master new skills at the individual and group levels [14].

Methodology

This study used a qualitative approach to describe the implementation of Digital Student Worksheets based on the scientific approach using Google Sites. The qualitative method was chosen because this research focuses on an in-depth analysis of students' experiences, perceptions, and responses to the use of the developed worksheets. The sample of this research was XI MIA class students at SMA Negeri 6 Medan as many as 60 students were involved in the research.

The instrument used in this research is a questionnaire. The questionnaire was designed to explore students' views and experiences in using the digital student worksheets based on the scientific approach. Data collection was carried out through questionnaires given to students after they completed learning with digital student worksheets based on a scientific approach. Questions in the questionnaire include aspects of ease, clarity, suitability, appearance, and attractiveness of using digital student worksheets using Google Sites. The data obtained from the questionnaire will be analyzed descriptively to identify patterns and themes that emerge from student responses. The data analysis technique used is Miles and Huberman. Activities in qualitative data analysis are carried out interactively and take place continuously until completion. Activities in data analysis, namely data reduction, data display, and conclusion drawing/verification [15].

Result and Discussion

The results of the development of digital student worksheets based on a scientific approach using Google sites with material traveling waves and stationary waves and containing instructions for use, learning competencies, material, worksheets, and conclusions in which there are also steps of a scientific approach including questioning, observing, gathering information, reasoning and communicating. For more details, please see the following image:

Figure 1. Digital Student Worksheets by Google Sites

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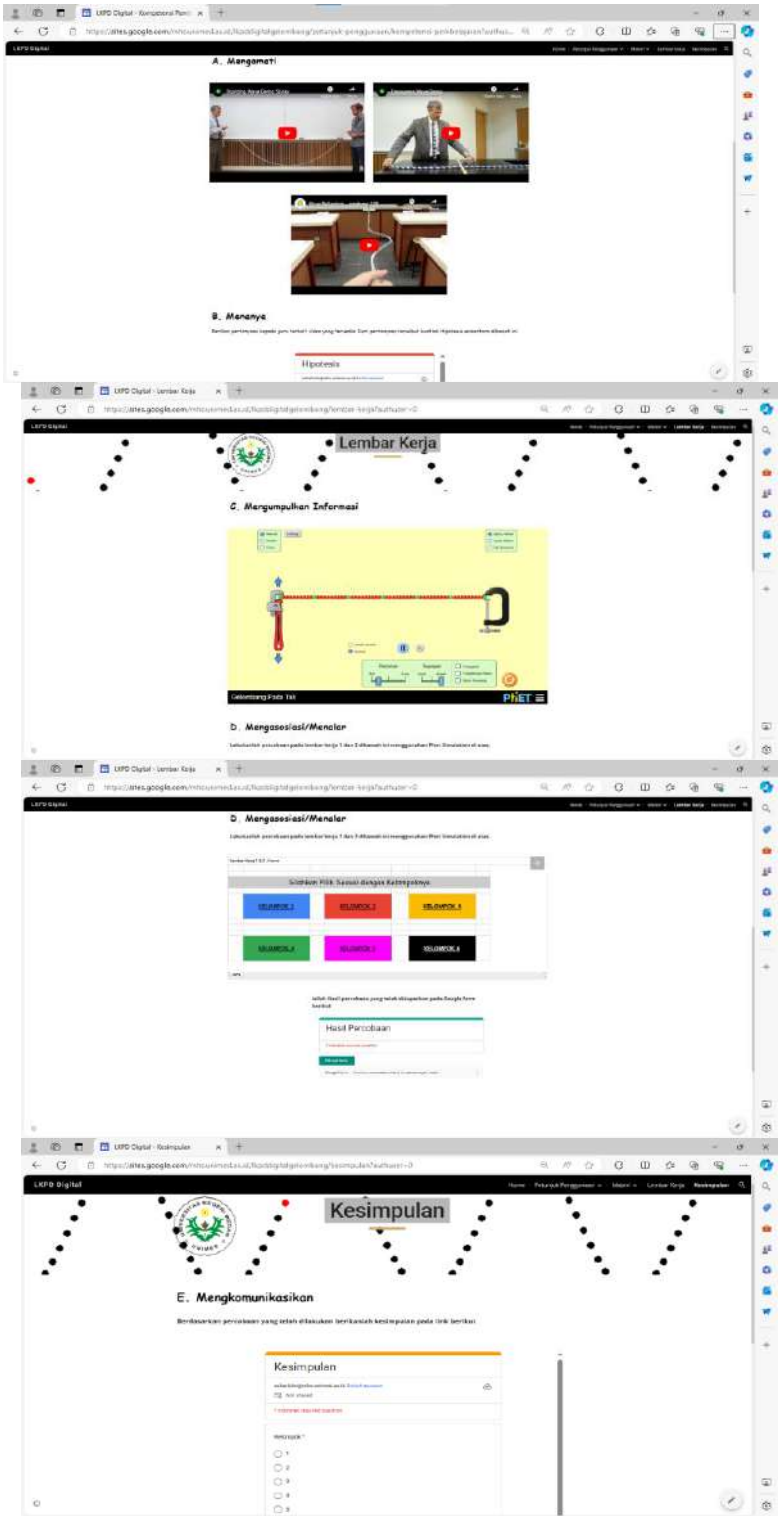

Figure 2. Scientific Approach to Digital Student Worksheets

The results of the questionnaire given to respondents can be seen in the following table:

Table 1 Questionnaire Response to Implementation of Digital Student Worksheets

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No	Aspect	Question	Total Score	Average	Category
1.	Ease	LKPD is easy to use or operate	249	4,2	
		LKPD can be used for self-study	242	4,0	
		Wave material becomes easy to understand	242	4,0	
		The instructions contained in the LKPD make it easy to do the experiment	260	4,3	Worthy
		The steps to start the experiment are easy to follow	256	4,3	
		LKPDs used are not limited to space and class	242	4,0	
		The language used is easy to understand	260	4,3	
2,	Clarity	Clarity of learning objectives	251	4,2	
		The material is presented systematically	252	4,2	
		Usage guidelines are presented	264	4,4	Worthy
		The experiment presented is clear	246	4,1	
		The readability of the writing on the LKPD is easy to understand	243	4,1	
3.	Compatibility	Learning objectives are following the material presented	260	4,3	
		Images and videos displayed follow the material of Walking and Stationary Waves	273	4,6	Very Worth it
		The simulation presented is following the learning objectives to be achieved	273	4,6	
		The experiments carried out follow the material	270	4,5	
4.	View	The digital LKPD used is by technological advances	273	4,6	Very Worth it
		Font, image, and video sizes are appropriate	254	4,2	
		The color selection on the media is appropriate	257	4,3	
5	Attractiveness	The simulation on the learning LKPD is interesting	265	4,4	
		The LKPD encourages me to be serious about experimenting.	246	4,1	
		LKPD can add basic concepts that are correct, real, and precise.	260	4,3	Worthy
		LKPD makes curiosity increase	248	4,1	
		LKPD can overcome the limitations of experience	254	4,2	
		LKPDs can allow for direct interaction	244	4,1	
		Total	6384	132,1	Very Worth it
		Average		4,3	

From the results of the questionnaire given, it can be seen that the respondents stated the convenience aspect with an average of 4.2 with a decent category, the clarity aspect with an average of 4.2 with a decent category, the suitability aspect with an average of 4.5 with a very decent category, the display aspect with an average of 4.4 with a very decent category and the attractiveness aspect with an average of 4.2 with a decent category.

Conclusion

From the results of the questionnaire given to respondents, it is known that participants are very happy and motivated by the use of digital student worksheets based on a scientific approach using Google Sites. Thus the results of the implementation of scientific approach-based worksheets using Google Sites are effective in supporting the learning process. From the results of the questionnaire data analysis, several main points were found, namely increasing motivation and willingness to learn by using technology as a support in the learning process.

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Development of electronic module (e-module) for basic physics on static fluid material

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Abstract. *This study aims to: (1) produce a product in the form of a basic physics electronic module (e-module), (2) describe the feasibility of the basic physics electronic module (e-module) product produced, (3) describe the practicality of using the basic physics electronic module (e-module) product produced. This study uses a research and development research method. The steps in the development research are adapted from Thiagarajan's 4D development model, namely: (1) the define stage through problem tracing and needs analysis, (2) the design stage through designing teaching materials by determining templates, compiling instructions for using teaching materials, selecting material references, preparing material descriptions, preparing sample questions whose solutions are adjusted to the problem-solving steps, preparing evaluation questions, (3) the development stage through making a draft (initial product) of the Basic Physics electronic module (e-module); initial product assessment through validation by experts, namely material experts and media experts; (4) the disseminate stage, namely the final product of the Basic Physics electronic module (e-module) in the form of a digital file that is ready to be used*

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by students. The results of the feasibility test of the material aspect of the basic physics electronic module (e-module) product on the static fluid material obtained an average score of 89.55 with a very feasible category, while the results of the feasibility test of the media aspect of the basic physics electronic module (e-module) product on the static fluid material obtained an average score of 86.33 with a very feasible category. So it can be concluded that the basic physics electronic module (e-module) on the static fluid material is very feasible to be used in basic physics lectures.

Keywords: Teaching Materials, Electronic Module, Development, Basic Physics, Static Fluids

Introduction

Students as Prospective Physics Teachers Require a Strong Understanding of Basic Physics Concepts, as they are expected to become professional physics teachers. Lecturers have the primary responsibility to conduct optimal teaching during lectures to achieve the learning objectives [1].

Post-COVID-19 pandemic, the Physics Education Study Program at Universitas Negeri Medan has returned to in-class learning, utilizing PowerPoint slides as instructional materials. The effectiveness of PowerPoint usage depends on the instructor's preparation and ability to deliver the material effectively. Typically, PowerPoint presentations are designed to highlight key points, and thus do not delve into the material in detail [2].

Similarly, in the basic physics course, the lecturer's presentation typically covers only key points, main concepts, and sample problems, without explaining theories in detail. Additionally, students do not seek alternative resources as learning materials, making developing supplementary teaching materials an essential solution. The organization of lectures is based on the principles of efficiency and effectiveness, optimizing the limited time to achieve learning objectives [3]. Educational institutions must provide, develop, and utilize diverse learning media and offer students opportunities to learn according to their needs and learning styles, thus enhancing the efficiency of the learning process [4].

The learning process cannot be separated from the media. Currently, the development of learning media has shifted to digital formats. Therefore, prospective teachers must be trained to effectively use this technological advancement to enhance their problem-solving skills. In the 21st century, human resource development (HRD) needs to be prioritized, particularly in the education sector, to foster the development of a new civilization within an increasingly advanced societal framework [5]. This aligns with the demand to prepare 21st-century generations with creative thinking, critical problem-solving skills, and the ability to communicate and collaborate. One of the essential skills for navigating the 21st century is problem-solving. Problem-solving refers to an individual's ability to analyze issues and find effective and accurate solutions to problems [6]. Problem-solving skills are critical for students, as they represent a series of thought processes after identifying and defining the issue [7]. Problem-solving requires logical thinking to find solutions, stimulating students to think creatively and innovatively [8].

Based on observations during lectures, it is evident that students' problem-solving abilities remain low [9]. Problem-solving skills are influenced by students' thinking abilities and their level of mastery of physics concepts [10], [11]. In the basic physics course, students struggle to digest the material because they tend to rely on mathematical solutions when solving physics problems, leading them to become trapped in mathematical routines without fully understanding the underlying physics concepts [12]. In the Basic Physics course at the Physics Department of

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Universitas Negeri Medan, e-modules have yet to be developed. A module, being self-instructional, is designed to be studied independently, covering the entire material, learning methods, and evaluation, and is systematically structured to engage students in the learning process [13]. Learning with e-modules aims to allow students to study independently and assess their abilities through learning outcomes, making the learning process more effective in achieving the learning objectives [14].

In response to the need to adapt teaching materials to technological advancements, the absence of e-modules for the basic physics course, and the results of a needs analysis indicating a necessity for the development of teaching materials, this serves as the rationale for the development of e-modules for the basic physics course, focusing on enhancing students' problem-solving skills. The development of this basic physics e-module is expected to serve as an alternative teaching material that enables students to study independently, regardless of time and place limitations [15], and to facilitate lecturers in managing and planning lessons more systematically, assigning tasks, and conducting evaluations [16].

Research Method

This research uses a mixed method approach [1], so the data were analyzed qualitatively and quantitatively. The feasibility of teaching materials was tested by material experts and media experts. The results of the validation test by material and media experts will be analyzed by calculating the average value of each aspect using equation (1). The analysis results are interpreted based on Table 1.

$$PS = \frac{\sum S_i}{n}\ 100\ \% \quad (1)$$

Description:
PS = Score Percentage
$\sum S_i$ = Total score in i aspect
n = Total indicator in i aspect

Table 1. Interpretation of Expert Validation Results

Percentage (%)	Classification
81 – 100	Very Feasible
61 – 80	Feasible
41 – 60	Feasible Enough
21 - 40	Less Feasible
0 – 20	Not Feasible

Results and Discussion

Results

The research conducted used the R&D 4-D research method, which consists of the stages: Define, Design, Development, and Disseminate. This research has resulted in a product, namely an electronic module (e-module) on the topic of static fluids. The e-module was created using the Canva application and published on the Heyzine platform. The appearance of the resulting e-module product is shown in Figure 1.

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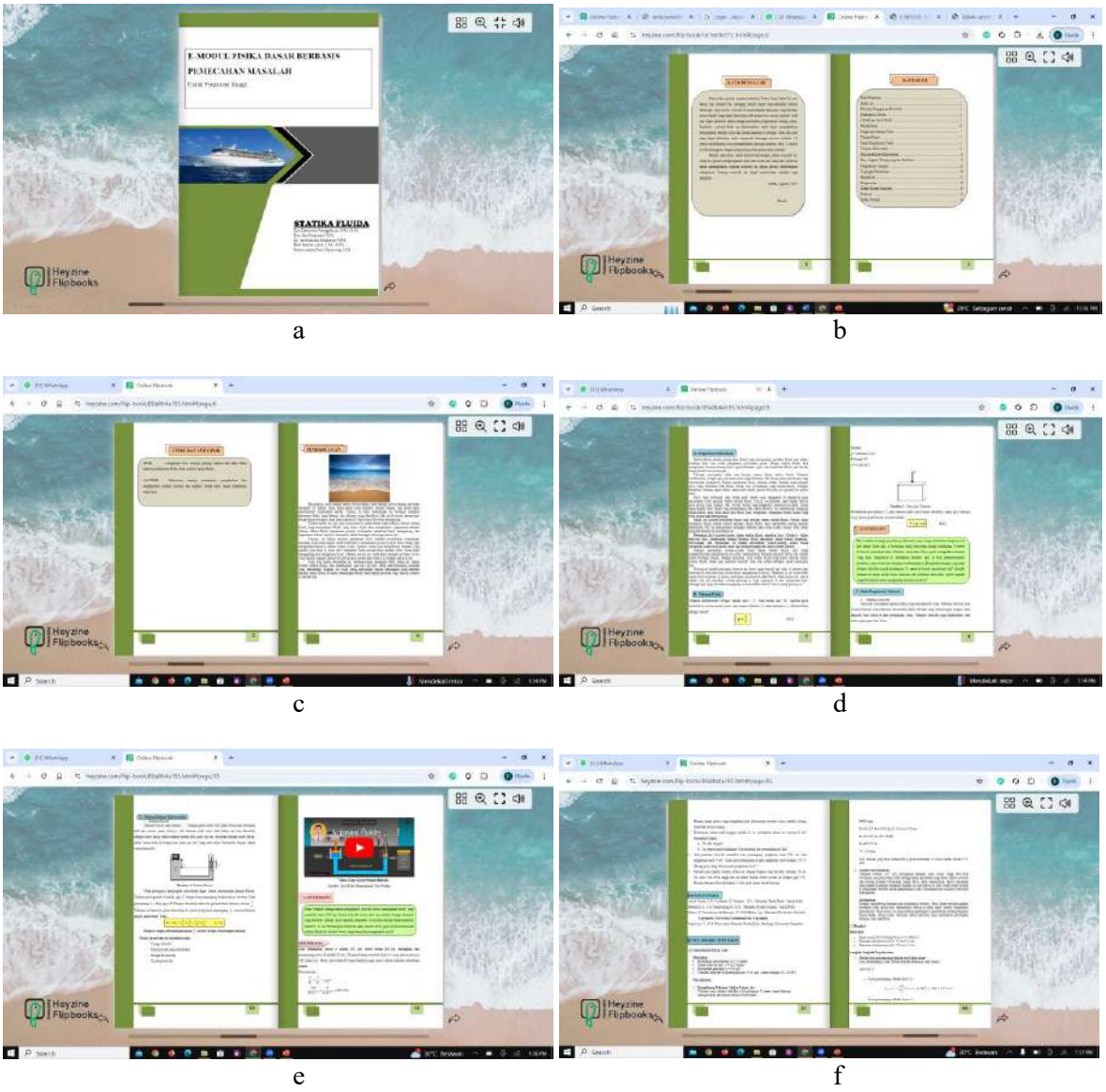

a b c d e f

Figure 1. (a-f) The Appearance Of The E-Module

Based on the results of research Development of Electronic Modules (E-Module) for Basic Physics on Static Fluid Material, it was found that the teaching materials were declared valid by material experts with an average score 89.5.5 The results of validation by material experts can be seen in Table 2 and Figure 2.

Table 2. Material Expert Validation Results

Assessment Aspect	Score
Content Feasibility	90.71
Presentation Feasibility	87.50
Language Feasibility	87.50

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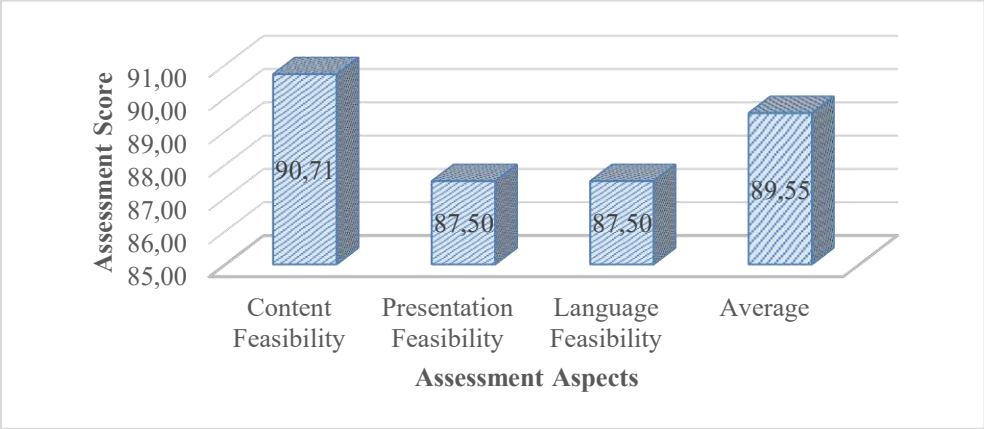

Figure 2. Material Expert Validation Results

Based on the results of validation by media experts, it was found that the assessment of the teaching material media developed was valid, with an average score of 86.33 Media validation results can be seen in Table 3 and Figure 3.

Table 3. Media Expert Validation Results

Assessment Aspect	Score
Design Appearance	84.00
Ease of Use	88.00
Consistency	93.33
Usefulness	80.00

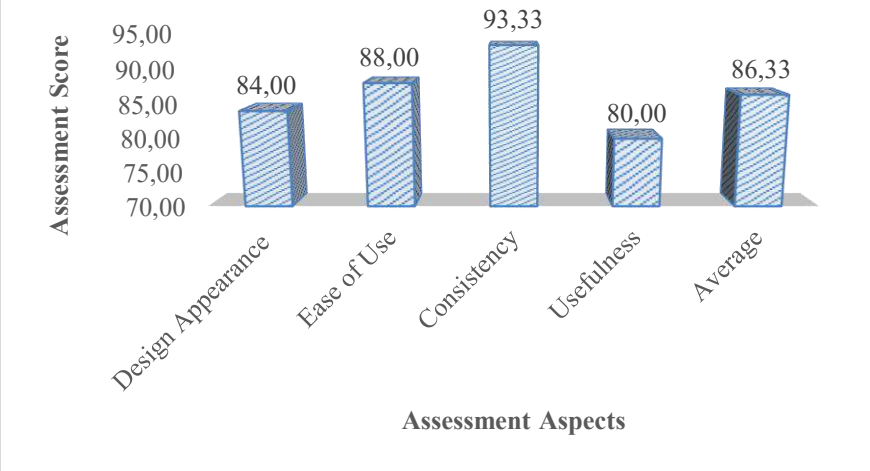

Figure 3. Media Expert Validation Results

Discussions

This study aims to produce a product in the form of an electronic module (e-module) for basic physics, evaluate its feasibility, and assess its practicality for use. The results show that the e-module for basic physics on static fluids is highly feasible as teaching material for basic physics courses. The development process of the e-module follows the 4D Thiagarajan development model, which consists of four stages: define, design, development, and disseminate.

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In the define stage, problem identification and needs analysis are conducted to identify gaps and challenges in the basic physics learning process. Based on this analysis, the need for technology-based teaching materials becomes clear, especially in facilitating the understanding of abstract physics concepts that are often difficult for students to grasp.

In the design stage, the e-module is developed with consideration of important elements, such as template selection, preparation of usage instructions, and development of appropriate teaching materials. The material is carefully arranged, starting from the material description, problem examples with step-by-step solutions, to evaluation questions that assess students' understanding of the taught material. The design aims to create a module that is not only informative but also interactive and engaging for students. The use of multimedia in the design can enhance students' understanding of the concepts taught, as the combination of text, images, and audio can stimulate more effective information processing compared to using text alone [18].

The development stage involves creating the initial draft of the product, the e-module, which is then evaluated by subject matter and media experts. A validation process is carried out to ensure that the content aligns with the curriculum and educational standards, and to assess whether the media used effectively delivers the material in an engaging and easy-to-understand manner. Trial tests of the draft product are also conducted to ensure that the e-module functions as intended, both in terms of content and technical aspects. The validation conducted by subject matter and media experts is essential to ensure the quality and effectiveness of technology-based educational products [19].

In the disseminate stage, the refined e-module is distributed in digital file format to students, ready for use in basic physics courses. The final product is expected to help students understand physics concepts in a more practical and enjoyable way, and to be accessible anytime and anywhere.

The product feasibility evaluation is conducted by testing two main aspects: content and media. Based on the feasibility test results, the e-module for basic physics on static fluids received an excellent score in both aspects. The content feasibility test results for the basic physics e-module showed an average score of 89.55, which falls into the very feasible category. This indicates that the content presented in the e-module is in line with the curriculum standards and is easily understood by students. The systematic presentation of material, supported by problem examples and clear solution steps, makes it easier for students to understand basic physics concepts, particularly in the topic of static fluids. A well-structured, technology-based module can improve student understanding [20].

The media feasibility test results for the e-module showed an average score of 86.33, which also falls into the very feasible category. The media used in the e-module, such as images, graphics, and animations, can help students visualize concepts that are difficult to explain with text alone. The use of visual media in learning modules can help reduce cognitive load and increase student engagement in the learning process [21]. The appropriate use of media also makes the e-module more attractive and interactive, enhancing the students' learning experience. Furthermore, the ability to access the electronic module anytime and anywhere provides greater flexibility in the learning process [22]. With excellent scores in both aspects, it can be concluded that the e-module for basic physics on static fluids is highly suitable for use in the course.

Conclusion

Based on the results of the feasibility test for the electronic module (e-module) on basic physics for the topic of static fluids, the content aspect received an average score of 89.55,

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categorized as highly feasible. Meanwhile, the media aspect received an average score of 86.33, also categorized as highly feasible. Thus, it can be concluded that the electronic module (e-module) for basic physics on the topic of static fluids is highly suitable for use in basic physics courses.

Acknowledgments

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A preview of problem solving skills based e-worksheet (E-LKPD)

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Abstact. This study aims to review the effectiveness of E-LKPD (Electronic Student Worksheet) based on problem-solving skills in learning. The designed E-LKPD presents various scenarios and contextual problems that are relevant to everyday life to facilitate students in identifying problems, formulating hypotheses, and finding solutions independently. Data were obtained through interviews, observations, and student response questionnaires. Data analysis shows that this problem-solving-based E-LKPD plays a significant role in fostering students' self-confidence in solving problems. In addition, student responses show that they feel more interested and motivated in participating in problem-based learning through electronic media. This E-LKPD is also effective in optimizing the role of teachers as facilitators and providing a variety of learning experiences that support improved learning outcomes

Keywords: E-LKPD, *Problem Based Learning, Electronic Learning Media, Development Of Digital Teaching Materials, Solution to Problem*

Introduction

The development of Information and Technology (ICT) is currently experiencing quite rapid development. This development has an impact on various fields, especially in the field of education , where strategies and patterns in learning continue to develop. Technology can expand learning activities, as evidenced by the fact that currently some learning has switched to unlimited online methods from previously only being carried out in the classroom. So that

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students can learn independently, either without the help or guidance of their teachers in class or outside of school (Ghofur, 2021). As an effort to realize active student involvement in the learning process, especially in physics subjects, appropriate media and teaching materials are needed that can meet student needs.The right media to meet the needs of students is by using E-LKPD. E-LKPD is one of the learning tools that plays an important role in the learning process so that it can be implemented properly. The E-LKPD that will be designed is by taking an approach based on problem-solving skills that can present various scenarios and contextual problems that are relevant to everyday life to facilitate students in identifying problems, formulating hypotheses and finding solutions independently.

Problem Solving Ability is one of the important competencies that students need to have to face challenges in the global era. Problem solving ability is the ability of children to be able to utilize their experience or knowledge in formulating hypotheses, collecting data, processing information, making conclusions based on the information obtained. Problem solving ability must be trained from an early age so that children are accustomed to thinking analytically and are able to make decisions independently (Audry, Hardiansyah, & Rezeki, 2022).

Therefore, efforts to integrate these capabilities into teaching materials, such as through E-LKPD, are strategic steps to produce more effective and relevant learning. This study aims to develop a preview of E-LKPD specifically designed to train and improve students' problem-solving skills. Through this study, it is expected to obtain an overview of how the preview of E-LKPD can be accepted by students, as well as how effective it is in improving problem-solving skills. The results of this study are expected to provide real contributions to the development of more innovative teaching materials that are in accordance with the needs of 21st century learning.

METHODOLOGY

This study uses a qualitative descriptive research design. Data collection methods include observation, interviews, and student response questionnaires. The author uses data collection techniques by distributing questionnaires. A questionnaire is a data collection technique that is carried out by giving a set of written questions or statements to respondents to be answered. (Sugiyono, 2017). The questionnaire used is a questionnaire on product attractiveness and ease.

RESULTS AND DISCUSSION

The results of the questionnaire on the attractiveness and ease of *E-LKPD* by students with 36 students as respondents obtained a score of 3.70 with a percentage of 92.7% with the category "very interesting and very easy" overall indicators. The attractiveness indicator with a value of 3.69 with a percentage of 92.4% and the ease indicator with a value of 3.72 with a percentage of 93.05% and both indicators in the category "very interesting and very easy". Overall, the *E-LKPD product* is feasible, interesting, easy and effective to use in the learning process.

This E-LKPD refers to the principle of constructivism-based learning, where students are trained to build their understanding through direct experience. This is reinforced by the use of interactive features that make learning more interesting and motivate students to think critically.

This e-LKPD has proven effective in improving students' problem-solving abilities. Providing contextual and relevant questions to everyday life makes it easier for students to understand problems

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and design solutions. Overall, this problem-solving-based e-LKPD provides a positive contribution to modern learning, especially in supporting the implementation of the Merdeka curriculum.

CONCLUSION

The results of the questionnaire on the attractiveness and ease of *E-LKPD* by students with 36 students as respondents obtained a score of 3.70 with a percentage of 92.7% with the category "very interesting and very easy" overall indicators. The attractiveness indicator with a value of 3.69 with a percentage of 92.4% and the ease indicator with a value of 3.72 with a percentage of 93.05% and both indicators in the category "very interesting and very easy". Overall, the *E-LKPD product* is feasible, interesting, easy and effective to use in the learning process.

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Synthesis and characterization of optical properties of aluminum doped zno thin film by sol-gel spin coating method

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Abstract. *Aluminum-doped ZnO thin film has been successfully synthesized by using the sol-gel spin coating method with the variation of Aluminum doping. XRD characterization results show a hexagonal wurtzite-shaped crystal structure and an increase in aluminum doping concentration along with a decrease in crystal size from 37.5 to 15.8 nm. SEM-EDS characterization results show that the particles cover the substrate without cracks and have good interconnection between each particle with an average size of about 100 nm. UV-Vis characterization results showed that the transmittance values obtained for all samples in the visible light region increased while the energy band gap decreased with increasing doping concentration. The band gap energy is greatest at Al 5% doping concentration.*

Keywords: Al-doped ZnO Thin Film, Aluminum Doping, Sol-gel Spin Coating

Introduction

Zinc Oxide (ZnO) has multifunctional properties with large binding energy, low sensitivity, large light capture characteristics, 3.37 eV band gap, and 60 meV free electron binding power, making them an excellent substitute for TiO_2 as a semiconductor [1]. The deficiency of ZnO thins films has unfavorable electrical characteristics with a low conductivity value of 6,24 x 10-7 (Ωcm)[2]. The doping method is frequently employed in terms of improving the physical, optical, and electrical properties of ZnO with extrinsic dopants from the III-A group of periodic elements such as B, Al, Ga, In, and Tl as materials substituted into the ZnO matrix [3]. Aluminum (Al) is a

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commonly utilized dopant due to its ability to boost ZnO thin film electrical conductivity up to 105 Ω.cm [4], as well as the result that Al atoms are replaced on the ZnO structure's lattice. Al's (0.54) atomic size is smaller than Zn's (0.74) [5].

ZnO can be easily deposited and grown on various substrates in one-dimensional (1-D) morphology using several growth processes such as molecular beam epitaxy, RF magnetron sputtering, pulsed laser deposition, spray pyrolysis, and physical vapor deposition [6-13]. However, these approaches are complex procedures performed with sophisticated machinery and may require high temperatures during the operation. In contrast, the sol-gel spin coating technique utilizes low synthesis temperatures and simple and affordable equipment. It does not require a high-vacuum chamber, the composition is homogeneous, the coating thickness can be controlled, and the microstructure is satisfactory [14].

Some studies on ZnO thin films utilizing Al-doped ZnO thin film [15], state that increasing doping concentration while decreasing crystal size and energy band gap increases the energy band gap. According to [16], the energy band gap rises as the Al doping concentration increases, however states that increasing the Al doping concentration reduces the intensity of the spectrum [17].

Experimental Procedure

The research materials utilized were zinc acetate dehydrate {$Zn(CH_3COOH).2H_2O$}, aluminum nitrate nonahydrate {$Al(NO_3)_3.9H_2O$, Isopropanol (C_3H_8O), and ethanolamine (C_2H_7NO) which are used as base material, doping, solvent, and stabilizer respectively. Zinc acetate dehydrates was doped with aluminum nitrate nonahydrate at various concentrations (0, 1, 3, 5, and 7 wt%). The refluxing method was utilized to achieve a homogeneous mixture of solutions. Zinc and aluminum precursors were dissolved in 50 mL of isopropanol solvent and maintained at 80 ºC under vigorous stirring. After 10 min, 1.76 mL of ethanolamine was introduced and mixed for 3 h. To form sol-gel, the solution was transferred into a beaker glass and evaporated for 30 min. The as-synthesized sol-gel was dropwise onto the ITO glass substrate, which was put on the spin coater. The spin coating was rotated at 5000 rpm for 1 min to achieve a uniform layer thickness. Furthermore, the as-deposited Al-doped ZnO thin film was dried at ambient temperature overnight. The Al-doped ZnO thin film was then heated with a pre-heating temperature of 250 ºC for 1 h and then post-heated at 500 ºC for 5 h. Finally, the Al-doped ZnO thin film samples were then characterized by the XRD, SEM-EDS, and UV-Vis.

Result and Discussion

Crystal Structure of ZnO:Al Thin Film

The XRD diffraction patterns of ZnO:Al thin film samples are shown in Figure 1. The results of XRD diffraction pattern analysis show that all samples have the same crystal plane, which is the (100), (002), and (101) planes, the same growth peak and oriented in the (101) plane and hexagonal wurtzite shape. The increase in aluminum doping is followed by a decrease in spectrum intensity, this result is in accordance with the results of research [17,18], which states that increasing the percentage of Al doping is in line with the decrease in spectrum intensity.

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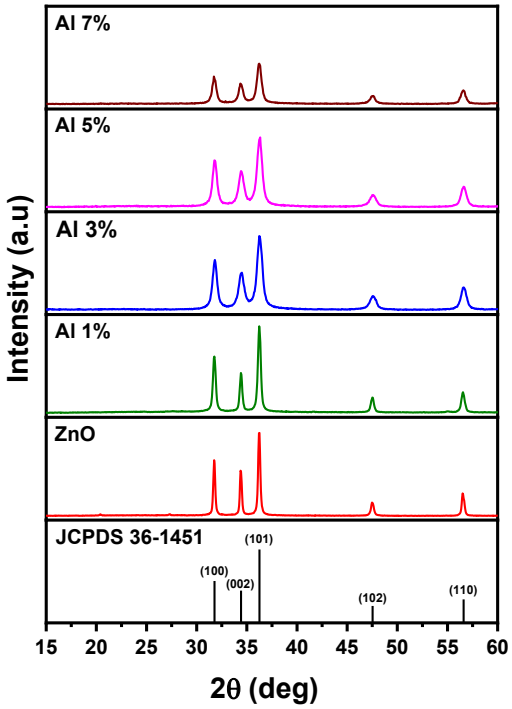

Figure 1. X-ray diffraction Spectra of Al-doped ZnO thin film.

The crystal size of Al-doped ZnO thin film with aluminum doping variation is obtained using the equation below:

$$D = \frac{0{,}9\,\lambda}{\beta \cos\theta} \quad (1)$$

with D = crystal size, λ = wavelength, β = FWHM (full width half maximum), θ = diffraction angle, the results of which are shown in Table 1.

Table 1. Crystal size of ZnO:Al Thin Films.

Sample	Peak		Crystal size (nm)
	2θ (degree)	**FWHM (degree)**	
ZnO:Al 0%	36.8	0.247	37.5
ZnO:Al 1%	36.8	0.292	30.2
ZnO:Al 3%	36.8	0.377	23.4
ZnO:Al 5%	36.8	0.480	18.4
ZnO:Al 7%	36.8	0.584	15.8

Based on Table 1, it can be seen that increasing the concentration of aluminum doping causes the crystal size to decrease from 37.5 - 15.8 nm, this is according to [19-21]. According to [22], the change in crystal size is due to the distortion of the crystal lattice after aluminum doping is incorporated into ZnO crystals and is also caused by lattice defects and the center of the atom.

Morphology of Al-Doped ZnO Thin Film

The growth process of Al-doped ZnO thin film was observed through morphology recording

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by Scanning Electron Microscope (SEM). Based on Figure 2, it can be seen that the ZnO and Al-doped ZnO thin films have a relatively homogeneous surface morphology. Grains measure around 100 nm and are evenly distributed across the surface of the thin film. This indicates that the film growth process has taken place well and produced a uniformly dense film layer. Even more, there is no significant crack or pore on the surface of the film, indicating good interconnection between the grains. Despite the variation of Al-doped concentration, there is no significant difference in the surface morphology of Al-doped ZnO thin films. This implies the addition of Al in tiny quantities (up to 7 wt%) has no substantial influence on the film growth process or surface shape.

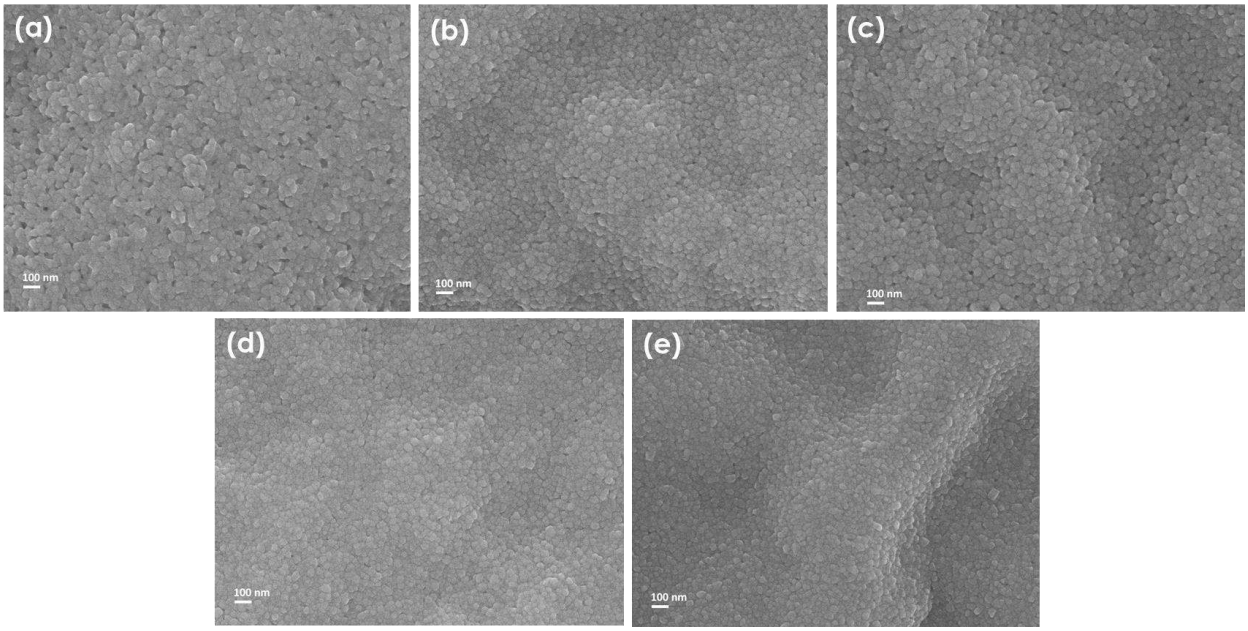

Figure 2. SEM images of the surface (a) ZnO Thin Film, (b) Al-doped ZnO thin film 1%, (c) Al-doped ZnO thin film 3%, (d) Al-doped ZnO thin film 5%, (e) Al-doped ZnO thin film 7%.

Energy dispersive spectroscopy (EDS) analysis was used to confirm the atomic percentage of each sample as shown in Table 2. The elements detected in the ZnO thin films with varying Al doping concentrations are Zn, O, and Al. The EDS results indicated that Al was successfully incorporated into the ZnO structure without causing significant changes to the surface structure of the samples. This is also evidenced by the XRD analysis which did not show any phase change after Al doping, only a decrease in the intensity of ZnO. The absence of other elements associated with contamination confirms that the Al-doped ZnO thin film is phase pure. In addition, the lower ratio of Zn compared to O could in principle to indicate the possibility of Zn vacancies in the crystal lattice, which could affect the density of the material. The percentage of Al atoms detected through EDS analysis does not appear to match the desired doping percentage. This is due to the precursor used which is Aluminum Nitrate. During the synthesis process, the nitrate group turns into negative ions that decompose and evaporate, thus affecting the accuracy of measuring the actual Al concentration in the sample. These consistent EDS results corroborate that Al as an extrinsic dopant was successfully doped into the ZnO structure.

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Table 2. Atomic Percentage of Al-doped ZnO thin films.

Sample	Aluminum (%)	Zn (%)	O (%)
ZnO	0	49,71	50,29
ZnO:Al (1%)	0,93	45,03	54,03
ZnO:Al (3%)	2,94	45,24	51,82
ZnO:Al (5%)	5,89	45,01	49,10
ZnO:Al (7%)	6,91	44,12	48,97

Optical Properties of Al-Doped ZnO Thin Film

Transmittance and absorbance spectra for all samples of UV-Vis test results in the range of 300-700 nm to analyze absorbance and transmittance are shown in Figure 3.

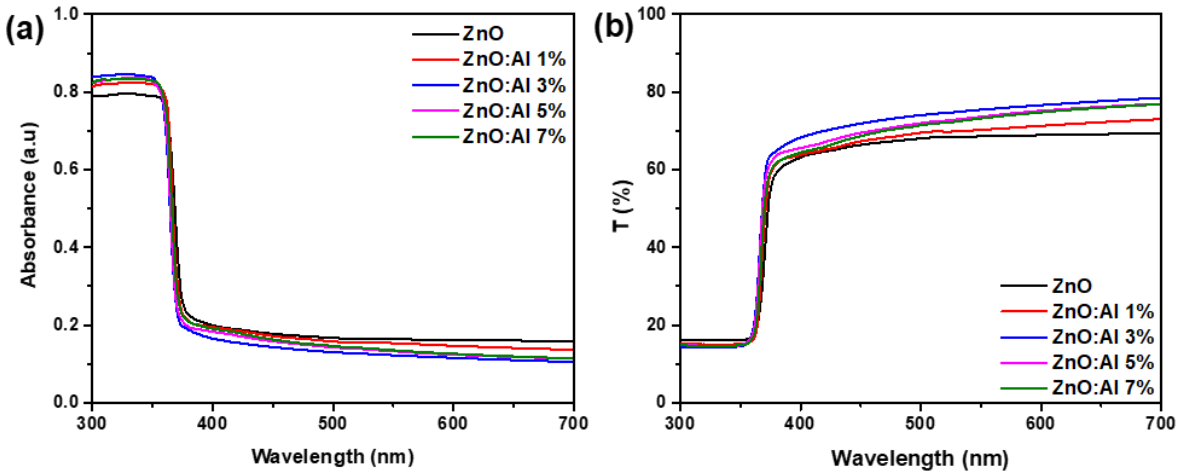

Figure 3. (a) Absorbance, and (b) Transmittance spectrums of Al-doped ZnO thin films.

Figure 3.a shows a slight increase in absorbance of the Al-doped ZnO thin film. In the transmittance spectrum (Figure 3.b), it can be seen that ZnO thin films with Al doping have increased transmittance compared to pure ZnO, especially at 3% and 5% doping. A higher increase in transmittance spectrum is shown by the 3% Al-doped ZnO thin film. This increase in transmittance can be attributed to the reduction of defects and increased regularity of the crystal structure due to Al doping, which allows more light to pass through the thin film. In contrast, a slight shift of the absorption edge and transmittance edge around 350 nm to 380 towards shorter wavelengths as the Al doping concentration increases, indicating a change in the optical properties of the ZnO thin films. This indicates a change in band gap energy in Al-doped ZnO thin films. Thin films that have high transmittance in the visible light region of 400 to 700 nm, are very good and suitable for application to solar cells [23,24].

For materials with a direct band gap, the relationship of absorbance to photon frequency satisfies the equation [25]

$$(\alpha hv)^2 = C_D(hv - E_{opt}) \quad (2)$$

Based on the Tauc Plot method, the band gap energy of Al-doped ZnO thin film with magnesium doping is shown in Figure 4.

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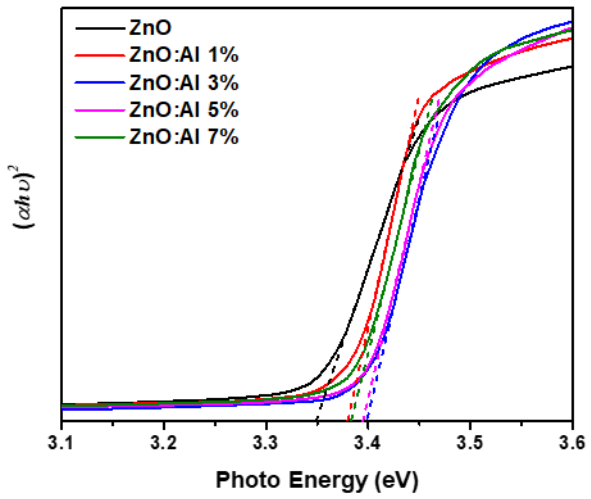

Figure 4. Energy Band Gap of Al-doped ZnO thin films.

Based on Table 3 the band gap values of ZnO thin films and Al doping variations show an interesting trend. The band gap value for pure ZnO is 3.35 eV, which is a typical characteristic of ZnO with hexagonal wurtzite structure. After the addition of 1% Al doping, the band gap value increased to 3.37 eV, and continued to increase to 3.40 eV at 5% doping. This increase in band gap value can be explained by the Burstein-Moss effect, where the increase in electron concentration due to Al doping shifts the Fermi level to the conduction band, so that the electronic transition requires more energy, which ultimately increases the observed band gap. However, at a higher doping concentration of 7%, the band gap value decreases slightly to 3.38 eV. This decrease can be caused by several factors, such as the appearance of crystal defects or the insertion of excess Al atoms into the ZnO lattice, which causes distortion of the crystal structure. When the doping concentration is too high, the interaction between Al atoms and the ZnO structure can lead to a decrease in crystal order and an increase in the number of defects, such as Zn or oxygen vacancies. These defects can act as electron trapping centers that reduce the effectiveness of band gap enhancement [27].

In addition, the decrease in band gap value at 7% concentration may also be due to the stronger carrier scattering effect at high doping, which hinders electron mobility and affects the energy transition. This phenomenon shows that although Al doping can increase the band gap value of ZnO up to a certain point, at too high doping, negative effects such as structural defects and carrier scattering begin to dominate, thus decreasing the measured band gap value [24, 28]. Thus, there is an optimal limit of Al doping at around 5% to obtain the highest band gap value without sacrificing the crystal order and structural quality of ZnO thin films.

Table 3. Energy Band Gaps of The Samples

Sample	**Bandgap (eV)**
ZnO	3.35
ZnO:Al (1%)	3.37
ZnO:Al (3%)	3.39
ZnO:Al (5%)	3.40
ZnO:Al (7%)	3.38

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Conclusion

Al-doped ZnO thin films have been successfully synthesized using the sol-gel spin coating method. The crystal structure of ZnO thin film is hexagonal wurtzite and the increase of aluminum concentration along with the decrease of crystal size from 37.5 - 15.8 nm. The surface morphology of the thin film is homogeneously distributed nanoparticle size, and there is no significant difference after Al doping. The increase in Al concentration is precisely related to the decrease in Zn and O content in the sample. The band gap energy is highest at 5% aluminum doping concentration.

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Analysis of the presence of microplastics in mussels in the waters of belawan, north sumatra

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Abstract. *Microplastics are highly dangerous for marine biota when ingested and enter the digestive system. The wedge clam (Donax sp.) is a type of clam favored by the public, making it important to conduct research aimed at identifying the presence and types of microplastics in wedge clams (Donax sp.) in the coastal waters of Belawan, Bagan Deli, Medan City. The research method involved field observation and microscopic analysis. Field observations were conducted by creating grids in the Belawan waters area. Microplastic content analysis was carried out in the Biology Laboratory of the Faculty of Mathematics and Natural Sciences. Sample collection was conducted with a total of 50 wedge clams. The samples were cleaned, and the clam meat was extracted, then softened using 10% KOH at a ratio of 1:10 for 12 hours at a temperature of 60°C. The samples were filtered using Whatman No. 540 filter paper until dry at 50°C for 5 hours in a vacuum machine. The microplastic content was observed using a binocular microscope. The research results showed that the wedge clams contained an abundance of microplastics in the form of fibers and fragments, with a total of 114 particles measuring 100-500 µm. The particles consisted of 98% fibers and 2% fragments. The presence of microplastics in the clam meat is a significant concern for*

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the public, as it poses serious risks to marine life and humans who consume the clam meat.
Keywords: Microplastic, Mussels, Fiber, Fragmen, Belawan

Introduction

Belawan is a coastal area with a strategic location between the eastern coast of Sumatra and the Malacca Strait, making it a hub for port-based industrial development as well as a marketplace for large-scale trade of fishery products. Various types of catches, such as clams and edible fish, are sourced from the waters of the *Malacca* Strait (Reza *et al*., 2019). One of the catches at the Belawan port, Bagan Deli, Medan City, North Sumatra, is the wedge clam (*Donax sp*.). Wedge clams are a type of shellfish rich in animal protein, containing 0.88% fat, 0.39% carbohydrates, 80.10% water, and 1.16% ash, making them widely consumed by the public (Lalopua *et al*., 2020). The protein-rich clams found in the Belawan waters, with their adequate nutritional content, are at risk of exposure to microplastics originating from land-based plastic waste that ends up in the sea.

Microplastics are plastic waste that has broken down and degraded into fragments or small particles measuring ≤ 5 mm (Sarasita *et al*., 2020). The impact of microplastics on marine organisms is significant due to their very small size and their ability to persist in the ocean for a long time (Senduk *et al*., 2021). Microplastics can be ingested and enter the bodies of marine biota, either intentionally or unintentionally, due to factors related to their foraging processes. Marine organisms may mistake microplastics for food because they have sizes and shapes similar to their actual food, such as clams (Yona *et al*., 2020).

Clams have *filter feeder* properties, meaning they can consume all types of particulate food, such as sediment and seawater, and are capable of accumulating pollutants or bioindicators. (Tuhumury & Agustina, 2020). The presence of microplastics in the bodies of clams can have adverse effects on humans when they consume these clams, leading to significant disruptions in the digestive system, hindering reproductive processes, and increasing the toxicity of additives found in plastics (Wright *et al*., 2013). The research aims to identify the presence and types of microplastics in wedge clams (*Donax sp*.) from the coastal waters of Belawan, Bagan Deli, Medan City. The research results are expected to provide preliminary information regarding the presence and types of microplastics in wedge clams, which are consumed by the local community.

Research methods

The research was conducted from July to August 2024. A total of 50 wedge clams (*Donax sp.*) were collected from the coastal waters of Belawan, Bagan Deli, Medan City. Microplastic analysis of the clam samples was carried out at the Biology Laboratory of Universitas Negeri Medan.

Sample Collection of Wedge Clams (Donax sp.)

The clam samples were collected directly in the field during low tide. The sampling locations were determined using the purposive sampling method, a technique based on specific considerations defined by the researcher, as well as the conditions and characteristics of the study area, to ensure the collection of clam samples (Ayuningtyas *et al*., 2019). A total of 50 clam samples were collected and placed in cold storage containing ice to maintain their quality before conducting microplastic testing in the laboratory.

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Laboratory Analysis

The collected wedge clam samples were taken to the laboratory to measure the morphometric characteristics of the shells, including length (cm), width (cm), and meat weight (g). The clam meat was softened using a 10% KOH solution at a 1:10 ratio for 12 hours at 60°C. The samples were then filtered using Whatman No. 540 filter paper and dried at 50°C for 5 hours in a vacuum machine. The presence of microplastics was observed using a binocular microscope with 0.10x magnification. The type of microplastics was identified through visual observation by directly examining the shape of the microplastic particles in the clam samples. The microplastic types were classified into fibers and fragments based on the identified particle types.

Data Analysis

The parameters in the microplastic research on wedge clams used a quantitative descriptive method, analyzing the data systematically and objectively to draw conclusions based on the observed phenomena (Hamzah *et al*., 2021). The analysis followed the formula by Boerger *et al.* (2010), as follows:

$$K = \frac{Ni}{N} \quad (1)$$

Description:

K = Microplastic Abundance (particles)
Ni = Number of microplastic particles (particles)
N = Number of clams in the sample

Results and discussion

Based on the identification results of 50 samples, two types of microplastics were found in the clam meat: fiber (Figure 1) and fragments (Figure 2). The fiber microplastic has a long, thread-like shape and originates from fishing activities, such as nets, traps, and lines that degrade from fishermen's nets. According to Yona *et al*. (2019), fibers are often found in the water column as they typically come from various domestic activities, one of which is laundry, as well as fishing activities (such as angling). Fragment-type microplastics are larger pieces of plastic, usually irregularly shaped and jagged, originating from plastic cuttings such as drink bottles, plastic bags, PVC pipes, gallon shards, and other food packaging (Labibah & Triajie, 2020). Fragments can originate from household waste found in coastal areas, such as ready-to-eat food packaging and discarded plastic drink bottles in water bodies, which degrade into smaller pieces, forming fragments. These plastics stem from microplastics that have degraded due to ultraviolet light, a process known as photodegradation, resulting in small plastic pieces (Sarasita *et a*l., 2020; Yona *et al*., 2021).

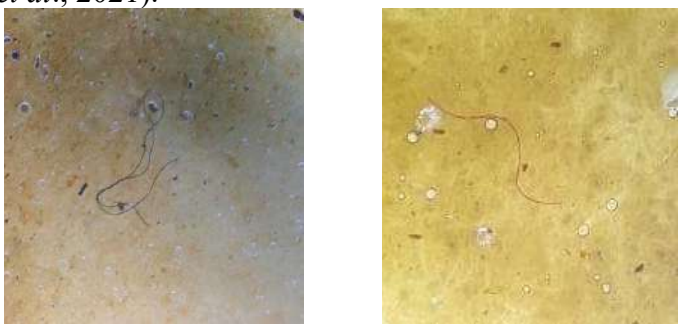

Figure 1. Fiber

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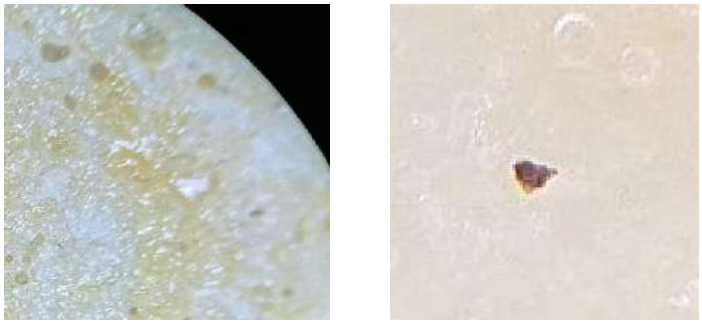

Figure 2. Fragmen

The most abundant type of microplastic found in the study of wedge clams was fiber, with a total of 112 particles. This aligns with the research by Bessa et al. (2018), which stated that fiber-shaped microplastics dominate marine biota. Fiber microplastics originate from synthetic clothing fibers that are released during the washing of clothes (Falco, 2019). The least frequently found microplastic form in this study was fragments, totaling 2 particles (Figure 3). The low occurrence of fragment-shaped microplastics in clam meat is suspected to be related to the predominant fishing activities of the local population. In situ data on fragment-shaped microplastics may originate from plastic bottles and other plastic items, such as PVC pipes, which have degraded into various forms. This is supported by research conducted by Kalogeraksi *et al*. (2017), which found that fragment-shaped microplastics appear as irregular pieces originating from larger plastic objects that have degraded (Kalogeraksi *et al*., 2017).

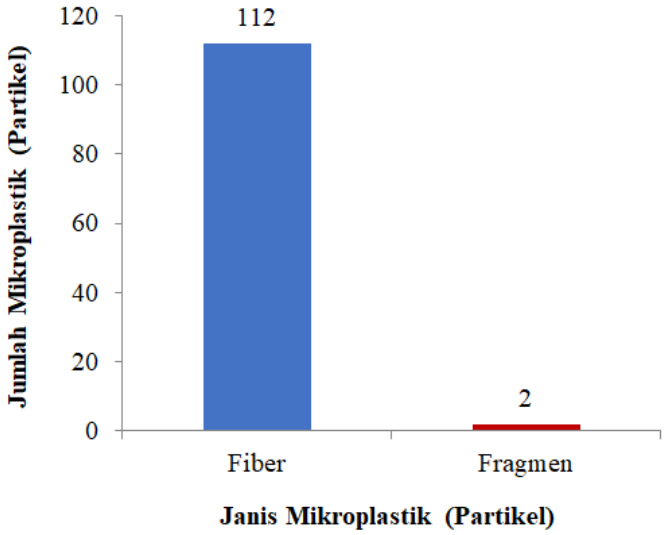

Figure 3. Microplastic Presence per Particle

Fibers are the dominant type of microplastic in the meat of wedge clams, accounting for 98% of the total microplastic particles found, which amounts to 114 particles (Tuhumury & Pellaupesy, 2021). The presence of fragments in the clam meat was found to be lower than that of fiber microplastics, with fragments making up only 2% (Figure 4). The low occurrence of fragment-type microplastics is attributed to their higher density compared to fibers, as fragments originate from strong synthetic polymer pieces that tend to sink more easily, making them more likely to be found in the sediment or deeper waters (Sarasita et al., 2020)

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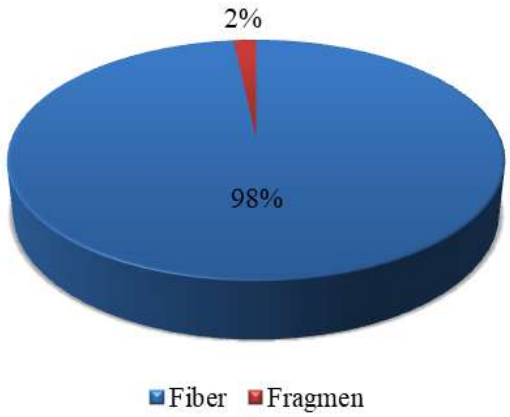

Figure 4. Total Percentage of Microplastic Particles in All Samples

Based on the colors of the microplastics found, black was the most dominant color across all samples (Figure 5), accounting for 56% (64 particles). This was followed by transparent microplastics at 12% (14 particles), brown at 11% (13 particles), red at 10% (11 particles), blue at 9% (10 particles), and the least common colors were purple and green, both at 1% (1 particle each). The study on the colors of microplastics in clam meat yielded varied results. The differences in color may be influenced by the original color of the plastic or other factors, such as exposure to sunlight during the degradation process (Erlangga *et al*., 2022). The colors found in this study are consistent with the research by Wang *et al*. (2020), which also identified black and white (transparent) as the dominant microplastic colors. According to Bassa et al. (2018), the color and shape of microplastic particles closely resemble the natural food of marine biota, such as phytoplankton and colored algae, leading marine organisms like clams to mistake and consume these microplastic particles (Suprijanto *et al*., 2021).

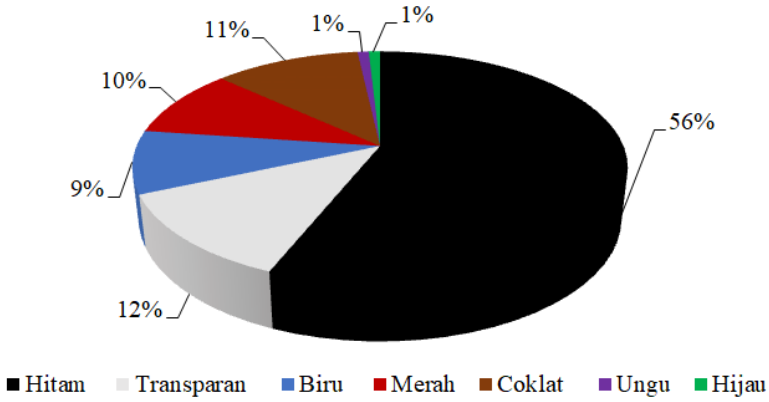

Figure 5. Percentage of Dominant Microplastic Colors

Conclusion

The types of microplastics found in wedge clams (Donax sp.) from the waters of Belawan are fibers and fragments, with fiber microplastics comprising 98% and fragments 2% of the total. The colors of the microplastics identified include black, transparent, blue, red, brown, purple, and green.

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Physical properties of light bricks by mixing the river and red sand

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Abstract. *The increasing demand in the construction industry emphasizes the need for innovative materials like lightweight concrete to address traditional weaknesses such as high density. Lightweight bricks are particularly useful in wall construction due to their reduced weight and larger size, which accelerates building processes. This research aims to enhance the quality of CLC (Cellular Lightweight Concrete) bricks by incorporating the mixing between river and red sand. The study employs experimental methods to evaluate the physical properties of CLC bricks, including density, compressive strength, and water absorption. Results indicate that adding red sand decreases the density but also significantly reduces the compressive strength of CLC bricks. XRD analysis reveals a high intensity of CaCO3, contributing to the brittleness of the bricks. Moreover, the addition of red sand increases water absorption, further compromising compressive strength. Despite the reduced density, the compressive strength does not meet the desired standards. Therefore, this study highlights the importance of*

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optimizing manufacturing processes, such as thorough mixing and blending, to achieve a more uniform material distribution and improve the overall quality of CLC lightweight bricks.

Keywords: Physical Properties, Light Bricks, River Sand, Red Sand, Sand Mixture

Introduction

In Indonesia, rapid population growth has significantly fueled the expansion of the construction sector, where concrete plays an essential role. Conventional concrete, however, is characterized by its high density, which can be problematic [1 – 2]. To mitigate this, the use of lightweight concrete, such as Cellular Lightweight Concrete (CLC) bricks, has become increasingly popular [3 – 6]. These bricks are crafted from a blend of cement, sand, water, and additives like foam or expanding agents, offering a reduced density while still providing adequate strength for building construction [7 – 10].

Recent research and development efforts have focused on improving the quality and performance of CLC bricks, with the selection of appropriate raw materials being a key aspect. Sand, typically sourced from rivers, is a main component in CLC brick production [11 – 13]. However, the increasing difficulty in obtaining river sand has prompted research into alternative sources. This study focuses on the use of red sand from Labuhan Batu Selatan, a region in North Sumatra, Indonesia, as a raw material for CLC bricks. Red sand from Labuhan Batu Selatan has the potential to reduce dependence on river sand. However, the impact of red sand on the physical properties of CLC bricks requires further investigation [14].

Our previous study showed that the mixture of 100% red sand demonstrated better performance in the physical properties of CLC bricks compared to the mixture of 100% river sand [15]. In this study, we aim to further improve the physical properties by mixing river sand and red sand. The objective of this research is to analyze the physical properties of CLC bricks by varying the compositions of river sand and red sand. We will examine the impact of these varying compositions on the compressive strength, water absorption, and density of CLC bricks. The findings are expected to benefit the construction industry and government by enhancing the quality of lightweight bricks and reducing reliance on river sand.

Materials and Methods

The test specimens were made in the form of cubes measuring 15 cm x 15 cm x 15 cm, with a total of 20 pieces consisting of 3 different compositions of the mixture between river sand and red sand. After all the samples were made, density testing was carried out on 3 samples of each variation, and 2 samples were taken for compressive strength testing and 1 sample for water absorption testing. Furthermore, 1 sample from each variation was tested for material characterization using SEM and XRD tests, as well as its resistance to high temperatures through furnace testing. The lightweight concrete mixtures of CLC are composed of various materials, including cement, river sand, red sand, foam agent, stabilizer, hardener, and water. The age of the lightweight bricks tested was 14 days.

The materials used in this study are PCC cement, red sand, river sand, water, foam agent, and other chemicals (stabilizer and hardener). The equipment used includes analytical scales, measuring cups, cement spoons, sieves, cube concrete molds (15x15x15 cm), mortar, compression testing machines, buckets, and rulers. The composition of the CLC concrete mixtures for each variation can be seen in Table 1.

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Table 1. Composition for making CLC lightweight bricks using red sand

Material	Composition for 4 test objects	Quantity per test object			
		25%	50%	75%	Unit
Cement	3,5	3,5	3,5	3,5	Kg
River Sand	3,5	2,625	1,75	0,625	Kg
Red Sand		0,875	1,75	2,625	Kg
Water	4,5	4,5	4,5	4,5	Litre
FoamAgent	0,05	0,05	0,05	0,05	Litre
Stabilizer	0,04	0,04	0,04	0,04	Litre
Hardener	0,03	0,03	0,03	0,03	Litre

The sample preparation began by providing a mixture of materials as listed in Table 1. Initially, the red sand was dried under sunlight to remove excess water and then sieved to eliminate impurities. Next, all tools and materials were cleaned and checked to ensure their quality, which is essential for obtaining optimal results in making CLC lightweight bricks.

After preparing the mixture, the surface was leveled with a scraper and left for 2-3 days in a room with access to sunlight. Once the bricks had hardened for 2-3 days, they were given a designated code number and then removed from the molds. The lightweight bricks were cured for 14 days.

Before conducting the compressive strength test, the density of the CLC lightweight brick test specimen was measured by calculating the ratio of mass to volume. The test specimen was placed horizontally on the testing machine, and the load at the end of the process was recorded. This load was then divided by the cross-sectional area of the concrete sample to obtain the compressive strength value.

For the water absorption test, the test specimen was soaked in a tank for 24 hours, and the wet mass was calculated. The dry mass (before soaking) was also measured to determine the water absorption capacity. Additionally, one sample, sized 7.5x7.5x7.5 cm from the best composition was taken for XRD and SEM analysis.

Results and Discussion

Density

The results of measuring the density of CLC lightweight bricks with the addition of various amounts of red sand, processed and aged for 14 days since casting, can be seen in the accompanying table and figure. The average density is presented in Figure 1. According to SNI 03-3449-2002, the density of lightweight concrete should be less than 1800 kg/m³. Therefore, the density of the samples still meets the requirements.

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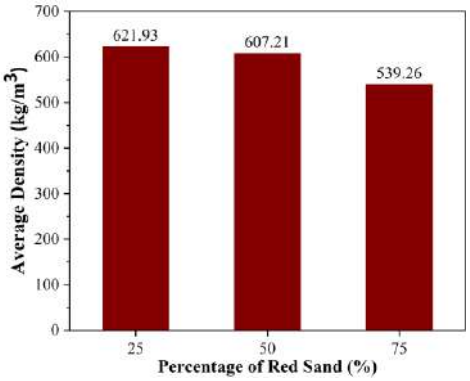

Figure 1. Average Density and Variation of Red Sand Composition

From figure 1, It is observed that the density value of CLC lightweight bricks decreases with the addition of increasing amounts of red sand. However, at a 75% variation, the density value of CLC lightweight bricks is the lowest compared to other samples. These results indicate that increasing the red sand composition is very effective in reducing the density value; thus, the more red sand used, the lower the density of CLC lightweight bricks.

Compressive Strength

The compressive strength of concrete is the amount of load per unit area that causes the test object to break when subjected to a load with a certain resistance to the pressure given by the compression test machine. Compressive strength is the most fundamental property in determining the quality of concrete compared to other properties. The value of compressive strength is influenced by the composition of the constituent materials. In this study, red sand was used and mixed with river sand. The results of testing the compressive strength of lightweight bricks with variations of red sand composition can be seen in Figure 2.

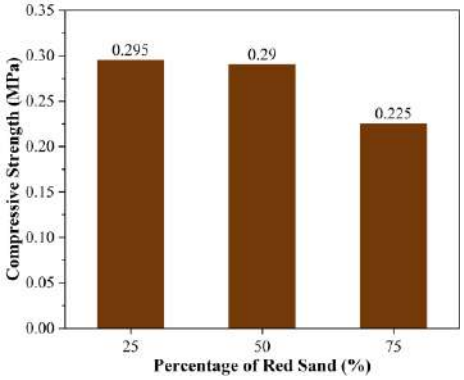

Figure 2. Average compressive strength of CLC lightweight bricks and variations

Based on the Figure 2, the composition of 25% red sand has the highest compressive strength with a value of 0.295 MPa. The compressive strength value of CLC lightweight bricks has a significant effect on its density value. The higher the density value, the higher the resulting compressive strength. In other words, if the brick is lighter, the lower its compressive strength and vice versa.

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According the research conducted, besides variations in red sand composition, the size of red sand particles can also increase the compressive strength of concrete [14]. The decreasing compressive strength value of concrete is influenced by the gradation of sand particles. Homogenous sand particle size can lead to empty spaces, which can be filled by smaller particles. Therefore, smaller particle sizes of sand can cover more empty space in the concrete, making the concrete composition denser and increasing its strength.

Meanwhile, research showed that using a red sand composition of 3% can produce the most optimal compressive strength value compared to red sand compositions of 5% and 7% [16]. Therefore, further studies are needed to examine the use of red sand in increasing the compressive strength of lightweight bricks in terms of variations in composition and particle size. Additionally, the addition of 20% foam agent can affect the compressive strength results along with different density variations [17]. However, their research was unable to reach the planned compressive strength of 25 MPa. The highest compressive strength result was obtained by adding a 20% foam agent with a density of 40 kg/m³, achieving 16.12 MPa with a density of 1803 kg/m³. Adding a 20% foam agent with varying densities can reduce the compressive strength and density of the resulting concrete.

The data obtained in this study does not match the planned compressive strength of 1 MPa. The results show the optimal compressive strength of CLC lightweight bricks at the age of 14 days to be 0.295 MPa. This discrepancy is likely due to the presence of many air bubbles in the lightweight brick sample. Therefore, it is necessary to consider the aforementioned factors to increase the compressive strength value of CLC lightweight bricks.

Water Absorption

Lightweight with a composition of 50% river sand has the highest absorption rate of 22.1%. According to research conducted, the more pores in the concrete, the higher its absorption capacity, which in turn reduces its durability [14]. The presence of voids or pores in the concrete is caused by the composition of its constituent materials and the inadequate quality of the materials used. Additionally, the additives used in the production of lightweight bricks or concrete play an important role in the manufacturing process as they can alter the properties of the concrete to meet specific needs.

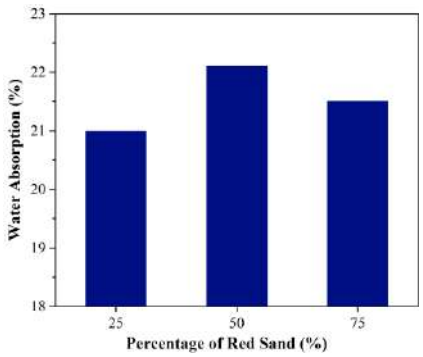

Figure 3. Average water absorption of CLC lightweight bricks and variations in red sand composition.

In this study, the additives used in the production of CLC lightweight bricks are foam agents and stabilizers. The purpose of using these materials is to reduce the density of the bricks, but it also increases their absorption capacity as the foam creates more pores in the lightweight bricks. In Figure 3, it can be observed that as the composition of red sand increases, the absorption rate

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also increases. This is because red sand is less effective in filling the pores formed during the casting process compared to river sand. The higher absorption rate resulting from the increased use of red sand corresponds to the compressive strength obtained.

SEM (Scanning Electronic Microscope)

In Figure 4, it can be observed that there are air bubbles detected. The presence of air bubbles in CLC lightweight bricks affects their density and compressive strength. The smaller the pores formed by the air bubbles, the higher the quality of the lightweight bricks in terms of compressive strength. However, as the pore size decreases, the density increases because the pores are filled with the constituent materials of the CLC lightweight bricks. Conversely, as the pore size of the air bubbles increases, the density decreases as the pores are filled with air.

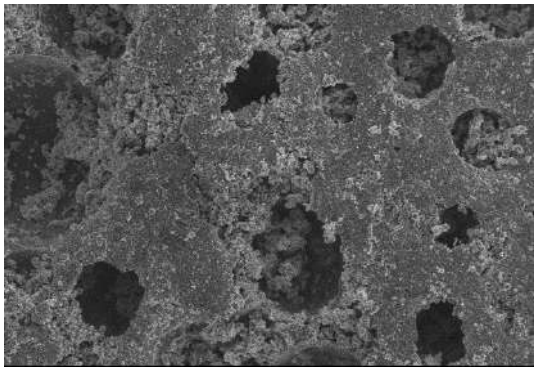

Figure 4. SEM analysis

XRD (X-Ray Diffraction)

In XRD testing, to identify phases in the sample, the obtained diffraction data from the sample with 50% red sand can be analyzed using Match-3 software. The diffraction patterns for each composition can be seen in Figure 5. The diffraction patterns in Figure 5 indicate the formation of $CaCO_3$, SiO_2, and $Ca(OH)_2$ phases. The diffraction peaks are dominated by the CaCO3 phase.

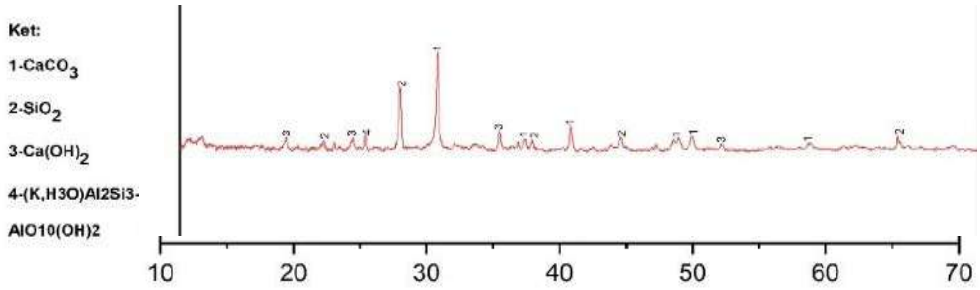

Figure 5. XRD testing.

Based on Figure 5, it can be seen that $CaCO_3$ has the greatest intensity compared to other elements contained in the concrete. The dominant presence of $CaCO_3$ in this composition makes the lightweight bricks more brittle.

Furnace

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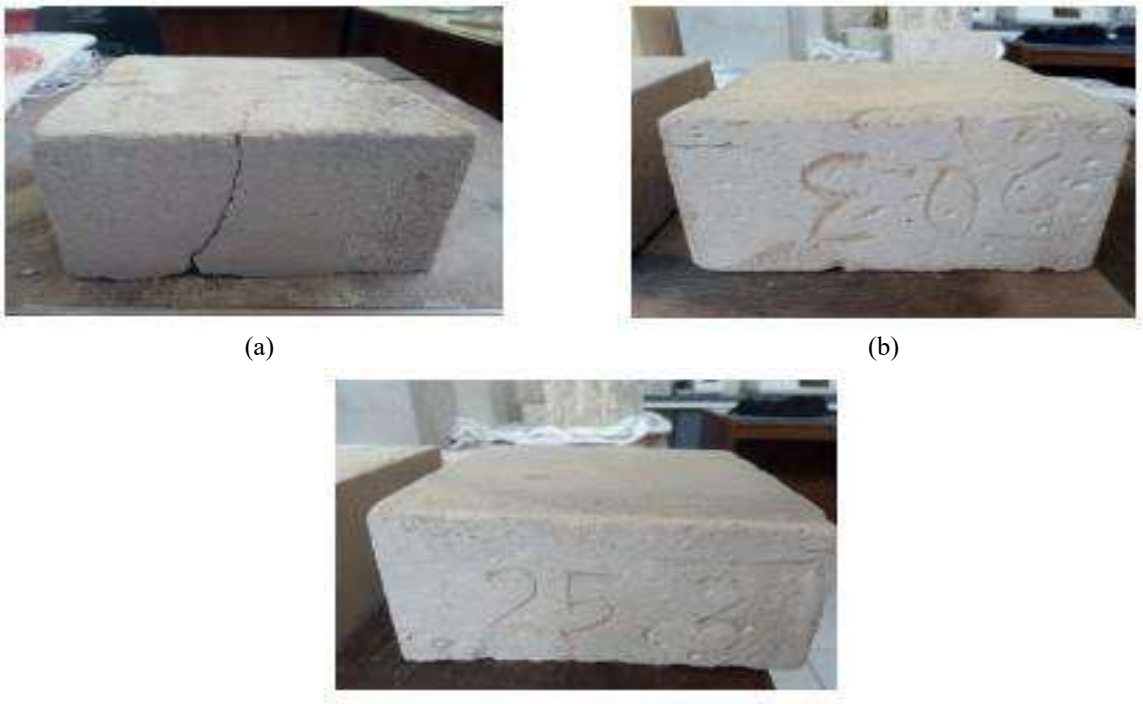
Figure 6 shows the results of testing the resistance to high temperatures up to 750°C. Images (b) and (c) still exhibit fine cracks, while image (a) shows significant cracks and even destruction. At previous temperatures, the CLC lightweight bricks experienced only fine cracks. It can be concluded that the optimal temperature for these CLC lightweight bricks is below 750°C, ideally up to 500°C.



(a) (b)

(c)

Figure 3. Furnace Results on CLC Lightweight Brick Samples with Red Sand Composition (a) 75%; (b) 50%; (c) 25% at a temperature of 750°C.

The results of this research are still not optimal because the crack patterns resulting from the influence of high temperatures cannot be clearly observed. This limitation is due to the use of a regular camera, which does not provide a clear view of the crack formation at each temperature change. Further studies with more advanced imaging techniques are necessary to accurately assess the impact of high temperatures on CLC lightweight bricks.

Conclusion

Our study highlights the potential and limitations of using red sand in the production of CLC lightweight bricks. While the use of red sand effectively reduces the weight of the bricks, it adversely affects their compressive strength and water absorption capacity. To improve the quality of CLC bricks with red sand, future research should focus on optimizing the manufacturing process, such as ensuring thorough mixing and blending, and possibly combining red sand with other materials to enhance strength and durability. This research contributes to the development of sustainable construction materials by exploring alternative sand sources and offers valuable insights for the construction industry in regions facing shortages of traditional river sand.

Acknowledgments

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The authors declare that there is no conflict of interest to disclose, and this study has been conducted with the ethical approval of all relevant bodies.

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Analysis of long short-term memory (LSTM) and geometric Brownian motion (GBM) models in stock price prediction

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Abstract. *In this research, stock closing price prediction is carried out using the Long Short-Term Memory (LSTM) and Geometric Brownian Motion (GBM) physics economy approaches to determine which method performs better in predicting stock prices. The data includes BBCA and BBRI closing stock prices from January 1, 2013, to December 31, 2023. The data is divided into training data (80%) and test data (20%). The LSTM hyperparameters varied include the number of epochs (25, 50, 100, 200, 400, 600) and batch sizes (8, 16, 32, 64, 128, 256), while the GBM hyperparameters include iterations (1, 10, 100, 1,000, 10,000). Model performance evaluation was conducted using the RMSE, MAE, MAPE, and coefficient of determination (R^2) metrics. Based on the performance evaluation, the results show that the LSTM model with 50 epochs provides more accurate stock price predictions compared to the GBM model, indicated by an R^2 value of 97.40%, which shows that LSTM is more effective in predicting BBCA and BBRI stock prices.*

Keywords: Stock Price, Deep Learning, Econophysics, LSTM, GBM

Introduction

The stock market in Indonesia has experienced significant growth in recent years, driven by factors such as increased investor interest, technological advancements, and increased volatility. Technological advancements have also contributed to the development of stocks, with higher price volatility and a more accessible market for investors [1,2]. Stock prices are becoming increasingly important in understanding how capital markets work. Despite attractive returns, investing in stocks carries a high risk due to the uncertainty and fluctuations in the stock market.

Investors can predict stock prices using two approaches: technical analysis and fundamental analysis. Technical analysis is used by investors to predict future stock price movements through charts and analyzing patterns[3], while fundamental analysis predicts future stock prices by studying the underlying company through published financial reports [4].

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One approach to predicting stock prices is to use the econophysics approach, which uses physical science methods to solve problems in economics and finance [5]. In the context of econophysics, many physics concepts such as thermodynamics, statistical physics, and physical mechanics are used to explain market behaviour [6–10]. For example, the first and second laws of thermodynamics can be used to measure economic growth by expressing energy in physics analogously to money or economic resources [11–14].

The use of physics approaches in capital market studies is to analyse stock market movements using the principles of statistical physics and computational physics. Deep learning, part of machine learning or machine intelligence, is used to solve numerical physics problems [15–17]. Research conducted by Hamzah et al., 2023 concluded that the Gated Recurrent Unit (GRU) provides accurate stock price trend prediction results with a loss function value using Mean Squared Error (MSE) of 0.0002 and Root Mean Squared Error (RMSE) of 0.0123 on test data [18].

Although several studies show that GRU provides good results in predicting stock prices, the existing studies still focus on algorithm optimisation only without considering variations in hyperparameter selection. One model that depends on the hyperparameters used is the Long Short-Term Memory (LSTM) model which has proven accurate in predicting stock prices [19–22]. In addition to using the LSTM and GRU models from deep learning methods, other models can be used to predict stock prices, namely Geometric Brownian Motion (GBM). GBM is a continuous time stochastic model where the random variables follow Brownian Motion and have proven accurate in predicting stock prices [23–25].

The research focuses on hyperparameter variations involving epoch and batch size to improve the performance of the LSTM model and iteration variations in the GBM model in predicting stock prices of PT BBRI (Bank Rakyat Indonesia) and PT BBCA (Bank Central Asia). This will ensure a more reliable model with high accuracy in predicting stock prices and gain a deeper understanding of how hyperparameters and iterations affect prediction accuracy in the context of stock price prediction.

Methodology

The research method used in this research is quantitative research with a secondary research approach. This research is defined as a systematic investigation of phenomena with data collected using statistical, mathematical, or computational techniques. secondary research involves collecting real-time and historical data from available sources and analysing it with publicly available data. This research was conducted by collecting BBCA and BBRI closing stock price data obtained through the finance.yahoo.com website, which provides real-time and historical data.

The research process involves several steps, including data pre-processing, data normalisation, data splitting, and LSTM and GBM models. Data cleaning involves cleaning the data by removing irrelevant information or insufficiently long data, such as blank data or stock market holiday dates. The data is normalised by using MinMax Scaller to achieve a homogeneous range between 0 and 1, with a minimum value of 0 and a maximum value of 1.

The normalised data is divided into train and test data. Train data is used to train the algorithm, while test data is used to evaluate the performance of the algorithm in generating new data. Filter data is used as a close filter to make it easier to split data and predict price changes. For this research, 80% of the data is used for training data and 20% for test data. The amount of train data is larger with the aim that the learning machine is better trained to learn the model. So that when the machine produces a model, it will provide predictions from more optimal test data.

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In the LSTM model, the hyperparameters will be varied, using epoch and batch size variations as shown in Table 1. In the GBM model, the hyperparameters used are iterations as in Table 1. The model also estimates parameter values, such as drift (μ) and volatility (σ), which are used as price prediction parameters.

Table 1. Variation of model hyperparameters

Model	Hyperparameters	Value
LSTM	Epoch	25, 50, 100, 200, 400, 600
	Batch Size	8, 16, 32, 64, 128, 256
GBM	Iterations	1, 10, 100, 1000, 10000

Result and discussion

Long short-term memory

This research explores the effect of epoch variation on the performance of stock price prediction models, with the aim of optimising prediction accuracy and minimising error. Six epoch variations were tested, namely 25, 50, 100, 200, 400, and 600. The evaluation metrics used are RMSE, MAE, MAPE, and R^2. The results obtained are listed in Table 2.

Table 2. Stock price prediction results with epoch variation

Stock Index	Epoch	RMSE	MAE	MAPE	R2
BBCA	25	249.36	213.33	2.53 %	85.91 %
	50	107.09	79.47	0.96 %	97.40 %
	100	112.22	84.88	1.02 %	97.15 %
	200	188.38	151.66	1.76 %	92.13 %
	400	317.79	269.11	3.10 %	77.12 %
	600	483.47	431.29	5.00 %	47.05 %
BBRI	25	189.63	168.59	3.45%	84.22 %
	50	93.32	72.19	1.50 %	96.18 %
	100	150.01	124.85	2.53 %	90.13 %
	200	121.91	94.53	1.89 %	93.48 %
	400	140.37	111.04	2.21 %	91.35 %
	600	208.34	162.18	3.20 %	80.95 %

The results show that the optimal performance for BBCA stock price prediction is at epoch 50 with the lowest RMSE value of 107.09, the lowest MAE of 79.47, the lowest MAPE of 0.96%, and the highest R^2 of 97.40%. Meanwhile, BBRI stock price prediction shows the best performance at epoch 50 with the lowest RMSE value of 93.32, the lowest MAE of 72.19, the lowest MAPE of 1.50%, and the highest R^2 of 96.18% as shown in Figure 1 (a) and Figure 1 (b).

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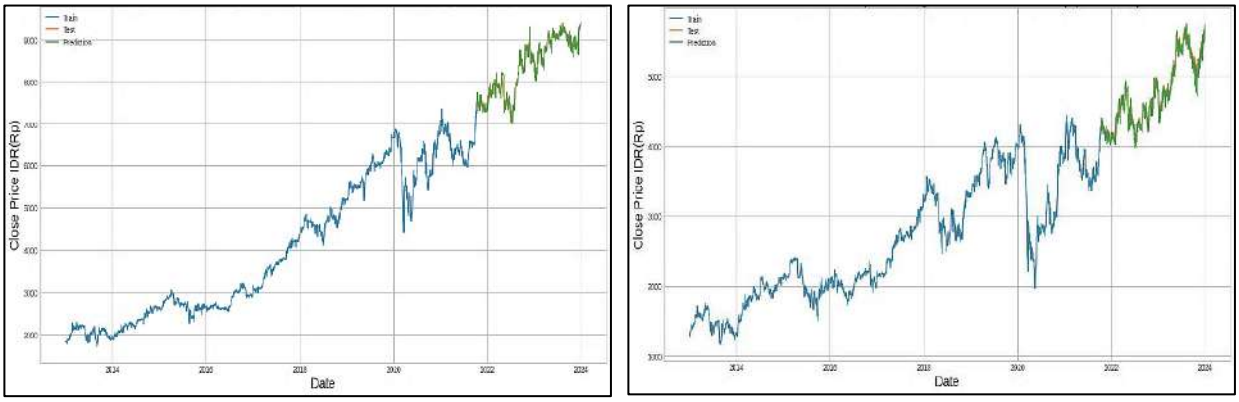

(a) (b)

Figure 1. Stock price prediction chart (a) BBCA with epoch 50, (b) BBRI with epoch 50

In addition, batch size variations in the stock price prediction model were conducted to explore the effect of batch size on model performance. In this study, six batch size variations were tested, namely 8, 16, 32, 64, 128, and 256. The results obtained are presented in Table 3.

Table 3. Stock price prediction results with batch size variation

Indeks Saham	Epoch	RMSE	MAE	MAPE	R2
BBCA	25	249.36	213.33	2.53 %	85.91 %
	50	107.09	79.47	0.96 %	97.40 %
	100	112.22	84.88	1.02 %	97.15 %
	200	188.38	151.66	1.76 %	92.13 %
	400	317.79	269.11	3.10 %	77.12 %
	600	483.47	431.29	5.00 %	47.05 %
BBRI	25	189.63	168.59	3.45%	84.22 %
	50	93.32	72.19	1.50 %	96.18 %
	100	150.01	124.85	2.53 %	90.13 %
	200	121.91	94.53	1.89 %	93.48 %
	400	140.37	111.04	2.21 %	91.35 %
	600	208.34	162.18	3.20 %	80.95 %

Based on Table 3, the results of predicting stock prices with batch size variations can be concluded for BBCA, with the lowest RMSE value of 297.11, the lowest MAE of 248.18, the lowest MAPE of 2.93%, and the highest R^2 of 80.00%. For the BBRI index, the results also show significant variations in each batch size. At batch size 32, it shows a better model than other batch sizes, with the lowest RMSE value of 158.42, the lowest MAE of 125.47, the lowest MAPE of 2.63%, and the highest R^2 of 88.99%. The stock price prediction trends for BBRI and BBCA can be seen in Figures 2 (a) and (b).

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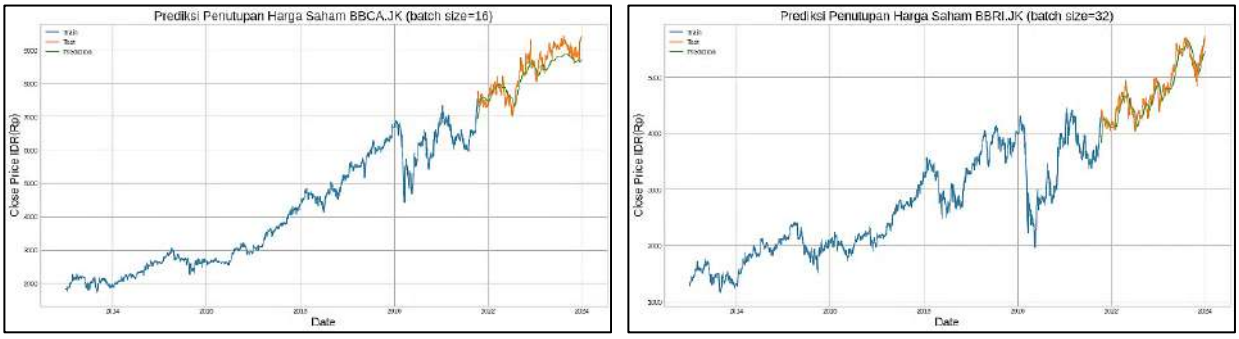

(a) (b)

Figure 2. Stock price prediction chart; (a) BBCA with batch size 16, (b) BBRI with batch size 32

Geometric Brownian Motion

In this study, five iteration variations were carried out with epoch values of 1, 10, 100, 1,000, and 10,000, respectively. Based on the research results, the data obtained are shown in Table 4.

Table 4. Stock price prediction with iteration variation

Indeks Saham	Iterasi	RMSE	MAE	MAPE	R2
BBCA	1	1311	1155	14.1%	-289%
	10	103	856	10.1%	-144%
	100	1046	902	10.7%	-148%
	1.000	895	690	8.5%	-81%
	10.000	962	784	9.5%	-109%
BBRI	1	549	441	9.6%	-32%
	10	512	429	9.2%	-15%
	100	784	623	13.6%	-170%
	1.000	681	523	11.3%	-103%
	10.000	987	761	16.4%	-327%

Based on Table 4, the BBCA stock price prediction results with GBM iteration variations, it can be concluded that the BBCA stock price prediction shows variations in model performance at five different epoch values. The highest RMSE value is recorded at iteration 1 with a value of 1311.21, while the lowest value is at iteration 1,000 with a value of 895.06. The MAE value follows the same trend, with iteration 1 having the highest value of 1155.98 and iteration 1,000 having the lowest value of 690.98. MAPE also shows that iteration 1,000 produces the best prediction with a value of 8.59%, while iteration 1 produces the highest value of 14.19%. In predicting the closing price of BBRI shares, it can be concluded that iteration with a value of 10 provides the best prediction results compared to other iterations. At iteration 10, the RMSE value is 512.90, MAE is 429.52, and MAPE is 9.20%, which are the smallest error values compared to other iterations. The trend of GBM model stock price prediction can be seen in Figure 3 (a) and (b).

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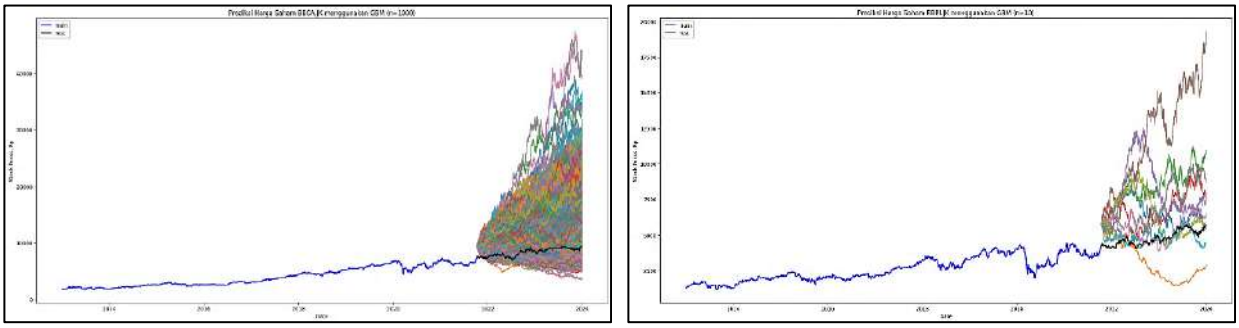

(a) (b)

Figure 3. Stock price prediction chart; (a) BBCA with iteration value 1,000, (b) BBRI with iteration value 10

Comparison of LSTM and GBM results with varying hyperparameters

In this study, the epoch variation for the LSTM algorithm, we can see that the epoch value that gives the most optimal accuracy results is the epoch with a value of 50. Meanwhile, the epoch variation accuracy graph is visualised in Figure 4.

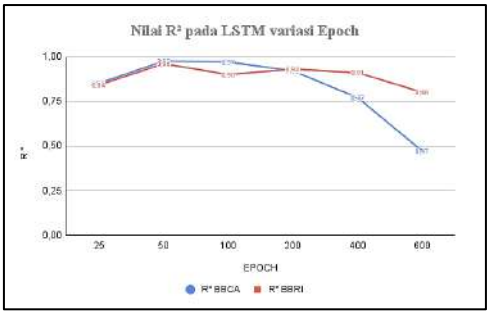

Figure 4. R^2 value of LSTM with Epoch variation

It can be seen that the R2 value for BBCA (blue line) tends to decrease as the number of epochs increases, while the R2 value for BBRI (red line) tends to increase until it reaches its peak at epoch 100, then decreases at higher epochs.

In this study, the batch size variation for the LSTM algorithm we can see that the batch size value that provides the most optimal accuracy results is the batch size with low values such as 16 and 32. Meanwhile, the accuracy graph of batch size variation is visualised in Figure 5.

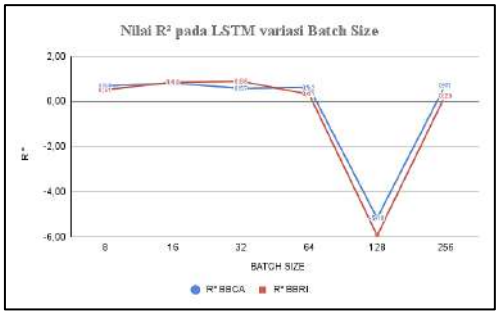

Figure 5. R^2 value in LSTM with Batch size variation

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At small batch sizes such as 8 to 32, the R^2 values for BBCA and BBRI were quite high, but then decreased dramatically to negative at a larger batch size of 128. The R^2 value then increased again at batch size 256.

In this study of iteration variations for the GBM algorithm, we can see that the iteration value that provides the most optimal accuracy results is iteration with a value of 10. Meanwhile, the accuracy graph of iteration variations is visualised in Figure 6.

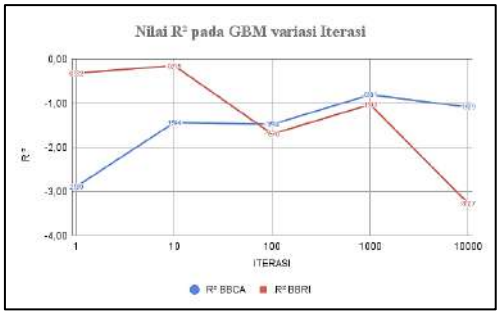

Figure 6. R^2 value on GBM with Iteration variation

Based on the graph, it can be seen that the R2 value for BBCA (blue line) tends to perform better at a higher number of iterations (1,000), BBCA's stock price tends to increase as the number of iterations increases, although the increase is not significant. Meanwhile, the R2 value for BBRI (red line) shows a different pattern. The R^2 value tends to decrease at a higher number of iterations (10,000) after previously increasing at a lower number of iterations (10).

Based on the research results that have been obtained, the prediction of the LSTM and GBM models is carried out, the results of BBCA and BBRI stock price predictions for the next 3 days, namely 02 January 2024 - 04 January 2024. The results obtained are as follows:

Table 5. Stock price prediction results for 3 days later

Date	LSTM		GBM	
	BBCA	BBRI	BBCA	BBRI
02 Jan 2024	9403,154	5607,7026	14071	7944
03 Jan 2024	9403,113	5607,6904	14085	7880
04 Jan 2024	9403,071	5607,6787	14091	7877

The visualisation of the stock price prediction for 02 January 2024 - 04 January 2024 can be seen in the graph below:

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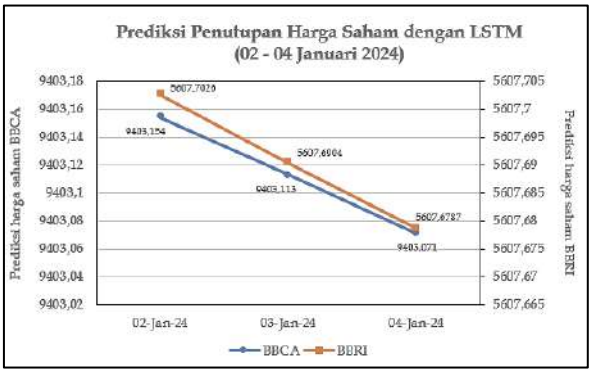

Figure 7. Prediction results of BBCA and BBRI closing stock prices using LSTM

Figure 8. Prediction results of BBCA and BBRI closing stock prices using GBM

In the results of predicting the stock price of the LSTM model epoch variation for BBCA and BBRI stock prices, the greater the epoch used, the RMSE, MAE and MAPE values tend to increase, while the R2 value tends to decrease. This shows that the larger the epoch used, the lower the prediction accuracy. Where the prediction results above are in line with previous research conducted by Aji Riyantoko et al. [26], where the results in the study are said to almost entirely have an accuracy above 90% and the prediction of the closing price of BBRI shares with epoch 50 has an RMSE value of 75.71 which is almost the same as this study.

The results of predicting the stock price of the LSTM model batch size variation on both indices, the model performance decreases after reaching the optimal batch size, indicating overfitting at larger batch sizes. As at batch size 128, there is significant instability with a negative R2 value, indicating that the model does not fit the data. This indicates significant overfitting in the prediction model. In line with previous research conducted by Arfan and ETP, 2019 [27], in which the study conducted parameter analysis with the number of batch sizes and the results found that the greater the batch size value used, the worse the prediction performance will be.

In GBM model iteration variation stock price prediction, there is no clear pattern between the number of iterations and model performance in predicting the stock prices of both indices. Based on the results obtained, the performance of the GBM model in predicting stock prices is still unsatisfactory, as seen from the negative R2 value in all iterations. In line with previous research conducted [28], where in this study predictions were made on several companies and found negative R2 results, namely the lowest -91.5% and also negative MAPE, namely the lowest 107.5%.

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Conclusions and Suggestions

The LSTM model outperforms the GBM model in predicting BBCA and BBRI stock prices. The highest R2 value is obtained at epoch 50 of 97.40%, while the lowest R2 value is obtained at epoch 128. The LSTM model also has a significant influence on prediction accuracy, where the epoch hyperparameter value affects the results. An epoch value of 50 consistently produces the lowest error value and the highest R2 value for both stocks. The GBM model did not consistently improve prediction accuracy, but different optimal iteration values were found for each stock. For BBRI stock, 10 iterations gave the best results with the lowest error value and highest R2, while for BBCA stock, 1,000 iterations gave the most accurate prediction results. However, the GBM model tends to be negative, which indicates the inability of this model to accurately capture data variations and accurately predict stock prices.

Future research is expected to expand the scope of stocks learned and optimise hyperparameters such as learning rate, dense layer, and hidden layer. Using statistical physics, quantum computing approaches such as the QNN physics method and Newton's cooling law, as well as the laws of thermodynamics in stock market analysis may provide new insights.

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Identify physics concepts at the muara bagan percut tourist place deli serdang district

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Abstract. *The Percut Sei Tuan area is a regional area estuary. The area own object tour estuary chart percut. Research this aiming for identify concepts physics found in the estuary chart cut as means education. In tourism estuary the identified concepts physics among others: Waves. Ebb and flow of water, dynamics Fluids, Archimedes' Law and Principles Buoyancy, Diffusion and Concentration, Erosion and Sedimentation, Thermodynamics, Velocity Wind, Speed Water waves. Research This is study qualitative with type phenomenology. In research this, Triangulation data collection techniques and researchers direct down to field for take data. Instrument research used is sheet interviews, observations and cameras. The results of identification concepts physics This expected can continued by researchers in making learning media.*

Keywords: *concept physics, tourism estuary*

Introduction

Physics is the science that studies causes and reasons behind the occurrence various phenomenon nature. As one of the branch science, physics play a role important in development knowledge and technology [1]. In order to be able to understand physics with good, learning process need done in a way contextual and natural, because student often lacking realize concepts physics in life daily. If learning physics considered difficult and abstract, understanding student to material physics becomes not enough maximum [2] . Deli Serdang Regency is one of the Regency in North Sumatra Province, Indonesia. In the Regency This there is one Subdistrict that is Percut Sei Tuan, where Subdistrict This is the Percut Sei Tuan There is there is estuary that becomes place tourism and eyes livelihood public local. Many activities the community that occurred in Muara Bagan Percut this is what it becomes base in draft physics. As for the activities society that often found in the area the Muara area, namely fisherman catch fish with use boat trawlers and

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also boats as tool transportation tour for those who want surround estuary until to Beach border.

Along with the development of the times and the activities carried out by society, many things that happen make condition physique area the estuary also experienced changes. Which becomes the cause is from activity from boat Fishermen, Construction of restaurants floating around estuary and discharge waste carried out by the local community. And activities This impact on the estuary chart Percut This Alone.

For condition phenomenon nature that occurs in the estuary it is very close the relationship with concepts physics. Estuary bagan cut is asset the area which is wisdom local in the District Percut Sei Tuan. In tourism estuary the identified concepts physics among others: Waves. Ebb and flow of water, dynamics Fluids, Archimedes' Law and Principles Buoyancy, Diffusion and Concentration, Erosion and Sedimentation, Thermodynamics, Velocity Wind, Speed Water waves. Research This done aiming identify concepts physics in place tour estuary chart Cut This as means education.

Methodology

Study This is study qualitative type phenomenology. Research This started with observations made researcher with pay attention and examine the situation area around estuary [3]. Then focus on the situation phenomenon nature that occurs in the estuary area conducted by researchers myself. Then researcher interview resident arouthe estuary area for get information activities carried out by the local community related to with concepts physics and documentation Community activities and phenomena nature. For data instruments collected by researchers Alone. Data sources used is primary data sources and techniques data analysis is analysis descriptive qualitative.

Results and Discussion

Study This identify concepts physics on the spot tour estuary chart Percut that exists in society Percut Sei Tuan. Identified concepts physics at the estuary the that is Waves. Tides, Dynamics Fluids, Archimedes' Law and Principles Buoyancy, Diffusion and Concentration, Erosion and Sedimentation, Thermodynamics, Velocity Wind, Speed Water waves.

Wave own more influence large at a very small estuary that flows directly open to sea. In contrast, the mouth of the river is more big in the calm sea more dominated by river discharge. Waves approaching the beach can produce current parallel to the coast that influences dynamic processes along the coastline. Coastal patterns around River estuaries are mainly determined by the angle and energy waves that reach the coastline. According to Dyer (1986). Modification Beach shape around estuary is function from dynamics wave this is what influences related beach morphology with Coastline profile. Activities wave along the coast forming pattern Parallel to the coast, it is influenced by waves that break and form contour of the coastline. When the waves interact with waters shallow along the coast, waves show characteristics like refraction, diffraction, shoaling and reflection. The properties This influence profile Beach shape, forming it along time. Therefore that, Efforts to reduce impact wave often involves adjustment Beach form of use control energy wave.

The wind blowing above the water surface will transfer energy to the water which causes the previous water surface calm disturbed and formed ripple or wave small. The more fast wind blowing, ripples the become more big. If the wind Keep going blowing, finally more waves big will also formed. The longer and the more strong wind said, increasingly big waves that are formed. In the open sea, the energy produced by the wind Already fully absorbed by the water

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surface to form waves. At speed wind certain, waves No can grow more big, so gust wind in progress longer than time required For to awaken waves. In conditions this, the waves that are formed become perfect. Condition perfect This means that at speed wind certain, waves are produced reach form maximum.

Table 1. Identification Results Physics Concepts In Place Muara Bagan Percut Tourism

No	Phenomenon	Physics Concept
1.	Ebb and flow of water **Figure 1.** Deep estuary tide conditions	ups and down is phenomenon periodic ups and downs sea level caused by the combination style gravity and force pull things astronomy, especially earth, moon and sun. Influence from object another sky is ignored Because the distance more far and size more small. Another factor of astronomy that influences tides especially in semi- enclosed water areas like bay is the shape of the coastline and topography base waters [6].
2.	Dynamics Fluid **Figure 2**. Current flow estuary	Dynamics fluid contained in the water flow in the estuary is flow turbulence. Where the flow This happen Because meeting fresh water current River with sea water so that produce current that is not regular. Turbulence This influenced by differences speed, direction current, and density between fresh water and sea water which causes the occurrence mixing as well as dynamic water movements in the estuary area.
3.	Archimedes' law and force floating **Figure 3**. Fishermen be on top a boat floating on the water	Archimedes' law states that a dipped object into the fluid (liquid) or gas) will experience style lift to on as big as heavy the fluid being displaced object the principle. This also applies to conditions in estuaries which are meeting areas. between fresh water from rivers and sea water. At the estuary this, happened mixing between fresh water and salt water which have density (mass type). Because sea water more congested than fresh water, objects that float or sink at the estuary will experience variation style lift depends on the point his meeting. In the section a deeper estuary lots of salt water, things will more easy float Because style pick it up more big, in line with Archimedes' law.
4.	Speed Wind	Speed wind is speed moving air horizontally influenced by the gradient barometric location place, height place and condition topography a place. For unit speed wind in meters per second, kilometers per hour or knots.

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Figure 4. Wind blowing at the estuary

5. Diffusion and Concentration

Diffusion and concentration is movement clean molecule from the area with concentration tall to the area with concentration low.

Figure 5. Water movement in the estuary

6. Erosion and Sedimentation

Erosion process This happen Because erosion part land or land so that transported and become sediment. And sedimentation this is what is called sedimentation and grains land carried by water and wind so that cause turbidity to water flow in the estuary the

Figure 6. Occurrence sedimentation

Conclusion

From the research that has been done carried out in the community in the area tour estuary chart Cut so identified concepts physics that is Waves. Tides, Dynamics Fluids, Archimedes' Law and Principles Buoyancy, Diffusion and Concentration, Erosion and Sedimentation, Thermodynamics, Velocity Wind, Speed Water waves.

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Implementation of ethnoscience-based problem based learning model to improve problem solving skills on sound wave material

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Abstract. *This study aims to implement an ethnoscience-based Problem Based Learning (PBL) model as an effort to improve students' problem-solving skills on sound waves. The integration of local wisdom and cultural elements in science learning is expected to enrich concept understanding and motivate students to be more involved in the learning process. This study used a quasi-experiment method with a pretest-posttest control group design, involving XI grade students from a randomly selected high school in Indonesia. The results showed that the application of ethnoscience-based PBL significantly improved students' problem-solving skills. In the experimental class, the average pretest score increased from 39.87 to 83.6 in the posttest, while in the control class, the average score increased from 36.27 to 75.47. Observations during the learning process showed that 7 students were classified as very active, 18 students were active, and 5 students were quite active. Questionnaires filled out by students also indicated an increase in motivation and interest in learning the material taught. The ethnoscience-based PBL model proved effective not only in improving problem-solving skills, but also in creating a learning experience that is more meaningful and relevant to students' cultural context. This model is recommended as an alternative innovative learning method in various educational contexts.*

Keywords: *Problem Based Learning (PBL), Ethnoscience, Problem Solving Skills*

Introduction

Sound waves are one of the important topics in physics learning that includes fundamental concepts such as frequency, amplitude and wavelength. However, based on existing data, students' problem-solving skills in this material are still low. Research by Widaningrum et al. (2020) and Yana et al. (2019) showed that more than 46.88% of students were in the low category in terms of problem solving related to sound waves. This is in line with the findings of Suyono et al. (2022), who stated that students' difficulties in solving physics problems on the topic of sound waves were

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largely due to their inability to translate physics concepts into the right mathematical form. In addition, Hidayat (2021) added that less interactive teaching methods are also an important factor affecting students' understanding of sound wave concepts. This study showed that students' level of understanding of sound waves only reached 38%, much lower than other wave materials, which indicates that students have difficulty applying physics concepts in everyday life and tend to only memorize formulas without understanding how to use them in solving more complex problems.

An interview with Mrs. Yanti Puspita Hakim, S.Pd., a physics teacher at SMA Negeri 1 Kisaran, revealed that students' low problem-solving skills in physics, especially sound waves, are strongly influenced by the lack of active participation in learning. Many students are unable to achieve the Minimum Completion Criteria (KKM) set by the school, and this is related to a lack of in-depth understanding of physics concepts. Research shows that when learning emphasizes memorizing formulas rather than understanding concepts, students have difficulty in applying that knowledge to solve more complex problems (Sari et al., 2022). In addition, students tend not to see the relevance of physics material to everyday life, which makes it more difficult for them to understand and solve physics problems, including the topic of sound waves (Setiawan et al., 2023; Hadi et al., 2021). Therefore, learning that emphasizes more on students' active involvement and in-depth understanding of concepts is needed to improve problem-solving skills in physics materials.

To prepare students for the global challenges of the 21st century, learning needs to integrate important skills such as critical thinking, creativity, and problem-solving skills. These skills are needed to overcome the growing complexity and dynamics of life. Therefore, the Problem-Based Learning (PBL) learning model combined with ethnoscience can be an effective solution. PBL encourages students to actively engage in problem solving that is realistic and relevant to their lives, while ethnoscience provides a cultural context that makes learning more meaningful and interesting (Hussain et al., 2022; Setiawan et al., 2023). This model not only helps students develop problem-solving skills, but also enhances creative and critical thinking skills that are crucial in facing global challenges (Sari, 2022; Tarigan et al., 2021).

Ethnoscience, which integrates local wisdom in science learning, provides a relevant cultural context for students. This approach allows students to better understand and feel the connection between physics concepts and their daily lives. By linking physics concepts with local culture, ethnoscience enhances student engagement and understanding. For example, research shows that the Sar culture of the Kanum Tribe in Marauke can be used to teach about global warming, while the dhadak Merak dance of Reog Ponorogo is used to explain Newton's Laws. This use of local culture in physics learning not only helps students understand science concepts but also enriches their learning experience with deep cultural values (Yuliana & Wijayanto, 2022; Hidayah & Sari, 2021; Prasetyo & Susanto, 2023).

Asahan Regency, where SMA Negeri 1 Kisaran is located, is rich in Malay culture, such as the art of pantun, theater, and traditional Gubang dance. This local cultural potential can be utilized in ethnoscience-based physics learning to increase student engagement and understanding. A study conducted by Dwiastuti and Setiawan (2023) showed that integrating local culture in physics learning can improve students' critical thinking skills and make the material more relevant to their lives. The results of the questionnaire distributed to students of class XI MIPA 6 SMA Negeri 1 Kisaran also showed that 71.53% of students were interested in learning physics using the ethnoscience approach, while 77.7% of students liked the discussion learning method to solve problems. This finding shows high interest from students in learning that is more connected to their culture and can train 21st century skills such as critical thinking, collaboration, and

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communication, as described by Nugroho and Hidayat (2021) regarding the important role of ethnoscience in increasing student engagement in science learning.

Research Methods

This research was conducted at SMA Negeri 1 Kisaran, which is located at Jalan Madong Lubis, Kota Kisaran, Asahan Regency. The research was conducted in the even semester of the 2022/2023 school year. This study used a quasi-experimental method with a pretest-posttest control group design. This type of research was chosen to determine the effect of the Ethnoscience-based Problem Based Learning (PBL) learning model on students' problem solving skills.

The population in this study were all students of class XI MIPA SMA Negeri 1 Kisaran. The research sample was selected using the Cluster Random Sampling technique, with two classes as samples: one class as an experimental class taught using the Ethnoscience-based PBL model, and the other class as a control class taught with conventional learning.

The independent variable in this study is the learning model, namely Ethnoscience-based PBL and conventional learning, while the dependent variable is students' problem solving ability. Data collection was done using several instruments, namely:

1. Problem solving ability test, which consists of 5 description questions based on Heller's problem solving indicators: focusing the problem, describing the problem in physics concepts, planning the solution, implementing the solution plan, and evaluating the solution. The test was given in the form of a pretest to measure students' initial ability and a post-test to measure the final ability after treatment.
2. Teacher interviews were conducted to obtain information related to the physics learning process at school.
3. Student questionnaires, used to determine student perceptions of ethnoscience-based physics learning.
4. Observation of student activity, conducted to monitor student involvement during the learning process.

The research procedure consisted of three main stages. In the preparation stage, initial observations, sample determination, preparation of learning devices, and validation of research instruments were carried out. The implementation stage began with giving pretests to the experimental and control classes, followed by the implementation of physics learning using the Ethnoscience-based PBL model in the experimental class and conventional learning in the control class. After the learning was completed, post-tests were given to both groups to measure students' final abilities. In the final stage, the pretest and post-test data were analysed to draw conclusions.

The data obtained was analysed using several statistical techniques, namely:

1. Normality test to ensure normal data distribution.
2. Homogeneity test to determine the similarity of variants between sample groups.
3. Hypothesis testing using t-test to test the significant difference between experimental and control classes.
4. N-gain to measure the improvement of problem solving skills with low, medium, or high categories.

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5. Effect size to determine the level of influence of the treatment on students' problem solving skills.

Discussion

The results showed that the Ethnoscience-based Problem Based Learning (PBL) learning model had a significant effect on students' problem-solving skills on sound waves. Based on the pretest data, the initial ability of students in the experimental and control classes did not show a significant difference (average 39.87 and 36.27 respectively). This shows that both classes have equal initial abilities before treatment.

Table 1. Pretest Data

Experiment Clas				Control Class			
Interval	Frk	average	Standard Deviation	Interval	Frk	average	Standard Deviation
Dec-19	4	39,86667	12,27201	16-21	4	36,26667	9,391608
20-27	0			22-27	1		
28-35	2			28-33	4		
36-43	11			34-39	5		
44-51	8			40-45	11		
52-59	5			46-51	5		
	n = 30				n = 30		

Table 2. Post-test Data

Experiment Clas				Control Class			
Interval	Frk	average	Standard Deviation	Interval	Frk	average	Standard Deviation
60-66	5	83,6	15,23517	52-60	10	75,46667	17,44298
67-73	6			61-69	2		
74-80	5			70-78	0		
81-87	0			79-87	10		
88-94	0			88-96	4		
95-101	14			97-105	4		
	n = 30				n = 30		

After the treatment, there was a significant increase in students' post-test scores in the experimental class compared to the control class. The average post-test of the experimental class reached 83.6, higher than the control class which reached 75.47. N-Gain analysis showed that the increase in problem solving ability in the experimental class was in the high category (0.72), while the control class was in the medium category (0.62). These results indicate that the application of the Ethnoscience-based PBL model is more effective in improving students' problem solving skills compared to conventional learning.

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Table 3. Prestes T Test Results

Class Data	Rate Average	t_Count	t_Table	Conclusion
Experiment Control	83,6 75,2667	1.923.525	1.671	H_a = accepted

The application of the Ethnoscience-based PBL model is able to connect physics concepts with local cultural contexts. This is in line with the statement of Nuralita et al. (2020) that learning that integrates local wisdom provides a more meaningful and relevant learning experience. In this learning, students are invited to orient the problem, work together in groups to organize solutions, conduct investigations, and present results and evaluate solutions. This process not only improves students' cognitive abilities but also their social skills.

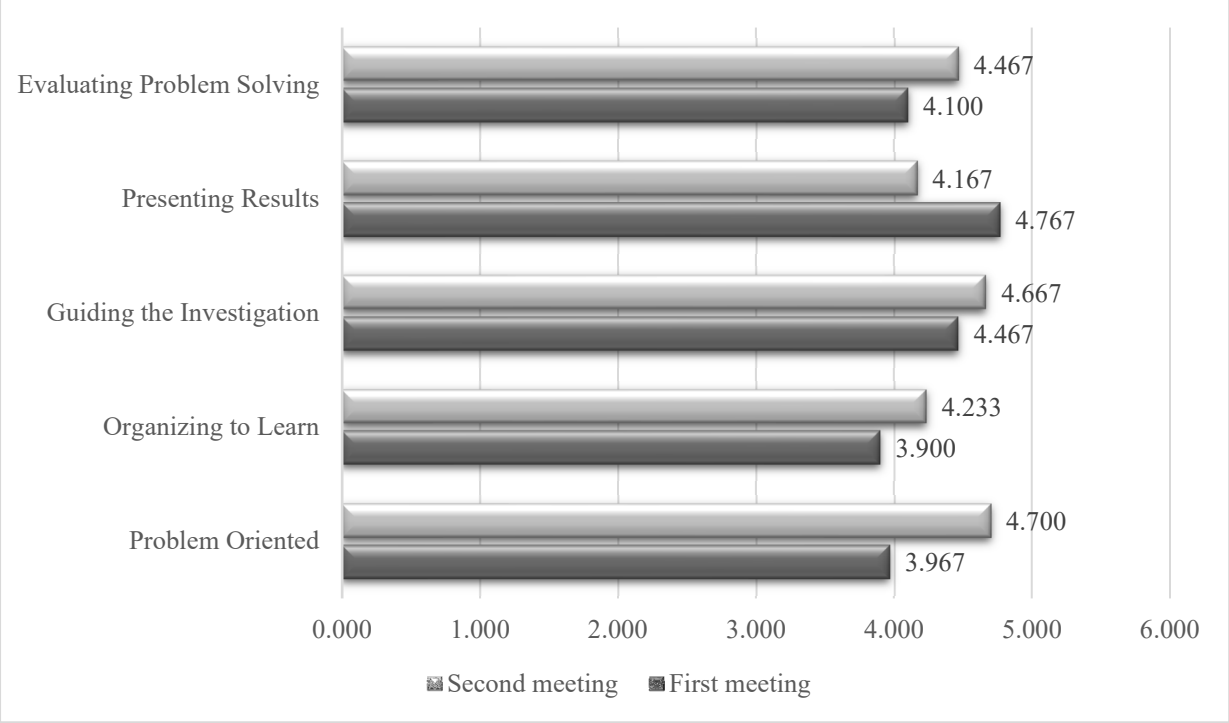

Figure 1. Student activity score

Observations during learning showed that student activity in the experimental class increased gradually. In the first meeting, the average student learning activity was 70.67 (active category), and increased in the second meeting to 74.11 (active category). The average overall activity reached 72.39, reflecting good student engagement during the learning process. This increase was influenced by students' adaptation to the PBL learning model that they had never experienced before.

Nevertheless, there are obstacles in the implementation of learning, especially at the group discussion stage. Students tend to be less focused, causing time delays in completing tasks. This obstacle can be overcome by providing more intensive motivation and direction before learning begins.

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The integration of ethnoscience values in the PBL model makes students more enthusiastic and motivated to learn. As stated by Shufa (2018), learning approaches that utilize local wisdom not only improve students' understanding of science concepts but also equip them with the ability to apply this knowledge in real life.

The results of this study support the application of the Ethnoscience-based PBL model as an effective learning alternative to improve students' problem solving skills. In addition, this approach also contributes to preserving local culture through the integration of cultural context in physics learning.

Conclusion

This study shows that the Ethnoscience-based Problem Based Learning (PBL) learning model has a significant effect on students' problem solving skills on sound waves. The pretest results showed that the initial abilities of students in the experimental and control classes were not significantly different, with an average of 39.87 and 36.27 respectively. After the treatment, the average post-test of the experimental class increased to 83.6, higher than the control class which reached 75.47.

N-Gain analysis showed that the improvement of problem-solving ability in the experimental class was in the high category (0.72), while the control class was in the medium category (0.62). In addition, the effect size test results show that this learning model has a moderate effect on improving students' problem-solving skills.

The application of Ethnoscience-based PBL not only improves students' cognitive abilities but also encourages their active involvement in learning. The average student activity in the experimental class reached 72.39 with the active category, which indicates that this model is effective in increasing student participation.

The integration of ethnoscience values in physics learning makes students more enthusiastic, understand concepts more deeply, and can relate physics knowledge to everyday life. This approach also contributes to the preservation of local culture, making it a relevant and meaningful learning alternative.

Thus, the **Ethnoscience-based Problem Based Learning** model can be used as an effective learning strategy to improve students' problem solving skills while introducing local culture as a learning context.

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References should be numbered using Arabic numerals followed by a period (.) as shown below and should follow the format in the below examples.

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Creating textbook based on CASE (creative, active, systematic, effective) to support the implementation of outcome-based education

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Abstract. *Outcome-based education emphasizes on obtaining specific learning outcomes and concrete knowledge that leads to skills and behaviors. To accomplish this objective, proper instructional resources, such as textbooks, must be developed and implemented. However, several of the existing textbooks focus on the content rather than the approach. Accordingly, in this research project, a CASE-based (Creative, Active, Systematic, Effective) textbook will be created to improve students' problem-solving and creativity skills. This book also contains learning media information with text, images, video barcodes, and student worksheets. Thiagarajan's 4D model, which includes the steps of Define, Design, Develop, and Disseminate, refers to the type of research as R&D. Data collection occurred out in several stages including expert validation (material experts, media experts, and assessment experts), student and lecturer response surveys and tests of students' problem-solving abilities and creativity. The effectiveness of the product was evaluated using the t-test and the N-gain. The product test results revealed that the textbook based on CASE was created for this study, as a teaching material model that encourages students' creative thinking, which fulfills the criteria for a practical and effective model.*

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Keywords: textbook, CASE, outcome, creative, education

Introduction

Education faces the predicament of having to prepare graduates with the skills or capacities to compete in the future. [1]. To accomplish this, Medan State University uses acceptable educational standards, specifically the OBE curriculum. Outcomes-based education (OBE), often known as standard curriculum, began in the late 19th century, with several countries adopting OBE ideas into their curricula [2]. There are several reasons why an OBE is necessary. First, OBE ensures that learning objectives and outcomes are aligned with real-world needs. As technology evolves rapidly, students have to possess skills and information that can be applied in a digital context. Second, flexibility is essential in schooling. [3] [4].

The current implementation of the Outcome-based Education curriculum is expected to achieve success in achieving educational competencies [5]. An educator must prepare innovative and creative teaching materials to achieve it [6]. The development of teaching materials is very necessary in accordance with curriculum demands, student characteristics and can solve problems [7]. Selecting appropriate teaching material is one aspect of success in achieving learning objectives [8] . In accordance with the analysis of student needs carried out, students chose to use textbooks as one of their learning resources. Therefore, textbooks should facilitate students to understand the learning objectives expected by educators [9]. Learning objectives in higher education must support graduate learning outcomes which are the formula for achieving graduate competency standards, namely the minimum criteria for graduate ability qualifications which include attitudes, knowledge and skills.

In the 21th century, learners must possess four competencies, or what is known as "The 4C Skills" formulated by the Framework Partnership of 21st Century Skills, including: communication, collaboration, critical thinking and problem solving, and creative thinking [10] . In learning media courses, the skills that students want to develop are the ability to think creatively to produce new things in making learning media innovations [11]. Creative thinking which consists of 4 indicators in the form of Fluency, Flexibility, Originality, Elaboration [12]. In order for students to be able to think creatively, they must have high-level thinking skills to solve problems [13] [14]. Creativity can be linked to divergent thinking skills and is often also linked to student talent. Talented students have special abilities in creativity which are supported by thinking abilities and other skills.

This creativity can be obtained by compiling CASE-based textbooks (Creative, Active, Systematic, Effective). According to [15] state that CASE (Creative, Active, Systematic, Effective) based teaching materials can provide encouragement for students to think creatively and participate actively in learning, so that learning becomes more interesting. In line with [16] states that CASE (Creative, Active, Systematic, Effective) interactive teaching materials are very good to use as teaching resources in the learning process. This teaching method is designed to help students learn how to be creative, active, systematic and effective to gain additional knowledge and understanding of the material during the learning process [17]. Creative means that the contents of the textbook can develop ideas and also disseminate information about the questions contained in the material [18] . Active is the content of teaching materials that trains students to actively find and overcome problems that exist in real life. Systematic means creating teaching materials using analytical and logical methods, which leads to the creation of systematic teaching materials. Effective means that the material instructions are arranged effectively, making it easier for students to understand and solve problems.

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The learning media course aims to teach students to understand the concept of learning media, create learning media and apply it in learning activities. With this book, it is hoped that prospective teacher students will be able to develop the learning media needed by students. Based on these problems, the research team developed a CASE (Creative, Active, Systematic, Effective) textbook to support the implementation of Outcome-Based Education. It is hoped that this research will become reference material for other courses that wish to prioritize curriculum implementation as the creation of teaching materials in the future.

Method

Research and Development research refers to the 4D model by Thiagajaran [19]. Research and development (R&D) can be used as a means to develop, manufacture and ensure the validity of products that have been developed and tested. The subjects of this research are experts, lecturers and students taking learning media courses in 2023/2024, majoring in biology, Medan State University. The aim of this research is to produce a CASE-based textbook to support the implementation of OBE. This book will be validated with material, learning and media experts to provide input and suggestions and demonstrate the effectiveness of the textbook that has been developed.

4D Model Development Stages

The 4D development design stages include the Define, Design, Develop and Disseminate stages. The stages in preparing textbooks include: The first stage of analysis, is the initial stage to find out what students will learn. The main activities of this stage include: 1) Define stage, at this stage 3 analyzes are carried out, namely curriculum analysis; needs analysis and; problem analysis. 2) Design stage, at this stage the steps taken are designing course learning outcomes (CPMK) subject matter, format and CASE-based textbooks, preparing evaluations at the end of the chapter, making video tutorials with video barcodes included. 3) Development stage (Develop), After the learning media textbook prototype is completed, it will be validated by material, learning and language experts. Validation will be carried out repeatedly until the product is valid. 4) Dissemination stage, the learning media textbook is then implemented in sample classes, and in the final stage, student creativity is tested.

Instrument and Data Analysis

The research instruments included validation sheets, questionnaires for practicality testing, and N gain tests. For data validation, instrument reliability consists of three expert lecturers: material experts, learning experts, and media experts. Meanwhile, for the product's practicality, this study examines two practical factors, lecturers and students. The validation results were utilized to assess the level of feasibility applying an equation adopted from eqn. (1):

$$P = \frac{\Sigma}{N} \text{ x } 100\% \quad (1)$$

Based on expert study, the proportion of textbooks with interpretive criteria will be applied, as shown in the table below:

Table 1. The Feasibility of Validation Criteria for the Teaching Materials

Criteria	Interval Percentage
Very less feasible	<21%
Less feasible	21% -40%
Quite feasible	41% - 60%
Feasible	61% - 80%

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Very feasible	81% - 100%

Based on this interpretation, the textbook developed by the researcher is declared feasible if it obtains a percentage of ≥61% by showing strong or very strong criteria. [20]

The practicality of the teaching materials was evaluated by the students' and lectures questionnaire response. The criteria for teaching materials practicality are shown in Table 2.

Table 2. The Assessment Criteria for Teaching Materials Practicality

Criteria	Interval Percentage
Very practical	X > 84
Practical	70< X ≤ 84
Quite practical	55 < X ≤ 70
Less practical	40< X ≤ 55
Not practical	X ≤ 40

After the book was declared suitable, a trial was carried out on 38 students. Product effectiveness was tested using the criteria of students' creative thinking abilities. The data analysis technique used is the gain test [21]. To determine the increase in creativity and problem solving after product testing, data analysis uses the Normalized Gain Score. The calculation is explained below eqn. (2)

$$G = \frac{Posttest\ Score\ -\ Pretest\ Score}{Maximum\ Score - Minimum\ Score} \quad (2)$$

The normalized N-Gain results are classified into three categories, shown in table 3.

Table 3. The Assessment Criteria for Teaching Materials Practicality

Criteria	Interval Percentage
g> 0.70	High
0.30 ≥ (g) <0.70	Middle
g < 0.30	Low

Result and Discussion

Defining Stage (Define)

The define stage (preliminary study) includes: initial final analysis, learner analysis, task analysis, concept analysis, and indicator formulation [22] . Initial and final analysis was carried out for literature studies, preparation of questionnaires and distribution of student needs questionnaires in learning media courses and questionnaires of lecturers' needs in carrying out the learning process. Learner analysis is conducted to describe student characteristics and student motivation in learning media courses. Task analysis is carried out to describe all the tasks required in learning media courses so that students can find formulas, concepts and principles in each material. The concept analysis stage is carried out to describe all concepts related to learning media courses. The formulation of indicators is carried out to describe all indicators that must be achieved by students after studying the textbook then proceed with the formulation of learning objectives that must be achieved by each student after learning by using the textbook that has been prepared.

Designing Stage

At this stage, it includes the components of writing CASE-based learning media textbooks (Creative, Active, Systematic, Effective) that will be developed [23]. The steps taken were the design of learning outcomes for the subject matter of the course, the format and components of the

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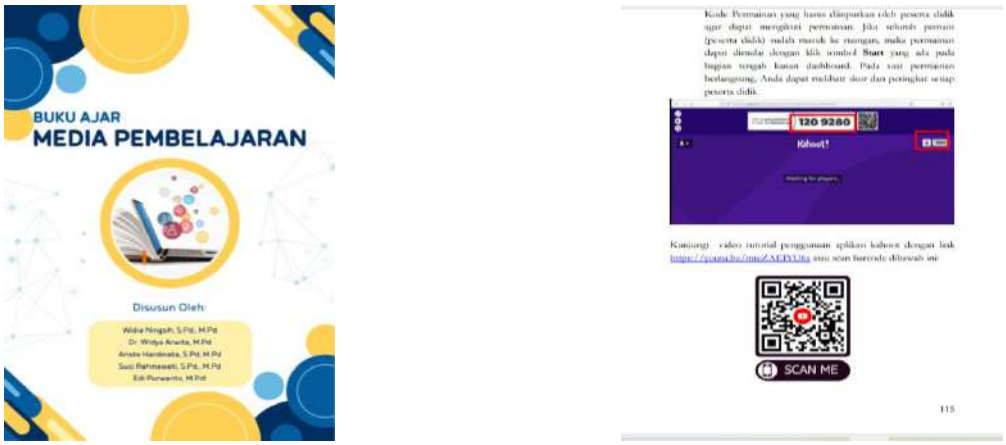
learning media textbook and the preparation of research instruments. In this process, the curriculum was analyzed, the design of learning activities, core competencies, basic competencies, and learning objectives, and the preparation of evaluation instruments [24]. The systematics of the designed coursebook consists of: cover, preface, table of contents, list of images, list of tables, learning media material equipped with sample questions, project activities, video tutorials, evaluation questions, and bibliography.



(a) (b)

Figure 1. A designed off textbook; a) Cover b)Tutorial and video barcode

Developing Stage

After the prototype of the learning media textbook is complete, it will be validated by material, learning, and design experts. Validation will be carried out repeatedly until the product is valid [25].

Table 4. The Validation Results of Material Content

Aspect	Validity Value (%)	Category
Material relevance with curriculum	97	Very Good
Material Scope	88	Very Good
Accuracy of Material Presentation	100	Very Good
Language Compatibility	75	Very Good
Average	90	Very Good

Based on table, the results of validation by material experts show that the average percentage of validity is 90%, which means that this textbook is very valid. This states that this book is very suitable in terms of the material compiled against the study material of the course. The content of a lesson is very important, because by compiling good material content, the concept of the material taught will be successfully conveyed by the educator so that learning is more meaningful [26]. Textbooks must also be relevant to learning, the following is a learning expert validation table below:

Table 5. The Validation Results of Learning Experts

Aspect	Validity Value (%)	Category
Material Suitability	82	Good
Compatibility with CASE Components	94	Very good

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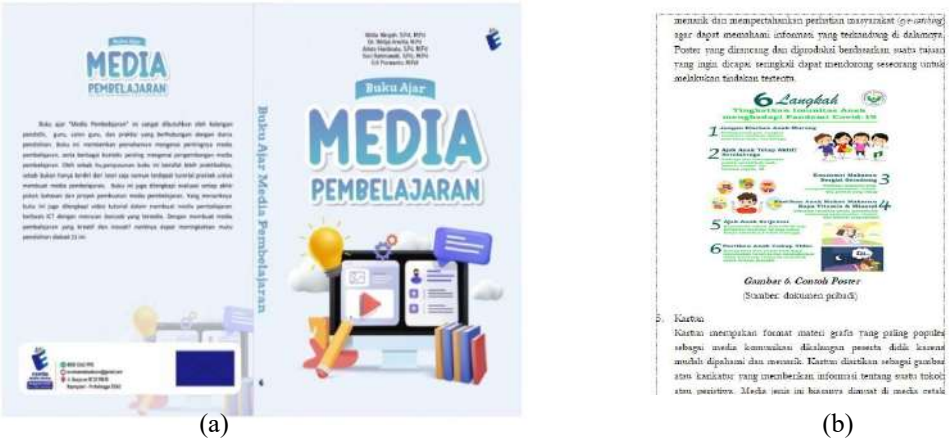
Learning Techniques	Presentation	94	Very good
Student Centering in Learning		96	Very good
Average		92	Very good

The results of the learning expert validation showed an average percentage of validity of 92% which means the book is very feasible to use in learning. Learning in this textbook is very supportive of student-centered learning, by using various learning models and there is also a project-based learning model applied . By applying this model can improve students' creative thinking skills [27][28]. Next, it needed for the textbook is the views of the media expert, which can be illustrate in the table below.

Table 6. The Validation of Learning Media Expert

Aspect	Validity Value (%)	Category
Coverview	88	Very good
Content Design	78	Good
Image and Illustration	94	Very good
Average	88	Very good

The validator provided several inputs regarding the textbooks that had been developed. Suggestions from material experts are to adjust learning outcomes in the outcome-based education curriculum. This is in accordance with the opinion that to make learning successful, the learning outcomes must first be determined which are linked to the learning process [29]. Meanwhile, learning experts suggested that the evaluation at the end of the chapter increase the number of questions, and the material should be more tailored to the students' ability level. Then the advice from media experts is to improve the cover, make the title text in the middle so that the cover is attractive. Then the images displayed in the book are used as learning resources. In Figure 2, there are improvements to textbooks based on expert suggestions.



(a) (b)

Figure 2. a) Corrected Cover b) Image Source Caption Improvement

Disseminating Stage

This dissemination involved distributing textbooks to 38 students and using them in the learning process during 12 meetings. From field trials, data was obtained about the practicality of textbook products. This data was obtained from a questionnaire response from lecturers and students which described several aspects regarding the practicality component. The data is

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presented in table 7 below.

Table 7. Student and Teacher Response Questionnaires on the Practicality of the Textbook

Aspect	PracticalityValue (%)	Category
Lectures	78	Practical
Students	86	Very practical

At this stage, the effectiveness of of textbooks used in learning to foster creative thinking skills, which is measured based on the N-Gain of pretest and posttes. The results of the effectiveness test can be shown in table below:

Table 8. The Results of Textbook Effectiveness on Creative Thinking

Pretest Average	Posttest Average	N-Gain	Criteria
52.55	89.39	0.78	High

The increase in students' creative thinking skills taught using this CASE-based textbook, based on the N-Gain test, was 0.78 with a high category. Several factors cause the effectiveness of the use of this module, the first is that the module has been validated by various relevant experts declared quite valid and practical and can be used in learning so that it can improve students' creative thinking skills [30]. Second, the textbook is prepared with contextual examples with language that is easier to understand so that students are motivated to learn as student responses through questionnaires. Third, it is arranged based on classroom learning consisting of course learning outcomes and indicators, concept understanding, evaluation, project-based learning, and self-reflection so that students can learn and measure their respective abilities [31].

Conclusion

The tlearning media textbook based on CASE (Creative, Active, Systematic, Effective) as a supporter of the outcome-based education curriculum according to material experts, media experts, and learning design experts are in the category of feasible use in learning. The development of CASE-based Learning Media Textbooks (Creative, Active, Systematic, Effective) is an effective way to increase student creativity that provides learning activities designed so that students and prospective teachers can improve their competence by utilizing each learning activity to develop appropriate learning media.

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Development of STEM worksheets based on science literacy PISA 2025 framework to improve science literacy abilities of prospective science teachers

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Abstract. *The problem of low Science Literacy skills of students in Indonesia has been a long-standing problem. Various efforts have been made by previous researchers including the Indonesian government by always developing appropriate curricula to improve students' science literacy skills. Based on previous research, there are still many teachers in Indonesia who are still unfamiliar with the term science literacy. This study aims to develop a Student STEM Worksheet based on Science Literacy following the PISA framework to improve the science literacy skills of prospective science teachers. This research is a Research and Development study. The model used in this study is the 4-D (Four D) model which is the right model in developing learning devices. The stages of this model consist of Define, Design, Develop, and Disseminate. At the development stage, the researcher validated the STEM Worksheet based on Science Literacy which consists of content validation, design validation, and media validation. In this study, it was found that the STEM Worksheet based on the PISA framework Science Literacy has good validation with a very valid category. So, it can be concluded that this STEM worksheet based on the PISA framework science literacy can be used in lectures to train the science literacy competencies of prospective science teachers.*

Keywords: STEM, worksheet, literacy, science, teacher

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Introduction

Education in Indonesia continues to move forward in line with global developments and the condition of human resources in Indonesia, especially students and teachers who are individuals who act on the front lines of education. This is marked by changes to policies that regulate education in Indonesia by the government. The Indonesian curriculum is a product of policies set by the Indonesian government. Since several decades ago, the curriculum in Indonesia has continued to change to adapt to the needs of the community, especially education actors, and to adapt to the goals of national education. The latest curriculum currently used in Indonesia is the Independence curriculum. Based on the decree of the Head of the Education Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology Number 008/H/KR/2022 concerning learning outcomes in early childhood education, elementary education levels, and secondary education levels in the Independence curriculum, it can be seen that the government's main focus in achieving learning objectives is to improve students' literacy and numeracy skills [1]. This is not without basis and reason. Almost all Red Flag programs run by the Indonesian government such as “Kampus-Mengajar”, Internship and Certified Independent Study, Independent Study, Student Exchange, Independent Entrepreneurship, Teacher’s Professionals Program, and others related to Education are not far from the term’s literacy and numeracy. The Indonesian government is implementing this because of the low literacy skills of students in Indonesia.

Indonesia is one of the countries that is a member of the international Organization for Economic Co-operation and Development (OECD). This organization was formed to facilitate developed and developing countries to work together to improve the economic quality of its member countries. The OECD believes that the quality of human resources greatly influences the economic development of a country [2]. Therefore, the OECD formed a program that was run to examine the literacy skills of 15-year-old children because it is believed that at this age, children have gained enough knowledge in school and are the right age to measure their competence so that in the future further action can be taken if necessary. This program is called the Programme for International Student Assessment (PISA).

The PISA international assessment program focuses on assessing 15-year-old children in mathematics, language, and science literacy competencies. Indonesia has participated in this program for approximately 20 years, but has never shown satisfactory results in mathematics, language, science, and other literacy fields. The achievements of Indonesian students over the past twenty years have always been below the PISA standard average of 500. From 2000 to 2022, Indonesia has always been in the bottom ten of dozens of countries that participated in this international study. In 2022, PISA has announced the latest results on children's literacy skills in Indonesia. In 2022, this international study was attended by 81 countries consisting of 37 OECD countries and 44 partner countries. In general, the PISA results of all countries participating in 2022 decreased compared to the average obtained in 2018. Therefore, although Indonesia's average fell 13 points from the 2018 average, Indonesia's ranking increased to the bottom 15 out of 81 countries participating [3]. However, this is not a good achievement because Indonesia is still far below other countries and still gets scores below the PISA standard average.

Learning or knowledge transfer can occur if there are important parts in learning. These important parts include students who will be taught, teachers who will be facilitators in the learning process, learning plans, teaching materials, teaching media, learning achievement measurement

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tools, and others. Based on the sequence, after students, of course the teacher's competence must also be questioned in facilitating students in learning. If students have difficulty in achieving the learning objectives that we are targeting, apart from the seriousness of the students in learning, the IQ of the students, and others, we also have to check whether the teacher has been a good facilitator in teaching students. Teachers have a very important role in helping students to develop their knowledge, especially information literacy, previous research has explained that students' literacy skills will not develop without deliberate guidance [4]. Therefore, it is important to prepare teachers who have literacy competencies, especially science literacy, before teaching the students themselves. This teacher competency preparation can of course be implemented since prospective teachers take education at university level. Based on data from the Central Statistics Agency of Indonesia, in 2022, there will be approximately 7 million students studying in the field of education [5]. Therefore, it has become the responsibility of researchers and lecturers at universities to prepare professional science teacher candidates.

Based on the study and analysis of the problems above, in order to solve the existing problems, it is important to conduct research on the development of STEM LKM Based on Science Literacy PISA 2025 framework to improve the Science Literacy skills of prospective science teachers at the UNIMED Science Education Study Program.

Research Methods

This research is a Research and Development (R&D) research. There are many models related to research and development research. The model used in this study is the 4-D development model. The 4-D (Four D) development model is a learning device development model. This model was developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I., Semmel [6]. The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate.

However, in this article, what will be described is the stage of content validation of the Student STEM Worksheet based on the PISA 2025 Science Literacy framework by experts in Content, Design, and Media [7]. This research was conducted in the Odd Semester of 2024/2025 in the Science Education Study Program, Faculty of Mathematics and Natural Sciences, State University of Medan. Expert Validators are lecturers at the State University of Medan who are experts in the fields of science content, Design, and Media.

Results and Discussion

This section will present the results and discussions related to the validation of the content of the Student STEM Worksheet based on the PISA 2025 Science Literacy framework based on expert validators in Content, Design, and Media.

Content Validation of Student STEM Worksheets Based on Science Literacy

Before the data is presented, it is necessary to explain that the aspects of content validity used in this study consist of the aspect of Content Correctness (A1), the aspect of Content Coverage (A2), the aspect of Understanding (A3), the aspect of Component Completeness (A4), the aspect of STEM completeness (A5), and the aspect of Science Literacy Competence (A6).

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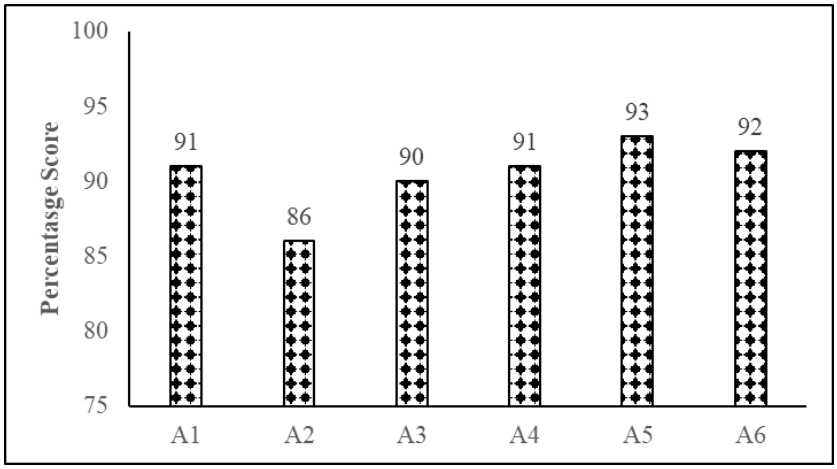

Figure 1. Percentage of Content Validity from Expert Validators in each Aspect

Based on the table above, it can be seen that the content correctness aspect obtained a validation result with a percentage of 91% with the category "very valid" [8], then the content coverage aspect obtained a percentage of 86% with the category "very valid", then the understanding aspect obtained a percentage value of 90% with the category "very valid", the component completeness aspect with a percentage value of 91% with the category "very valid", the aspect of STEM completeness with a percentage value of 93% with the category "very valid", and finally the scientific literacy competency aspect with a percentage value of 92% with the category "very valid. Therefore, because the average of each aspect is in the very valid category, it can be concluded that the validation according to the content expert validator is in the category "very valid'.

Design Validation of Student STEM Worksheets Based on Science Literacy

Before the data is presented, it is very important to explain that the aspects that will be validated by the expert design validator are the aspects of Design Display (B1), and the aspects of Layout and Writing Clarity (B2).

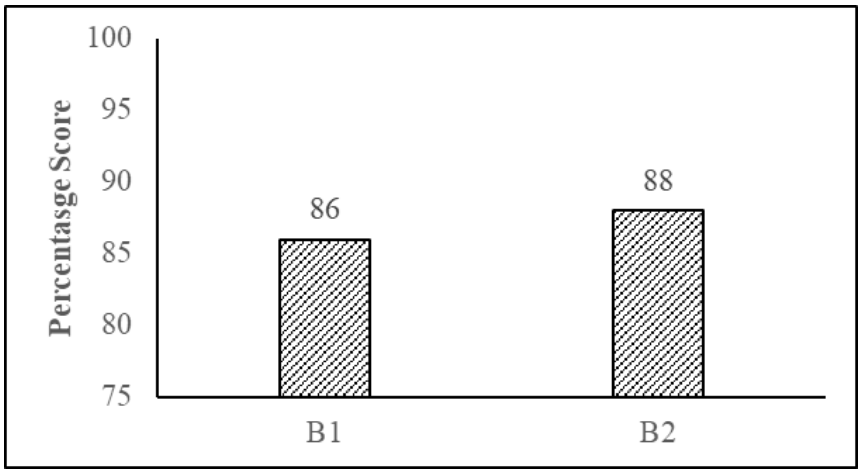

Figure 2. Percentage of Design Validity from Expert Validators on All Aspects

Based on the data in the graph above, it can be seen that in terms of design, the percentage obtained from the expert validator assessment is 86% with the category "very valid". Likewise,

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seen from the aspect of writing clarity, the percentage obtained is 88% with the category "very valid". It can be concluded that the design validation of the STEM Worksheet based on Science Literacy for Prospective Science Teachers is in the very valid category.

Media Validation of Student STEM Worksheets Based on Science Literacy

Before the data is presented, it is necessary to first explain the aspects measured in the media validation by expert validators on this scientific literacy-based STEM student worksheet. The aspects assessed consist of, Display Design Aspect (C1), Layout Aspect (C2), Font Usage Aspect (C3), Image Quality Aspect (C4), Appearance Aspect (C5), and Component Completeness Aspect (C6).

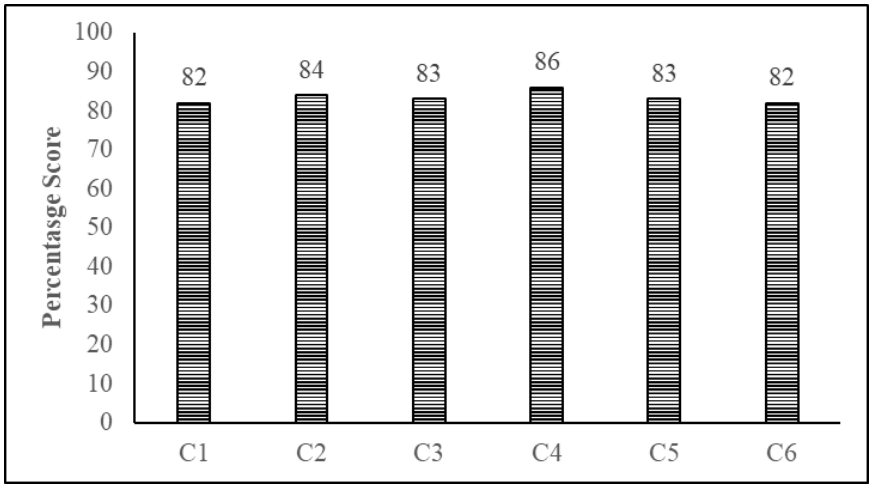

Figure 3. Media Validation Percentage from Expert Validators from All Aspects

Based on the graph above, it can be seen that the average percentage of media validity aspects from expert validators is at a percentage above 80% with the category "very valid". Therefore, it can be concluded that the STEM Worksheet for students based on Science Literacy for prospective science teachers is very valid in terms of media validity.

Conclusion

Based on the previous results and discussions, it can be concluded that the Student STEM Worksheet Based on Science Literacy PISA 2025 framework for Prospective Science Teachers has very good validity, namely in the very valid category. So, it can be concluded that this Student STEM Worksheet based on Science Literacy can be used in lectures to improve the STEM and Science Literacy skills of prospective science teachers.

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Analysis of scientific literacy abilities in pre-service science teachers based on the PISA framework

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Abstract. *The results of PISA 2022 show that Indonesia's literacy learning outcome ranking has increased by 5 to 6 positions compared to PISA 2018. However, Indonesian students are still lagging behind compared to countries in Southeast Asia. This research aims to determine the scientific literacy profile of Pre-service science teachers at State University of Medan seen from the competency aspect based on the 2018 PISA framework. The scientific literacy competency indicators used in this research are competency to explain phenomena scientifically; competence to design and evaluate scientific investigations; competence to interpret data and scientific evidence. This type of research is descriptive qualitative. The population in this study were students in the second semester of the Science Education Study Program, State University of Medan. The sampling technique was total sampling with 59 respondents involved. The instrument used was a scientific literacy test question which was developed based on the main scientific literacy competencies of the PISA Framework, validated with a score of 3.6 (very good category). The research results show that the scientific literacy profile of Pre-service science teachers is based on the PISA framework. Based on three indicators of competency aspects, namely explaining phenomena scientifically with an average of 73.1 in the good category, evaluating and designing scientific investigations with an average of 68.9 in the sufficient category and interpreting data and evidence scientifically with an average of 64.5 in the sufficient category.*

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Keywords: scientific, literacy, pre-service, science, teachers

Introduction

Scientific literacy is defined as the ability to use scientific knowledge, identify questions, and draw conclusions based on evidence in understanding and making decisions regarding nature and changes made to nature through human activities [1][2]. Scientific literacy is one of the PISA (Program for International Student Assessment) study areas which focuses on a person's ability to use scientific knowledge and skills in making decisions and solving problems [3][4].

Scientific literacy is very necessary for students to be able to adapt to advances in science and technology to understand the environment, economy, health and the challenges faced by modern society [5][6]. The results of the PISA (Program for International Student Assessment) study, which is a literacy study that Indonesia participates in, is carried out every 3 years, the average scientific literacy ability of Indonesian students in 2022, Indonesia is ranked 66th out of 80 countries with a score of 383 in the science aspect. This score is below the international standard set at 485, indicating that Indonesia's scientific literacy abilities are classified as category 1a or very low [7] [8]. The results of PISA 2022 show that Indonesia's literacy learning outcomes ranking has increased by 5 to 6 positions compared to PISA 2018. However, Indonesian students are still lagging behind compared to countries in Southeast Asia [7][9]. This shows that students in Indonesia are still unable to understand scientific concepts and processes and apply the scientific knowledge they have learned in everyday life [10][11].

The low scientific literacy abilities of Indonesian students are generally caused by learning activities that are not yet oriented towards developing scientific literacy because as many as 8% of schools have very low human resources (HR) and 34% of schools have very low teaching resources and the percentage of availability of technological resources. Communication Information (ICT) to support the learning process in schools with ICT infrastructure for learning, and 20% lack support for increasing ICT capabilities for teachers [7]. Several studies in Indonesia also reveal teachers' low understanding of literacy [12][13][14]. Scientific literacy is not only associated with knowledge and skills but also scientific attitudes and mindsets in identifying problems, identifying new knowledge, and how to draw conclusions based on facts, and awareness of how science and technology shape the natural, intellectual and cultural environment, as well as the desire to involved and able to take a stand on current issues based on science [15][16] scientific literacy must be seen as not just dwelling on problems in the academic world but must be related and directly related to the current and everyday context humanity [17][18].

Scientific literacy is important for students to master because it can foster thinking and creativity in students, forming students' characters who care and are responsible for themselves, society and the environment. Scientific literacy plays an important role in prosperity and humanity in the future [19][20]. Prospective teacher students need good scientific literacy skills so they can transfer scientific material to students in more depth so as to form students who have scientific literacy [13][21]. prospective teacher students with good scientific literacy will use appropriate learning approaches or models, develop questions and be able to create or develop evaluation instruments that can develop students' scientific literacy [22][23]. Natural science (science) is considered difficult for most students because it contains 3 topics, namely Biology, Physics and Chemistry, so every prospective science teacher must have a strong knowledge base. As a prospective science teacher, it is very important to equip yourself with scientific literacy when learning science. Scientific literacy skills as a prospective science teacher will impact good student learning outcomes. Through scientific literacy, prospective science teacher students can use this

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knowledge in various aspects of life, find solutions to problems, make decisions without doubt so that they can improve the quality of life [20].

This basic research, carried out in the Biology Department of the Natural Sciences Education Study Program, State University of Medan, tries to describe the initial scientific literacy abilities of Science Study Program students as future science teacher candidates. The aim of this research is to determine the scientific literacy profile of Pre-service science teacher at State University of Medan seen from the competency aspect based on the 2018 PISA framework. The scientific literacy competency indicators used in this research are competency to explain phenomena scientifically; competence to design and evaluate scientific investigations; competence to interpret data and scientific evidence.

Research Methods

The research method used is a descriptive method with a quantitative approach. This method aims to describe quantitative data obtained regarding the condition of a subject or phenomenon in a population. In this study, the data described are the results of an analysis of scientific literacy of Pre-service science teacher. Scientific literacy of Pre-service science teacher is analyzed and described based on the scientific literacy competency indicators used in this research, namely competency to explain phenomena scientifically; competence to design and evaluate scientific investigations; competence to interpret data and scientific evidence

This research was conducted for approximately two months, namely April and May 2024. The population in this research were students in the second semester of the Science Education Study Program, State University Of Medan. The sampling technique was total sampling with 59 respondents involved. The instrument used was scientific literacy test questions which were developed based on the main competencies of scientific literacy in the 2018 PISA Framework. This research began with preparing an instrument for scientific literacy questions and instrument validation, both content validation and construct validation. Validated instruments were used for data collection, namely 30 multiple choice questions, consisting of competency aspects 10 questions, Evaluating and designing scientific investigations 10 questions; and Interpreting data and evidence scientifically 10 questions.

The analysis used in this research is descriptive analysis in the form of scientific literacy scores which describe the scientific literacy profile of Pre-service science teacher categorized based on the provisions of Table 1.

Table 1. Literacy Level Criteria for Pre-Service Science Teacher

Score	Scientific Literacy Level Category	Category
93 – 100	Level 6	Very good
73 – 92	Level 5	Good
55 – 72	Level 4	Enough
40 – 54	Level 3	Not enough
14 – 39	Level 2	low
7 – 13	Level 1a	Very low
0 – 6	Level 1b	Very low

[24]

Results and Discussion

The scientific literacy abilities of Pre-service science teacher are seen from the competency aspect based on the 2018 PISA framework, namely the competency to explain phenomena

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scientifically; designing and evaluating scientific investigations; interpreting data and scientific evidence can be seen in Figure 1.

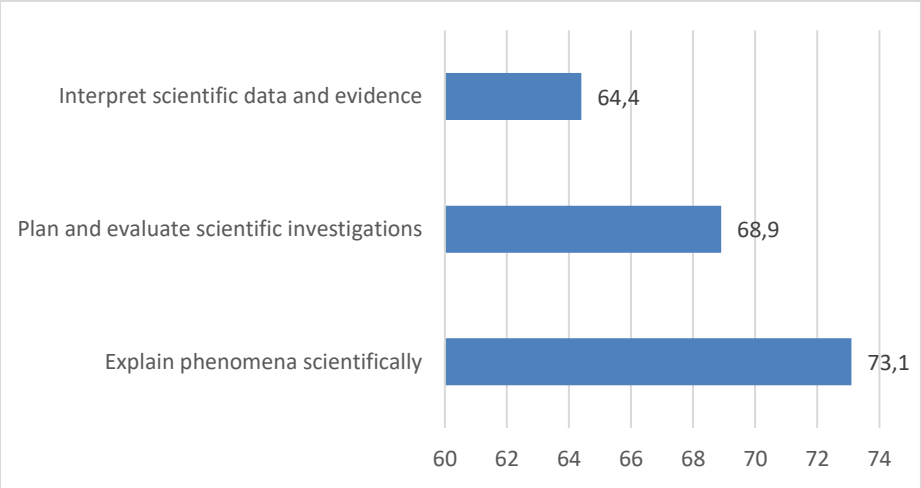

Figure 1. Science Literacy Profile of Pre-service science teacher

Based on Figure 1 above, it is found that the scientific literacy profile of Pre-service science teacher is seen from the aspect of competency in explaining scientific phenomena 73.1 in the good category, explaining scientific phenomena in the good category of prospective science teachers is because in lectures the lecturer has linked basic science and laboratory concept material with natural phenomena. is around so that students' mastery of concepts is good. According to [25] a scientific phenomenon can be said to be an event or occurrence that arises from the symptoms of an object/material or substance. Where, this is logical and empirical or can be proven through experiments. During lectures, lecturers also use virtual laboratories such as PhET Simulation to support lectures, [26] PhET simulation is an interactive simulation of physical phenomena, with a research approach on physics, chemistry and biology.

The competency aspect of planning and evaluating scientific investigations is 68.9 in the sufficient category, indicating that students still have difficulties in designing and evaluating scientific investigations that are carried out because in lectures on the basics of science and laboratories they only use virtual laboratories in the form of simulations which require student independence to use them, [27] some of the limitations of virtual laboratories, one of which is Phet simulation, are a) access to implementation in this learning must use a computer, b) success in learning depends on student independence in following the lesson, c) students feel bored if they don't understand how to use it. computer, and in the competency aspect of interpreting data and scientific evidence 64.4 in the sufficient category, this finding shows that students are able to hypothesize, but when they need to explain their hypothesis, they have difficulty. The explanations given are related to general phenomena that exist in an event, not based on hypotheses made. In lectures it was also found that students were stronger in using their assumptions based on experience rather than looking at data on experimental results. This finding is also in line with the research of [28][29][16], teachers' ability to interpret scientific data and facts is low.

To see the percentage and qualifications of scientific literacy abilities of Pre-service science teacher for each sub-indicator of scientific literacy abilities of Pre-service science teacher, see Table 2.

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Table 2. Conclusions on the Science Literacy Ability of Pre-Service Science Teacher

Competency Aspects	Sub Indicators for Scientific Literacy Competency Aspects	percent (%)	Criteria
Explain phenomenon scientifically	Remembering and applying knowledge/concepts	89	Good
	Identifying problems	80.5	Good
	Make and justify correct predictions	70.3	Enough
	Offers an explanation hypothesis about phenomena that occur in everyday life	76.3	Good
	Explain the potential implications of scientific knowledge for society	49.2	Not enough
Evaluate and designing investigation scientific	Using scientific evidence in identifying questions regarding problems	83.1	Good
	Differentiating questions which allows it to be investigated scientifically	64.4	Enough
	Suggest ways to explore questions	74.6	Good
	Evaluate how to explore	66.9	Enough
	Describe and evaluate methods based on problems	55.9	Enough
Interpret data and evidence scientifically	Converting data from one representation to another	79.7	Good
	Analyze and interpret data and draw appropriate conclusions regarding changes that occur	70.3	Enough
	Identify assumptions, evidence, and reasoning in texts	50.8	Not enough
	Distinguish between arguments based on evidence and scientific theory and arguments based on other considerations	64.4	Enough
	Evaluate arguments and scientific evidence from various sources involving concepts	56.8	Enough

Based on Table 2 above, the aspect of explaining scientific phenomena has five sub-indicators, three categories good, one category sufficient and one category poor, namely explaining the potential implications of scientific knowledge for society. This shows that the material studied by students has not yet reached the point of implementing knowledge for society. In the aspect of evaluating and designing scientific investigations, two sub-indicators obtained two good categories and three adequate categories, namely in terms of distinguishing questions that allow for scientific investigation, evaluating ways of exploring and describing and evaluating methods based on problems. These findings indicate that Pre-service science teacher are not yet accustomed to applying scientific methods [30][31]. In the aspect of scientifically interpreting data and evidence from the five sub-indicators, one sub-indicator is good, three sub-indicators are sufficient and one indicator is poor, namely identifying assumptions, evidence and reasoning in the text. These findings show the inability of Pre-service science teacher to interpret data from the questions presented [32].

The level of ability of Pre-service science teacher in solving scientific literacy questions can be seen in Figure 2.

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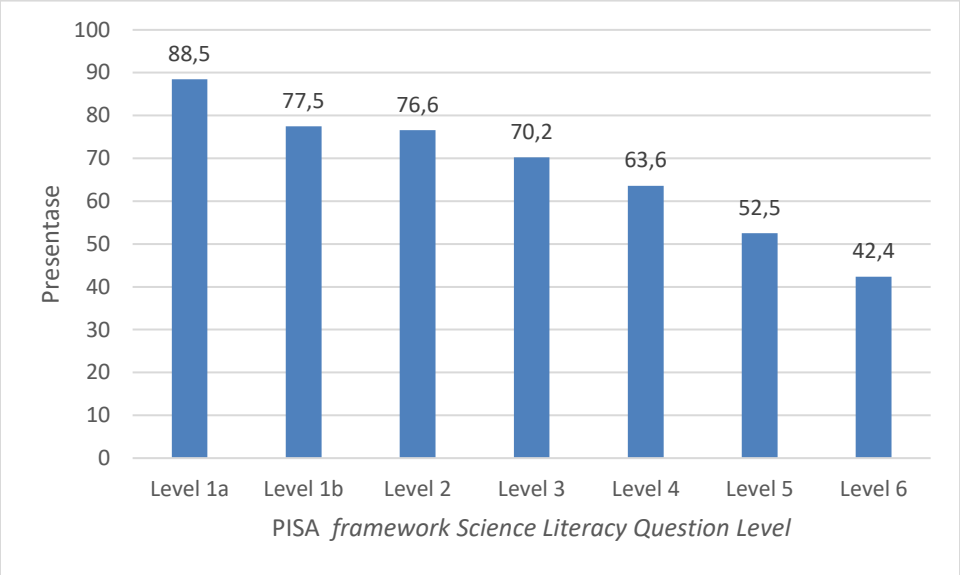

Figure 2. Ability of Pre-service science teacher to Complete PISA Level Questions

Based on Figure 2, it shows that the ability of Pre-service science teacher to solve literacy questions based on levels continues from level 1a in the good category to level 6 in the poor category. This finding is also in line with the OECD findings that Indonesia is at level 1 of 4 levels of scientific literacy. illustrates that students' scientific literacy is relatively low [8]. Efforts to foster a spirit of literacy in students are not easy, motivation is needed in the learning process [33]. The hope is that with the findings of this research, efforts can be made to improve students' literacy skills by first finding out the extent of students' current literacy skills. This is important because it can inform and provide guidance regarding what components of scientific literacy have been mastered or have not been mastered.

Based on interviews conducted with students in lectures on basic science concepts and laboratories, several factors were found that influence students' low literacy skills, including: 1) the textbooks that serve as references do not contain scientific literacy; 2) The syllabus prepared in lectures does not yet support the development of students' scientific literacy skills; 3) lectures have been linked to real life contexts and students' environments but students have not been able to independently search for other material contexts; 4) The learning held is not oriented towards the process and achievement of PISA framework competencies

Conclusion

The scientific literacy profile of Pre-service science teacher at State University of Medan is seen from the competency aspect based on the 2018 PISA framework, based on three competency aspect indicators, namely explaining phenomena scientifically with an average of 73.1 in the good category, evaluating and designing scientific investigations with an average of 68.9 in the sufficient category. and interpreting data and evidence scientifically with an average of 64.5 sufficient categories. To improve the scientific literacy abilities of Pre-service science teacher at State University of Medan, they should refer to references that support increasing students' scientific literacy, design tools and lectures to support the development of students' scientific literacy abilities.

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Ethnoscience studies analysis of karo oil as traditional medicine by karo ethnic and their integration in science learning at junior high school

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Abstract. *This study aims to examine the indigenous knowledge of the traditional oil formulation of the Karo ethnic using an ethnoscience approach. The ethnoscience approach is a learning method that reconstructs indigenous science into scientific knowledge. This research is a descriptive qualitative study. Data was collected through a literature review, observations, and interviews with the Karo ethnic residing in Medan. The results show that the Karo oil formulation involves various types of spices, leaves, and roots. There are 56 species of plants used in the processing of Karo oil. The interview results show that Karo oil has many health benefits, including relieving muscle pain, treating cramps, healing wounds and scars, curing colds, and addressing sprains or strains. Based on the results obtained, the study further explores indigenous science using an ethnoscience approach. The reconstruction of indigenous knowledge into scientific knowledge in the processing of Karo oil can be observed in the following stages: 1) The collection of spices applies the concept of friction and pressure, 2) The cooking process of Karo oil applies the concept of solutions and combustion reactions, and 3) The cooling process of Karo oil applies the concept of heat transfer. The integration of karo oil processing into Junior High School science learning can be seen in the topics of classification of living things, chemical reactions and their dynamics, and temperature, heat, and expansion. It can be concluded that the processing of traditional Karo oil is integrated with science learning at the junior high school.*

Keywords: ethnoscience, karo, oil, ethnic, learning,

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Introduction

The Merdeka Curriculum offers students the freedom to learn according to their potential and characteristics. One strategy that can facilitate this is through ethnoscience. Ethnoscience comes from two words: ethno and science. Ethno means culture, while science means knowledge [1]. Therefore, ethnoscience means cultural knowledge. However, etymologically, ethnoscience refers to the indigenous knowledge of a community. Sudarmin defines ethnoscience as a body of knowledge held by a particular community/tribe/nation, acquired through specific methods that are part of the community's tradition and can be empirically tested and validated [2].

In the context of education, ethnoscience is understood as a strategy for creating a learning environment and designing learning experiences that integrate culture into the teaching activities [3]. Ethnoscience is a new finding that integrates science and local culture[4]. Ethnoscience is an instructional approach that uses local knowledge as a source/object of learning, which can be integrated into teaching presented contextually. The ethnoscience approach is designed to address existing challenges, with the expectation that students can learn contextually by utilizing their environment as a learning resource [5].

The relevance of ethnoscience in science education can be seen from research findings that indicate ethnoscience can be integrated into science teaching. For instance, research by Akmal et al. concluded that integrating ethnoscience into the curriculum is effective when ethnoscience is incorporated into core content, and curriculum development should integrate ethnoscience to make the learning process more meaningful and contextual [6]. Furthermore, research by Mukti et al. concluded that ethnoscience can be integrated into science education, even though there are differences between indigenous science and scientific science (natural sciences) [1]. Integration of ethnoscience into teaching can be achieved through teaching materials, learning resources, approaches, methods, models, and media. Integrating ethnoscience into science education can enhance students' understanding of concepts, process skills, character, interest, academic achievement, and critical thinking abilities.

The Karo ethnic group is an ethnic group residing in the highlands of North Sumatra, specifically in the Karo Regency. A distinctive greeting from the Karo ethnic is 'Mejuah-Juah,' which means a wish for peace and good health for the Karo community when they meet. Generally, the Karo ethnic in Karo Land still strongly adhere to their customs and culture, which they believe provide strength in continuing their lives. These customs and traditions then integrate the Karo ethnicity into a very strong sense of familial relationships. The customs and culture of the Karo ethnic have made them aware of the importance of maintaining harmony and good relations within their community.

The Karo ethnic are one of the ethnic groups in North Sumatra, and they continually interact with their natural environment in their daily lives. The Karo community utilizes plants for various needs, such as food, traditional ceremonies, and traditional medicine. This demonstrates that the Karo people are knowledgeable about various illnesses and their treatments. This knowledge is considered one of the local wisdom that has been preserved over time [7]

The indigenous knowledge of the Karo ethnic community is passed down from one generation to the next, inherited directly from their ancestors [7]. Karo oil is a traditional medicine that has been used for generations and continues to be utilized in traditional healing practices today. Karo oil is made from herbs and spices that are handed down from ancestors, cooked or roasted in coconut oil to ensure that the mixture is infused into the oil [8].

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Previous research on traditional medicine and the use of herbal remedies among the Karo ethnic group includes a study conducted by Helen Anjela Simanjuntak and colleagues. The findings revealed that Karo oil can be used to treat various conditions, such as colds, muscle aches, sprains, misalignments, joint issues, stomach acidity, headaches, allergies, cuts, burns, fractures, itching, and bites from venomous animals [9].

This study aims to describe and reconstruct scientific knowledge related to the traditional medicine of the Karo ethnic, specifically Karo oil. The Indigenous knowledge within the community regarding this traditional medicine needs to be explored, investigated and examined and then transformed into scientifically accountable knowledge. The findings will later be integrated into middle school science education materials, as part of an effort to introduce students to Karo traditional medicine and its processing and to connect this knowledge with scientific content and understanding

Methodology

The type of research used in this study is qualitative descriptive research. The subjects who will serve as informants in this study are the local Karo ethnic residing in Medan City. The data sources used in this study are both primary and secondary data. Primary data are obtained through interviews and direct observations of the Karo ethnic, then identification of traditional medicinal ingredients of karo oil in the Biology Laboratory of FMIPA UNIMED. Secondary data are derived from theoretical studies related to the processing and application of karo oil. The stages of the research can be seen in Figure 1 below:

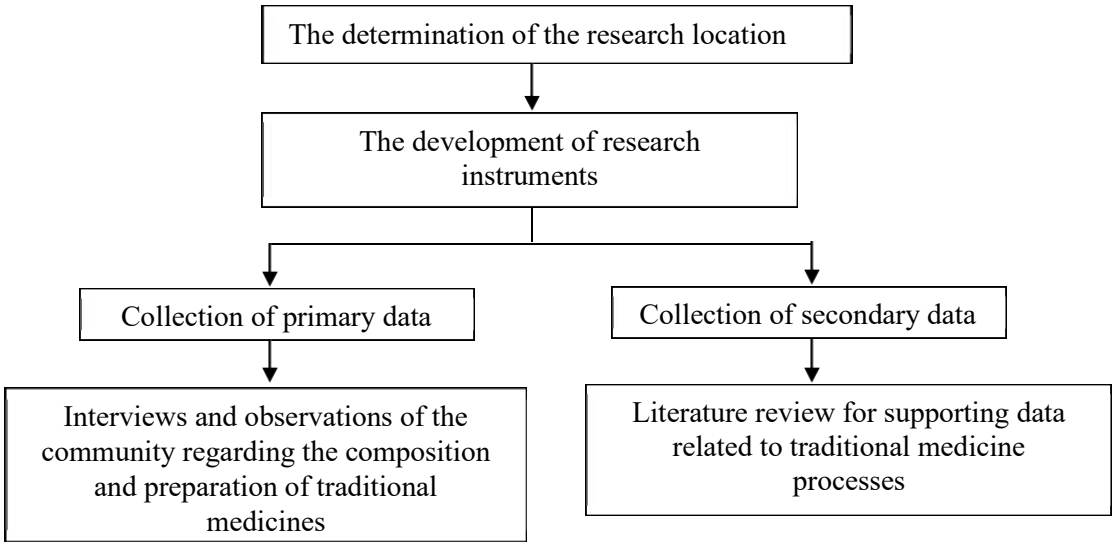

Figure 1. The stages of the research

The primary data, which consist of indigenous knowledge, are analyzed using an ethnoscience approach. The ethnoscience approach is a learning method that reconstructs indigenous science into scientific knowledge. The results of the reconstruction of the community's original knowledge become scientific knowledge and are then integrated into the materials found in the Junior High School Science curriculum. The research flowchart can be seen in Figure 2 below.

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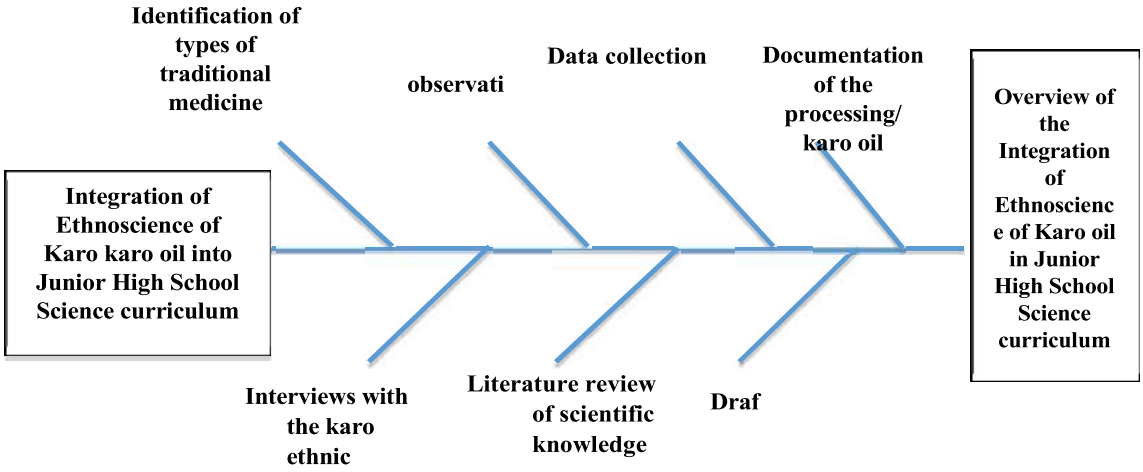

Figure 2. The research flowchart

Results and Discussion

Identification of Karo Oil Composition

The research findings indicate that the processing of Karo oil involves the use of various types of spices, leaves, and roots. There are 56 different types of spice plants used in the processing of Karo oil, as detailed in Table 1

Table 1. Types of plants used in the processing of Karo oil

No	Scientific Name	Local Name	Suku	Used organ
1	*Areca catechu* L	Betel Nut	Arecaceae	Root
2	*Calamus rotang* L	Rattan	Arecaceae	Root
3	*Cycas rumphii*	Pakis haji	Cycadaceae	Leaf
4	*Gynura procumbens* (Lour.) Merr.	Sembung nyawa	Asteraceae	Leaf
5	*Syzygium polyanthum* Miq.	Salam	Myrtaceae	Leaf
6	*Allium cepa* L	Onion	Liliaceae	Umbi
7	*Eugenia grandis* Wight.	takur lebo	Myrtaceae	Leaf
8	*Centella asiatica* (L.)Urb	Pegagan	Apiaceae	Leaf
9	*Sida rhombifolia* L	Sidaguri	Malvaceae	Leaf
10	*Phaleria macrocarpa* L.	Mahkota dewa	Thymelaeaeceae	Leaf
11	*Melaleuca leucadendra* (L.)L	Kayu putih	Myrtaceae	Root, Leaf
12	*Piper aduncum* L.	Sirih hutan	Piperaceae	Leaf
13	*Plectranthus amboinicus* Lour. (Spreng.)	Ikat ayam	Lamiaceae	Leaf
14	*Sansevieria trifasciata* Prain.	Sisik naga	Asparagaceae	Leaf
15	*Pinus* sp.	Pinus	Pinaceae	Leaf
16	*Phyllanthus niruri* L.	Meniran	Phyllanthaceae	Leaf
17	*Cocos viridis*	Kelapa	Arecaceae	Buah
18	*Ocimum sanctum* L.	Ruku-ruku	Lamiaceae	Leaf
19	*Nicotiana taubacum* L.	Tembakau	Solanaceae	Leaf
20	*Acorus calamus* L.	Jerangau	Acoraceae	Root
21	*Senna alata* (L.) Roxb.	Sitiga	Fabaceae	Leaf
22	*Cosmos caudatus* Kunth.	Kiung	Asteraceae	Fruit
23	*Cucumis sativus* L.	Timun	Cucurbiataceae	Fruit
24	*Lagenaria siceraria* (Molina) Standl	Labu air	Cucurbitaceae	Fruit
25	*Euphorbia pulcherrima* Willd.	Gundur, Kastuba	Euphorbiaceae	flower

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No	Scientific Name	Local Name	Suku	Used organ
	ex Klotzsch			
26		Siliguri		flower
27	*Urena lobata* L.	Pulut-pulut	Malvaceae	flower
28	*Zingiber zerumbet* (L.) Roscoe ex Sm.	Garingging	Zingiberaceae	flower
29	*Cucurbita moschata* L.	Labu	Cucurbitaceae	flower
30	*Oryza sativa*	Padi	Poaceae	seed
31	*Piper Betle* L.	Sirih	Piperaceae	Leaf
32	*Allium sativum* L.	Bawang putih	Liliaceae	Umbi, Leaf
33	*Coleus aromaticus* (Roxb.) Benth.	Terbangun	Lamiaceae	Leaf
34	*Cymbopogon nardus* L. (Rendle)	Serai wangi	Poaceae	Leaf, stem
35	*Elettaria cardamomum* L. Maton	Kapulaga	Zingiberaceae	seed
36	*Cinnamomum verum* J. Presl	Gundera	Lauraceae	Leaf, fruit
37	*Gynura divaricate*	Dewa	Asteraceae	Leaf
38	*Lantana camara* L.	Pupuk mula jadi	Verbenaceae	Leaf
39	*Zingiber officinalle* L.	Jahe	Zingiberaceae	Leaf
40	*Curcuma zanthorrhiza* Roxb.	temulawak	Zingiberaceae	Rhizome
41	*Bischovia javanica* Blume	Cingkam	Phyllanthaceae	bark
42	*Cassia alata* L.	Gelinggang	Fabaceae	Leaf
43	*Citrus aurantifolia* L.	Jeruk nipis	Rutaceae	Fruit skin
44	*Imperata cylindrical*	Lalang	Poaceae	Leaf
45	*Carica papaya* L.	papaya	Caricaceae	Leaf
46	*Piper* sp.	Selawan	Piperaceae	Leaf
47	*Hierochloe odorata* (L.) P. Beauv	Rumput manis	Poaceae	Leaf
48	*Mikania micrantha* Kunth.	Sipil-sipil	Asteraceae	Leaf
49	*Blumea balsamifera* (L.) DC	Sembung	Asteraceae	Leaf
50	*Vitis gracilis* Wall.	Gegatan harimau	Vitaceae	Leaf
51	*Myristica fragrans* Houtt.	Pala	Myristicaceae	Fruit,
52	*Sansevieria* sp.	Buntut naga cina	Asparagaceae	Leaf
53	*Kaempferia galangal* L.	Kencur	Zingiberaceae	Rhizome
54	*Curcuma longa* L.	Kunyit	Zingiberaceae	Rhizome
55	*Curcuma heyneana* Valeton & Zijp	Temugiring	Zingiberaceae	Rhizome
56	*Chlorophytum comosum* (Thunb.) Jacques	Paris	Asparagaceae	Leaf

Out of the 56 types of plants used in the production of Karo oil, they belong to 26 different families. The most commonly encountered family is Zingiberaceae, with 7 types (see Figure 3). Zingiberaceae family has traditionally been able to cure various diseases, especially diseases related to pregnancy and hereditary problems. Some plants that are used will work optimally if in the form of concoctions, namely a combination of plants in one herb. This is related to the active substance in the form of secondary metabolites contained in it. Active substances in this family are thought to be stable and work optimally when mixed with active substances contained in other plants [10].

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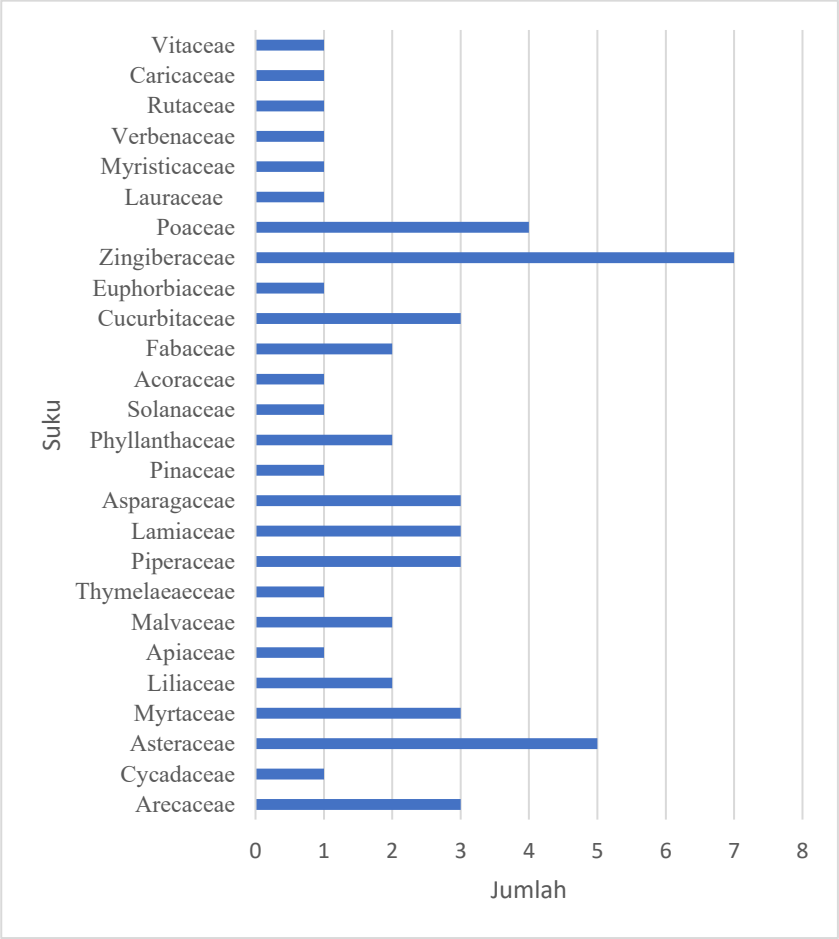

Figure 3. Number of species within each family used in the production of Karo oil

The plant organs used in the processing of Karo oil include roots, leaves, stems, flowers, fruits, seeds, bulbs, and rhizomes. Among these eight organs, leaves are the most commonly used in Karo oil production, accounting for 58% (see Figure 4).

Karo Oil Processing

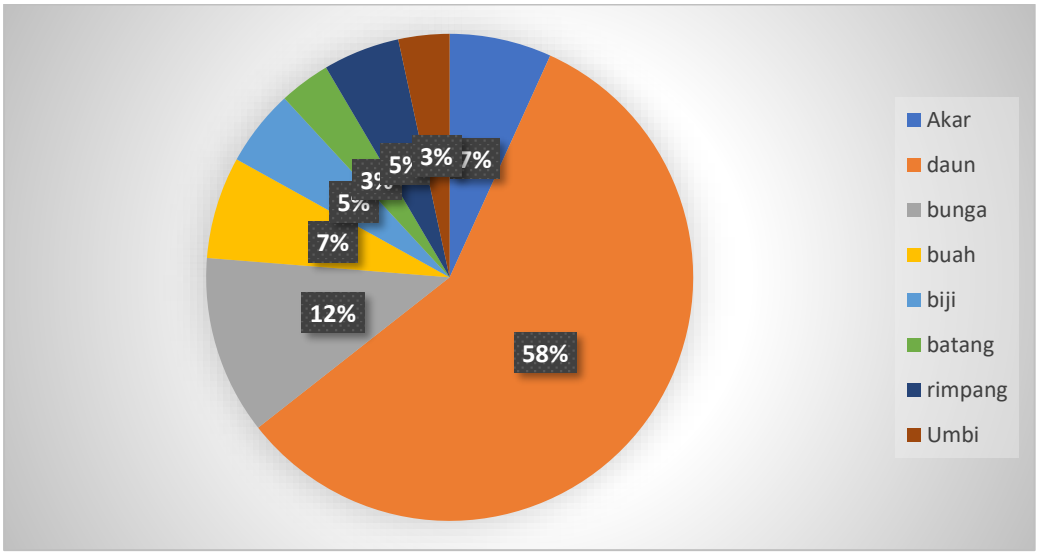

Figure 4. Percentage of plant organs used in the processing of Karo oil.

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The process of making Karo oil begins with cleaning all the available spices, which are then ground into a paste. Freshly squeezed coconut milk is added to a large pan along with the ground spices. Ingredients such as citrus and various leaves are also added to the pan. The mixture is then cooked over medium heat, stirring continuously until it turns a brownish color and has transformed into oil. This process takes quite a long time, approximately 5-7 hours. Afterward, the oil is cooled and filtered before being bottled.

Based on interviews conducted by the researcher with Karo oil producers, it is known that Karo oil has many health benefits, including relieving muscle pain, treating cramps, healing wounds and scars, treating colds, and addressing sprains or strains. Karo oil is also used in the treatment of various conditions such as muscle strain, joint dislocations, acid reflux, headaches, allergies [11], cuts, burns [12] broken bones, itching, and stings from venomous animals

The implementation of ethnoscience in science education can be carried out by reconstructing ethnoscience into scientific knowledge. This approach can help build students' understanding through discovery activities using specific methods that are part of community traditions and can be empirically tested for validity [3]. The indigenous knowledge of t the processing of Karo oil can be reconstructed into science education for junior high school students, as illustrated in Tables 2, 3, and 4 below.

Table 2. Reconstruction of Indegenous Knowledge into Scientific Knowledge in Karo Oil Processing

No.	process	Indegenious science	Scientific knowledge	Explanation
1.	Spice Collection Process	Cleaning and grinding all the spices	Principles of Friction and Pressure	The process of washing spices helps remove microorganisms such as bacteria and fungi. During the grinding process, physical principles such as pressure and friction are involved. When grinding tools (blenders, mortars) use friction to grind the spices, pressure is applied as the spices are pushed towards the blades of the blender. Grinding spices is also a process involving both physical and chemical changes.
2.	Karo Oil Cooking Process	Cook all the ground ingredients, add the fresh coconut milk, and cook over medium heat until it turns into oil, for 5-7 hours.	Solutions and Combustion Reactions	During the cooking of spices and the addition of fresh coconut milk, the dissolution of chemical compounds (essential oils, fatty acids, and aromatic compounds) from these ingredients will merge with the oil produced from the coconut milk. The Karo oil cooking process also includes an example of an oxidation reaction, involving a reaction between the oil (which is largely composed. of triglycerides or fats) and oxygen in the air. The combustion of the oil generates thermal energy to assist in the cooking process.
3	Karo Oil Cooling Process	The finished oil is cooled and filtered.	Principle of Heat Transfer	The filtration process involves the principle of filtering used to separate much smaller particles. The tools commonly used are filter paper or cloth with small pores designed to separate larger particles from the oil. Larger particles are retained by the filter, while the smaller oil particles pass through. In the cooling process, the principles of thermodynamics also affect the cooling of the oil.

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Table 3. Integration of Karo Oil Processing into Junior School Science Curriculum

Biology		
Content	**Basic Competencies**	**Explanation**
Classification of Living Things (Grade 7)	Classify living things and objects based on observed characteristics.	Based on the classification of living things according to taxonomic hierarchy, for example, turmeric leaves are classified as follows: Division Spermatophyta, Class Monocotyledoneae, Order Zingiberales, Family Zingiberaceae, Genus Curcuma, and Species Curcuma domestica..
Chemistry		
Content	**Basic Competencies**	**Explanation**
Chemical Reactions & Their Dynamics (Grade 9)	Understanding pH as a measure of a substance's acidity and using it to classify materials (acids and bases based on their pH)	In the 'combustion reaction,' the process of making Karo oil involves using LPG (liquefied petroleum gas), where this reaction always involves a flame that produces oxygen due to the rapid release of thermal energy. When we use LPG (liquid petroleum gas) for cooking, propane gas is burned. The following is the combustion reaction of propane: C_3H_8 (g) + $5O_2$ (g) → $3CO_2$ (g) + $4H_2O$ (g)
Physics		
Content	**Basic Competencies**	**Explanation**
Temperature, Heat & Thermal Expansion (Grade 7)	Analyzing the concepts of temperature, thermal expansion, heat, heat transfer, and their applications in daily life.	Regarding the temperature used, 'cook over medium heat and stir continuously until the mixture turns brown and becomes oil,' a thermometer can be used to measure this temperature. The principle of a thermometer is based on thermal equilibrium. The thermometer measures the temperature of the surrounding environment or the object being tested. Naturally, heat flows from a higher temperature to a lower temperature. This concept is also known as Black's Principle or the First Law of Thermodynamics.

Based on Tables 2, 3, and 4, it can be concluded that ethnoscience can be integrated with Physics, Chemistry and Biology teaching and learning. Based on the data above, t is evident that the scientific study of ethnoscience, which is then reconstructed into scientific knowledge, aims to transform the negative image and perceptions of indigenous science often viewed as myths or superstitions into valuable and accountable knowledge. This reconstruction is expected to contribute to the preservation of national culture, particularly local traditions that contain scientific values and content.

The integration of the karo oil production process in science learning is an ethnoscience

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approach applied in science learning in junior high schools. According to Tjokorda gde putra wirama, the ethnoscience can be integrated with the natural sciences teaching and learning through the adjustment of the instructional models, materials, and media so that it can emphasize on students' background[13]. The ethnoscience approach has a positive influence on learning science at school, The implementation of the ethno-science approach in science learning is effective in increasing various abilities and skills of students such as thinking skills, problem-solving skills, process skills and scientific literacy [14].

Conclusion

Based on the results obtained, the study further explores indigenous science using an ethnoscience approach. The reconstruction of indigenous knowledge into scientific knowledge in the processing of Karo oil can be observed in the following stages: 1) The collection of spices applies the concept of friction and pressure, 2) The cooking process of Karo oil applies the concept of solutions and combustion reactions, and 3) The cooling process of Karo oil applies the concept of heat transfer. The integration of karo oil processing into Junior High School science learning can be seen in the topics of classification of living things, chemical reactions and their dynamics, and temperature, heat, and expansion. It can be concluded that the processing of traditional Karo oil is integrated with science learning at the junior high school.

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E-comic based on STEM to improve critical thinking skills of elementary school teacher education students

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Abstract: *This study develops learning media for e-comic learning media for science based on STEM (Science, Technology, Engineering and Mathematics) to help students solve their problems. The development of e-comic learning media based on STEM uses ADDIE method which in this study was carried out until the initial product refinement stage. Students' critical thinking skills and motivation after using e-comic learning media for science based on STEM (Science, Technology, Engineering and Mathematics) were measured as a description of the effectiveness of using e-comic learning media based on STEM and as a projection for subsequent research. Based on the research results obtained, the results showed that 1) The media developed was in the form of e-comic based on STEM about 'explore space' for Elementary School Teacher Education Student (PGSD) using the ADDIE model, 2) The developed media met very valid criteria with a percentage of 91,7 % based on the assessment of the validator, 3) The e-comic media developed for students received a positive response and met 'practical' criteria with a percentage of 3,78 %, while the results of the lecture's response received a positive response and met 'very practical' criteria of 90% and could be used in learning.*

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Keywords: e-comic, media, STEM, critical, thinking

Introduction

Elementary School (SD) education units are slowly starting to shift from the 2013 curriculum to the independent curriculum. There are several differences between the two curricula. Although there are differences, there are still similarities between the 2013 and independent curricula. The application of thematic in the 2013 curriculum is almost the same as the independent curriculum, especially those related to Natural Sciences (IPA). The content of IPA which has so far been included in the theme or sub-theme, in the independent curriculum, IPA is integrated with IPS (IPAS).

The difficulty of students in understanding IPA material and integrating it with IPS is a challenge for lecturers to provide learning that can accommodate these needs. Variations in learning media can help students understand the material better and build their creativity. Various learning media must be tested and researched as an effort to maximize learning outcomes. PGSD students who are expected to be able to become future teachers, in addition to being required to master the material, must also be able to learn various learning methods. Innovation in learning media is also considered important to respond to developments in the era.

One of the learning media that is quite interesting to test is electronic comics (hereinafter e-comics). E-comic learning media is quite interesting because it contains learning materials described in the form of pictures and stories. Students' imagination and creativity can be honed through this learning media. In addition, the form of material in the form of pictures makes it easier for students to understand and apply learning materials. It is hoped that through e-comic media, students can better understand the concept of science and integrate it with social studies.

In the context of this research, e-comic learning media was developed in the STEM (Science, Technology, Engineering and Mathematics)-based science course of the Elementary School Teacher Training Program, FIP Unimed. Science Learning courses are often considered difficult courses because they require students to memorize. Conventional science learning methods that emphasize memorization, create a disconnection between science and human life. In fact, science courses must be applicable in everyday human life. STEM can also train students to solve problems, think critically, and creatively [1].

The development of this e-comic learning media will be made in a participatory manner with students. In this development process, students are not only objects but also subjects. So that they are able to apply this e-comic learning method in the teaching and learning process. In the context of PGSD students, this e-comic learning media is expected to be used by elementary school students to improve learning outcomes. Moreover, elementary school students tend to like observation and game learning methods. Science material described through pictures and stories can certainly attract the attention of elementary school students. Various previous studies have also proven that the use of e-comic media for elementary school students has a positive impact on learning [2] [3].

The development of e-comic media as a learning medium is also a response to the rapid development of information technology in the era of the industrial revolution 4.0. Through e-comic media, students not only have to build basic skills in writing stories, but can also train students to use digital devices to a higher level. In addition, the content of the e-comic that will be developed in this study is related to STEM. The stories in the e-comic use STEM material so that they are relevant to the needs of students.

From this study, it is hoped that the development of STEM-based science e-comics can be tested as a learning medium for students in the PGSD FIP Unimed study program. The development of e-comic learning media is expected to be a variation of learning media that can improve the understanding of science concepts in the application of the independent curriculum. Through e-comics, the learning process is expected to be more interesting, relevant to everyday

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human life, and can improve learning outcomes.

The role of e-comic learning media

Comics are often considered as reading media that have no role in the learning process. Comics are only considered as entertainment reading materials that do not contain science. But now, various developments in comics as learning media have been carried out. Comics no longer only contain fictional content, but also science. Just look, the famous biology writer and philosopher, Yuval Noah Harari launched a comic series from his best-selling book Human History. This comic is expected to be able to help younger readers understand the book material. Several knowledge books that talk about nature and the universe are also made in comic form. Comic books like this are very easy to find in bookstores. This means that comics are already considered as one of the learning media. Along with the development of the era, comics are also developed in digital form, known as e-comics.

Various studies show the positive benefits of comics in learning. Research conducted in Mexico [4]. This research is based on the context of Mexico which has a low literacy rate. Through this research, comic media was developed to see its benefits in encouraging literacy rates, especially in the field of sustainable natural sciences. From the results of this study, it was found that comics can reach people with low literacy levels. In addition, the results of the study also illustrate that the comics in this study successfully communicated scientific information well. By using the RIRC method, this study showed that more than 50% of respondents managed to remember the scientific content contained in the comics.

In addition to containing images, comics also emphasize their content on stories. Through stories, science is conveyed to readers. Through stories in comics, students have learned new vocabulary, writing techniques, and also science that is included in the story. This means that literacy skills can be the basic foundation of education built through stories. Various studies also show the positive benefits of stories in the learning process and outcomes.

In the context of science courses, the learning methods used often tend to be boring and irrelevant to everyday life. This is what causes students to be uninterested in studying science more seriously. Therefore, one way to attract students' interest in science courses is to use the storytelling method. We know many entertainment products in the form of films and comics known as science fiction. These entertainment products usually sell well on the market because their stories are interesting. According to Negrete and Latirgue [5], storytelling techniques are interesting in the learning process because:

"Storytelling is an amusing way to create an interest in science. Narratives are attractive and memorable; their structure is familiar to children; they involve the reader in their need for denouement, and use an interpretative language, which encourages thought and dialogue. Also, they liven up the imagination, which in turn has proved to facilitate the learning process"

Furthermore, using storytelling methods in science learning can help connect science with human life. Not only is it useful for encouraging students' interest in learning, but it also makes science relevant and applicable. More broadly, through the storytelling method, science is not reduced to material in educational institutions, but can be of interest to the wider public because of its benefits in life.

STEM-based learning

The development of education in the world continues to produce various breakthroughs and new innovations. One of them is STEM-based learning. STEM (Science, Technology, Engineering and Mathematics) is an educational innovation that began to be widely disseminated in the United States in the 1900s by the National Science Foundation with the aim of creating a workforce and young generation of Americans who are knowledgeable and skilled in the STEM fields so that they will increase the global competitiveness of the United States and excel in the

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fields of science and technology [6]. STEM-based education has now begun to be developed in various countries, such as Japan, Finland, Australia, Taiwan, China, Vietnam, the Philippines, and Malaysia [7]. These developed countries realize the importance of the four STEM fields to face global competition at the international level. They must prepare human resources who can compete with human resources from other developed countries in order to continue to obtain decent employment.

Indonesia has begun to pay attention to this STEM element in its education. This is evident from the implementation of the 2013 curriculum which uses a scientific approach in classroom learning. However, this has not had a real impact on achieving educational goals because the STEM elements in its learning are still separate and unrelated to each other. STEM-based education is carried out by not only strengthening the content of the material in the STEM field separately, but also developing an educational approach that combines science, technology, engineering and mathematics by emphasizing the learning process on solving real problems in everyday life [8].

Method

The research conducted is a type of development research or Research and Development (R&D). "Research and development (R&D) come from two words, namely research and development" [9]. According to Dwi, research and development or Research and Development (R & D) is a type of research that aims to produce products in the field of education to improve or enhance the quality of learning. This researcher refers to the model developed by Dick and Carry, namely, the ADDIE model includes: Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation [10]. The product that will be produced in this study is an E-comic learning media based on Science, Technology, Engineering and Mathematics (STEM) for PGSD FIP Unimed students.

The population in this study were all PGSD FIP Unimed students in the odd semester who had taken the Basic Science Concepts course in Elementary School with a sample of 35 PGSD FIP Unimed students. The data collection technique of this research uses observation, questionnaires, interviews, expert validation questionnaires, teacher response questionnaires, student response questionnaires. Furthermore. data collection techniques using quantitative descriptive will be used for review and improvement materials in the development of this e-comic media. In addition, data analysis techniques include needs questionnaires and validation questionnaires to make them easier to read, so the Likert scale score is used as follows:

Table 1. Score Scale Likert

Information	Score
Very Agree (ST)	5
Agree (S)	4
Disagree (KS)	3
No Agree (TS)	2
Very No Agree (STS)	1

Based on results data the can analyzed with count amount percentage answer the use formula following [11]:

$$P = \frac{\sum x}{\sum x_i} x\ 100\ \%$$

Information :
P : Precentage
Σx : Amount mark answer response in 1 item

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Σx_1 : Total ideal value in item

Results score the Then searching for the average use formula [12]:

$$P = \frac{f}{N} \times 100\%$$

Information :
P : Number presentation data questionnaire
f : Frequency Which searching for
N : amount frequency

Research results

This research and development were carried out to produce an e-comic learning media. The stages of the procedure used are 5 stages of the ADDIE model, the five of which are as follows:

Analyze stage

At this analysis stage, two stages are carried out, namely needs analysis and competency and instructional analysis. Needs analysis is related to the problems and characteristics of students and the software needed in the development stage of learning media. The gap in the use of technology used in the learning process with social reality is one of the causes of the lack of enthusiasm for student participation in the learning process. The use of varied technology can increase student motivation and creativity, in addition, it can make it easier for educators to convey the learning objectives to be achieved.

Based on the results of data analysis and observations, it was found that most students already have personal smartphones, there are LCD projectors in each class and there are wi-fi facilities for internet access purposes. The availability of these facilities and technology needs to be considered in the learning process. Therefore, the packaging of learning media in digital form can later be applied in schools and at home, making technological developments familiar to students. In the end, the developed media can be used as an independent learning medium or as a learning aid in the classroom.

Design stage

The product planning stage (media) is designed with the Pixton application which can be used online. The characters used are elementary school students because these students will later become teachers for elementary school students. The appearance that can attract attention and provide motivation, the stages of e-comic that will be created include planning the background, characters, conversations, facial expressions, and body movements. Researchers also compile each character's conversation according to the storyline that will be displayed in the e-comic. This conversation also goes through an editing process by Indonesian language experts to meet the elements of an interesting comic and in accordance with the age of the reader.

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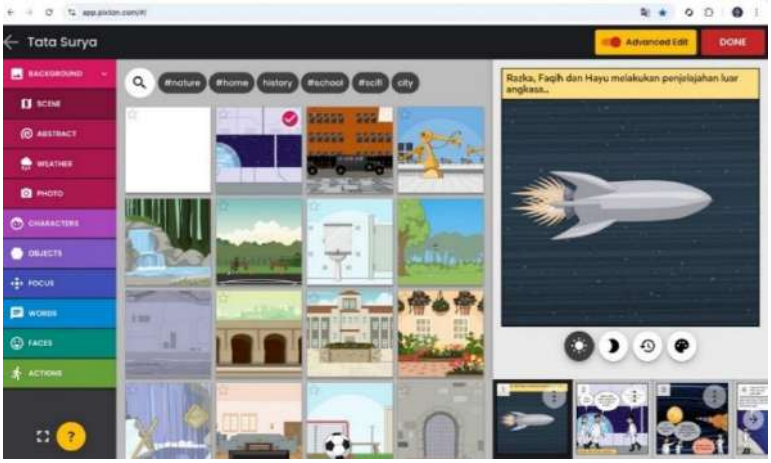

Figure 1. Application menu display by Pixton

In compiling the content of e-comic products, the focus is on presenting illustrations that are in accordance with the topic of discussion and the character of the figure to be displayed. Furthermore, the researcher created an e-comic content framework based on Science, Technology, Engineering and Mathematics and arranged the sequence.

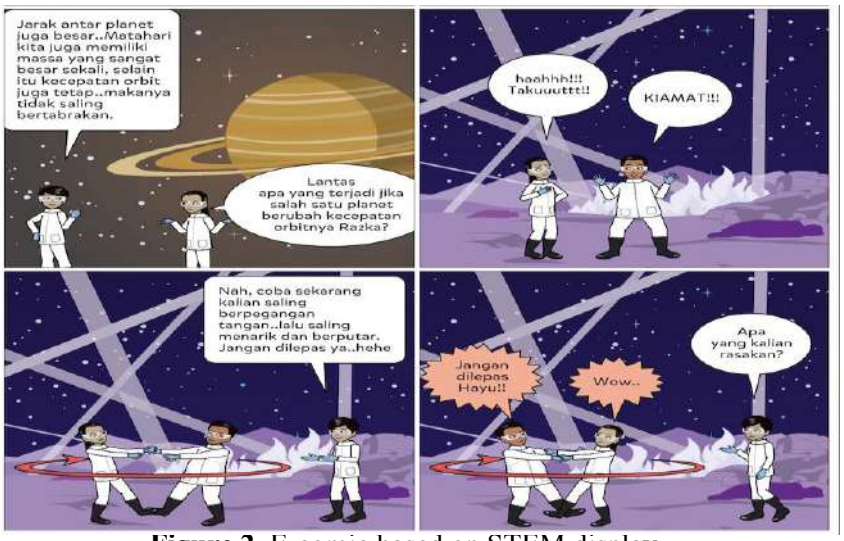

Figure 2. E-comic based on STEM display

Development stage

Project-based e-comic media is currently being developed and adjusted to the demands of project learning and student characteristics. Stages and revisions are carried out at this stage in order to produce a truly valid product, this development stage includes a series of activities including 1) Design development, researchers determine the initial design and the means used in the manufacturing process, namely with the Pixton software program to organize all designs for E-comic media, and Flipbook Software to organize the final appearance of the E-comic media. 2) Validation by material experts, media experts and teachers, from the results of each assessment given by the experts, the media developed is declared valid and suitable for use as learning after revision. The results can be seen in the following table:

Table 2. Results Tabulation Test Expert Material

Percentage Result	Criteria	Information
92 %	Very Worthy	Without Revision

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Tabel 3. Results Tabulation Test Expert Media

Percentage Result	Criteria	Information
89 %	Very Worthy	Without Revision

Tabel 4. Results Tabulation Test Response Lecturer

Percentage Result	Criteria	Information
94 %	Very Worthy	Without Revision

Implementation stage

The implementation stage is carried out by conducting a usability test in the field targeting 35 PGSD students of the Faculty of Education, State University of Medan. The purpose of this stage is to determine the feasibility of the STEM-based e-comic media created by looking at the responses from lecturers and questionnaires that have been created and distributed to students.

Based on the results of the practicality response questionnaire obtained from 35 students, the average score was 3.78%, so this student response questionnaire falls into the 'practical' criteria and it can be concluded that the media developed makes it easy for students to learn to use the media. Meanwhile, the response results from lecturers who also teach the Basic Concepts of Physics and Chemistry courses obtained 90% with the 'very practical' criteria. So, it can be concluded that the STEM-based e-comic media developed by researchers is feasible to use by improving students' critical thinking skills.

Evaluation stage

At this evaluation stage based on the results of the implementation to students who have taken the basic concepts of Physics and Chemistry courses, there are still several shortcomings that must be fixed based on student input to the researcher. (1) The discussion of each character regarding the stages of the experiment or demonstration carried out still has unclear instructions, (2) The implementation time for learning takes longer. From the results of this input, the researcher made improvements to the dialogue of each character, especially when talking when conducting simple experiments or demonstrations. The researcher also revised the stages of learning to be more efficient and effective in implementing this STEM-based e-comic.

Discussion

Research entitled the development of STEM-based e-comic media to improve critical thinking skills of PGSD FIP Unimed students. The research and development procedures carried out used the ADDIE method as a basis for developing the media. This research and development were motivated by the lack of variation in teaching media used by lecturers in the learning process, making students feel bored and most students were passive when lecturers explained or delivered the material. In addition, the independent curriculum that has begun to be applied to students requires them to complete 6 KKNI assignments.

The KKNI assignments faced by students require them to carry out Critical Book Review (CBR), Critical Journal Review (CJR), Mini Research, Idea Engineering and Projects requiring critical thinking skills. According to Alanur [13], the results of their research stated that students need teaching materials/media that are in accordance with their needs, namely those that can deepen the material and support the independent curriculum learning activities implemented by PGSD FIP Unimed. As a result, they can complete the required assignments in the Basic Concepts of Physics and Chemistry courses in the PGSD study program. From several theories and studies that have been carried out that are relevant to this study, researchers collect and analyze data as a basic guideline in developing a new media draft. After the e-comic media draft has been completed, it is continued to the next stage, namely the validation test stage by material experts and lecturers who also teach the same course. Through the results of this validation, assessments, comments, and suggestions for improving the media are obtained. Himmah [14]

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also explained that in her development research, she also used a validity test to measure the feasibility of the product according to the level of each category.

The results of the validation assessment of the STEM-based e-comic learning media to improve the critical thinking skills of students in the PGSD study program that were developed obtained positive results, including material experts getting a percentage of 92%, media experts 89% and lecturers 94%. It can be concluded that the media developed is suitable for use as a learning medium.

The practicality of STEM-based e-comic media is assessed based on the results of the student response questionnaire and the lecturer response questionnaire after the product trial. Testing has been carried out to determine how practical the STEM-based e-comic media that has been developed is. Obtaining the assessment results given by students and lecturers on the trial of the practicality of STEM-based e-comic media, the average percentage of student responses was 3.78% which was categorized as "very practical", while the lecturer's response that gave a positive percentage was 90% and was categorized as "very practical". This shows that this STEM-based e-comic learning media has been proven to be practical for use in learning the concept of the Solar System in the Basic Concepts of Physics and Chemistry courses.

Based on the practical criteria of student and lecturer responses, it can be said that the product developed has very good practical properties and this STEM-based e-comic media meets the very practical criteria, namely: (1) STEM-based e-comic media can improve students' critical thinking skills (2) STEM-based e-comic media can improve students' literacy skills, (3) This STEM-based e-comic media can encourage students to be creative while still upholding the values of Pancasila through the project assignments that have been presented.

Conclusion

Based on the results of research and development, it can be concluded that the process of developing STEM (Science, Technology, Engineering and Mathematics)-based e-comic media for PGSD FIP Unimed students is based on the ADDIE development steps with the following steps: (1) Analysis, (2) Design, (3) Development, (4) Implementation, (5) Evaluation. For wider use, it has been successfully created and tested, by providing an assessment of the feasibility of the media by material experts, media experts and lecturers who teach the Basic Science Concepts course by providing e-comic media. The results of the expert assessment obtained an overall average of 96% from the experts and 94% from the teacher's assessment results which can be said to be very feasible. Meanwhile, in the usability test during the trial of 15 students, the average overall aspect reached 90% which is categorized as very feasible. Therefore, it can be said that STEM-based e-comic media can be used as a learning medium for the Basic Science Concepts course in elementary schools in the PGSD FIP Unimed study program.

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Behavioral determinants of energy conservation in Malaysian universities students

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Abstract. *The rapid increase in energy consumption coupled with the limited availability of resources in developing countries underscores the urgent need for effective energy conservation strategies. However, research on the determinants of energy-conserving behaviors among university students remains limited. This study addresses this critical gap by investigating the factors that influence energy-conserving behaviors among university students in Malaysia. Specifically, it examines the roles of environmental education, attitudes, perceived behavioral control, and intentions in shaping these behaviors grounded in the Theory of Planned Behavior. Employing structural equation modeling (CB-SEM), the study analyzes data collected from 400 university students revealing that environmental education, perceived behavioral control, and attitudes significantly and positively influence students' intentions to engage in energy-saving practices. Among these factors, environmental education emerges as the most influential driving both intentions and actual energy- conserving behaviors. These findings offer actionable insights for Malaysian policymakers aiming to develop and implement targeted energy-saving initiatives. Moreover, the study provides a valuable foundation for stakeholders committed to fostering sustainable behaviors in educational institutions across Malaysia.*

Keywords: determinants, energy, conservation, Malaysian, students

Introduction

A key factor contributing to energy waste is human behavior, particularly in settings where energy consumption is closely tied to daily activities and routines [1]. In educational institutions such as universities, where a large population of students, faculty, and staff interact daily with energy-intensive facilities, understanding and influencing behavior becomes crucial. University students represent a unique demographic whose behaviors, attitudes, and intentions toward energy use not only affect current consumption levels but also have long-term implications as they transition into

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future leaders and decision-makers [2]. Despite the critical role that human behavior plays in energy consumption, there has been relatively little research focused on the energy-saving behaviors of university students [2]. This gap in the literature is significant, given that universities are not only large consumers of energy but also influential in shaping the habits and attitudes of future generations. Understanding how students engage with energy-saving practices is essential for developing targeted interventions and educational programs that can reduce energy waste and promote sustainability within these institutions and beyond.

Given the significant role that universities play in shaping societal norms and values, research into the energy-saving behaviors of university students is of paramount importance. By identifying the factors that drive or hinder energy conservation among students, such research can inform targeted interventions aimed at promoting sustainable practices. Moreover, since universities often serve as microcosms of larger society, insights gained from studying student behaviors can be extrapolated to broader contexts contributing to more effective energy management strategies at the national or even global level.

In Malaysia, where energy management and conservation are pressing concerns, such research is particularly critical. Understanding how students perceive and engage with energy- saving practices can help policymakers and university administrators develop more effective policies and initiatives that not only reduce energy consumption on campus but also instill long- lasting sustainable habits in the wider population. This research, therefore, is not just about reducing energy waste in the short term, but about fostering a culture of sustainability that extends beyond the university environment and into society at large.

This study aims to fill the existing research gap by examining the behavioral determinants of energy conservation among university students in Malaysia. Specifically, it explores the impact of environmental education, attitudes, perceived behavioral control, and intentions on energy-saving behaviors. By employing structural equation modelling (CB-SEM) to analyze data collected from 400 students, this research provides a comprehensive assessment of how these factors influence students' energy-conserving practices.

An appropriate framework for measuring students' intentions to engage in energy- conserving behaviors is the Theory of Planned Behaviors (TPB). Formulated by [3] in 1991, the TPB is an extension of the Theory of Reasoned Action (TRA). Considering behavioral drivers derived from psychological theories provides deeper insight into the key factors that influence behavior from the user's perspective. This understanding can inspire fresh ideas and contribute to the creation of new solutions aimed at fostering sustained energy-saving habits [1]. According to the TPB, intention is the primary motivator for individuals to perform a particular behavior [3]. To evaluate the effectiveness of the TPB, [4] conducted a scoping review of 126 independent studies, concluding that the TPB is one of the most effective models for creating behavioral interventions. For instance, [5] used the TPB to implement several strategies aimed at altering energy behaviors on college campuses in Illinois. They observed a substantial energy saving of up to 50% and noted a positive long-term impact of the intervention. This article can guide scholars in developing more environment-related interventions based on TPB studies. Additionally, the TPB is known for its adaptable structure, allowing the integration of additional variables from other theories. Consequently, this research used the TPB as the foundational theory for creating the Energy Conservation Behaviors Survey (ECOBS). The Theory of Planned Behaviors (TPB) posits that behaviors are influenced by four primary predictors: attitude, subjective norms, perceived behavioral control, and intention. In this study, attitude is defined as the extent to which a student has a positive or negative evaluation of energy conservation. Perceived behavioral control refers

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to a student's belief in their ability to engage in energy conservation. Environmental education is described as a comprehensive learning process that enhances an individual's knowledge about energy conservation and environmental protection through various educational methods. It is crucial to model the influence of these predictors on intention, as intention directly contributes to more positive pro-environmental behavior as illustrated in Figure 1. Building on these theoretical foundations, the current study aims to investigate the relative influence of environmental education, attitudes, perceived behavioral control, and intention on energy-saving behaviors among Malaysian university students.

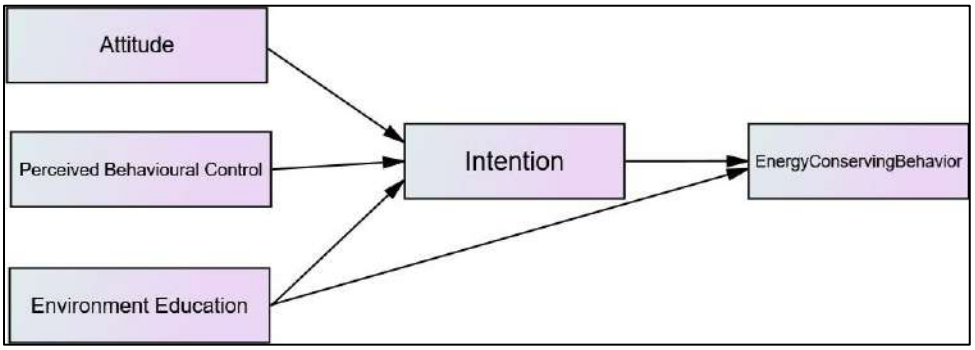

Figure 1. The Conceptual Framework of the Study

Energy conserving behavior

In an era where environmental sustainability has become a global priority, energy conservation plays a critical role in mitigating climate change and ensuring the responsible use of natural resources. Energy-conserving behavior refers to the actions and practices individuals adopt to reduce energy consumption, whether through personal lifestyle choices or the use of more energy-efficient technologies. As the world faces increasing demands for energy alongside dwindling natural resources, cultivating energy-conserving behavior has become essential for addressing environmental challenges.

While many individuals recognize the importance of conserving energy, certain barriers may prevent them from adopting energy-efficient behaviors. These barriers can be both psychological and practical, and the complexity of users' actual behaviors further complicates the implementation of energy-conserving practices [1]. The adoption of energy-conserving behavior is influenced by a variety of factors including personal values, knowledge, external incentives, and social influences. Understanding these factors can help inform policies and initiatives aimed at promoting energy conservation.

One of the most important determinants of energy-conserving behavior is awareness of environmental issues. Individuals who are knowledgeable about the impacts of excessive energy consumption, such as climate change, pollution, and resource depletion, are more likely to adopt conservation behaviors. Educational campaigns, sustainability programs, and environmental advocacy can raise awareness and motivate individuals to act in environmentally responsible ways.

Other than that, social dynamics strongly influence energy-conserving behavior. Individuals are more likely to engage in energy-saving practices when they see their peers, family members, or communities doing the same. Social norms can create a culture of conservation where energy-saving behaviors become a collective responsibility. Public awareness campaigns, peer group discussions, and community-based initiatives can foster positive social norms around energy conservation. Therefore, social norms play a crucial role in shaping both attitudes and perceived

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behavioral control regarding energy conservation among students. Positive social norms surrounding energy-saving practices can foster favorable attitudes, increase students' sense of responsibility, and boost their confidence in performing energy-efficient behaviors. By fostering a supportive social environment where energy conservation is valued and practiced, universities can significantly enhance students' commitment to sustainable practices.

In addition, the relationship between intention and energy-conserving behavior is central to understanding how and why individuals engage in actions that reduce energy consumption. According to the Theory of Planned Behavior [3], intention is the most immediate and significant predictor of behavior. In the context of energy conservation, intention refers to a person's conscious decision or plan to perform energy-saving actions, while energy-conserving behavior refers to the actual practices that reduce energy consumption. Numerous studies show that individuals with strong intentions to conserve energy are more likely to engage in energy- saving practices. Despite the strong link between intention and behavior, there can be an intention-behavior gap where individuals who intend to conserve energy fail to act on their intentions. This gap occurs due to various internal and external barriers such as competing priorities, lack of motivation and situational factors like poor energy infrastructure.

The relationship between attitude and intention to ECB

The relationship between attitude and intention to engage in energy-conserving behavior (ECB) is a well-studied concept within the field of pro-environmental behavior. Attitude refers to an individual's favorable or unfavorable evaluation of energy conservation, while intention represents the commitment or willingness to perform energy-saving actions. A strong positive attitude towards energy conservation is generally associated with a higher intention to engage in such behaviors, particularly among university students.

Research conducted in Hong Kong dormitories [6] has shown that students' attitudes toward energy conservation are positively related to their intention to engage in energy-saving behaviours. When students hold positive attitudes about the importance of saving energy, they are more likely to form strong intentions to take action, such as turning off unused lights, reducing appliance use, or conserving water. This positive relationship suggests that the more favourable students' attitudes toward energy conservation are, the more committed they are to taking steps to reduce their energy consumption.

Previous studies have consistently demonstrated that positive attitudes are strongly linked to behavioral intentions which making attitudes a critical predictor of behavior in various settings. This link is evident in research analyzing the effects of the energy crisis on energy- saving behavior among Romanian youth. The study examined the direct and mediated effects of knowledge on energy saving through attitudes about energy savings on responsible behavior and environmental ethics [7]. The findings identified significant positive relationships between knowledge, attitudes, and subsequent behaviors, reinforcing the idea that fostering positive attitudes can enhance energy-saving actions.

Similarly, research by [8] has shown that the positive attitudes of hospital occupants significantly influenced their intentions to conserve energy which suggesting that positive attitudes toward energy conservation effectively motivate intentions across diverse contexts including residential, institutional, and educational environments. A study conducted at the University of Tehran further supports the importance of attitude revealing that students' attitudes toward energy conservation were relatively strong compared to their social norms, energy-saving intentions, and actual behaviors. Despite their positive outlook, these attitudes did not fully translate into equally

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strong behaviors or intentions. This finding suggests that while attitude plays a central role, other factors such as social norms and behavioral control is likely could moderate the relationship between intention and actual behavior. Thus, considering the above findings, the first research question (RQ1) is formulated as follows:

RQ1: Is there a significant relationship between attitude and the intention to engage in energy conservation behavior (ECB)?

The relationship between perceived behavioral control and intention to ECB

Perceived behavioral control (PBC), as extensively studied and defined by [3], refers to an individual's belief in their capacity to manage or enact a specific behavior. Research consistently indicates that individuals who perceive they possess the necessary resources and opportunities are more intend to adopt that behavior [9]. However, while PBC has been shown to significantly influence various pro-environmental behaviors and intentions, the extent of its impact may vary across different contexts and populations. For instance, [10] identified PBC as a primary determinant of students' intentions and pro-environmental behavior in Portuguese higher education institutions (HEIs), suggesting a crucial role for awareness and dissemination efforts among students to foster environmentally responsible behaviors. This raises important questions about the effectiveness of current educational strategies in enhancing PBC and whether similar results would be observed in other cultural or institutional settings.

Moreover, [11] found that PBC positively affects household energy conservation intentions, highlighting a significant correlation between perceived control and the intention to save energy. This finding aligns with [12] who observed a strong correlation between PBC and the intention to conserve energy in Kuwaiti academic buildings. These studies underscore the critical role of PBC in shaping energy-saving behaviors, yet they also reveal a gap in understanding how these intentions translate into actual behavior.

Furthermore, the implications of these findings suggest that merely recognizing the importance of PBC is insufficient. Developing effective policies and plans by governments and institutions is essential to facilitate the expression of energy conservation intentions and behaviors by users. These measures must go beyond awareness-raising to actively remove barriers that hinder these practices, thereby empowering individuals with greater perceived control. Addressing these obstacles can potentially enhance energy-saving intentions and ultimately contribute to more sustainable energy use. However, future research should critically examine the long-term effectiveness of such policies and whether they lead to sustained behavioral change. Only through a comprehensive approach that integrates psychological insights with practical interventions can we hope to achieve meaningful progress in energy conservation. Hence, the next research question (RQ2) was formulated as follows:

RQ2: Is there a significant relationship between perceived behavioural control and the intention to ECB held by Malaysian university students?

The relationship between environment education and ECB

Environmental Education (EE) plays a critical role in shaping Energy-Conserving Behavior (ECB). By fostering awareness and understanding of environmental issues, EE enhances individuals' cognitive development, which significantly influences their intentions to engage in energy-saving activities. Cognitive development refers to the growth of knowledge, skills, and attitudes necessary for understanding complex environmental issues, and this intellectual framework is crucial in motivating individuals to act in an environmentally conscious manner.

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Among various factors affecting ECB, such as attitudes (att) and pro-environmental behaviors (PEB), EE has been identified as the most significant. This is because EE not only provides individuals with information about the environmental and energy-related consequences of their actions but also equips them with problem-solving skills to address such issues. According to [2], the development of educational programs specifically focused on energy conservation, the implementation of state policies promoting energy efficiency, and the creation of widespread awareness regarding energy conservation issues are instrumental in shaping energy-saving behavior.

When individuals are educated about the importance of energy conservation and how their personal actions contribute to broader environmental outcomes, they are more likely to form positive intentions and take concrete steps toward reducing their energy consumption. EE thus serves as a foundation for fostering a mindset that supports sustainability, encouraging individuals not only to adopt energy-conserving habits but also to advocate for larger systemic changes that support environmental protection. In conclusion, EE significantly impacts ECB by empowering individuals with the necessary knowledge and skills to make informed decisions about their energy use. This, in turn, leads to greater energy conservation at both individual and societal levels. Thus, the third research question:

RQ3: Is there a significant relationship between environment education and the energy- conserving behavior of Malaysian university students?

The relationship between behavioral intention and ECB

Behavioral intention is known as the motivational factor that affect people willingness to execute an action [13]. A strong intention is evident in students' confidence to showcase their commitment to good behavior [14]. Energy-saving intention is linked to the constructs of the Theory of Planned Behavior (TPB) which assess an individual's tendency to conserve energy and their positive or negative evaluation of energy-saving behaviors [12]. Previous studies have shown that energy-saving intention in young people are significantly influenced by PBC [2], EE [15], and positive attitudes [6] toward energy conservation.

Research Methods

The current research employs a cross-sectional causal research design to explore how alterations in independent variables are expected to influence the dependent variable. Information was gathered from a sample of 400 university students in Malaysia higher education institutions, utilizing a multistage sampling approach to ensure more representative sample selection. Data for this study were collected using a standardized closed-ended questionnaire. Table 1 provides an overview of the number of items utilized for each construct, and the scale intervals. The final part of the questionnaire focuses on gathering demographic information from the respondents.

Table 1. Research Instruments Utilized

Construct	No of items	Adapted from	Scale
Attitude	5		
Environment Education	6		
ECB	4	[16]	1-10
Intention	8		
PCB	4		

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Demographic characteristics

The sample consisted of 400 participants, with 46.2% (N=140) identified as male students and 53.8% (N=163) as female students. Regarding their field of study, the majority, 66.0% (n=200), were from science-related fields, whereas 34.0% (n=103) were from non-science disciplines. In terms of age distribution, 17.2% (n=52) of the respondents were between 18 and 19 years old, 24.8% (n=67) were aged 20 to 21 years, 37.0% (n=93) were aged 22 to 23 years, and 30.0% (n=91) were aged 24 to 25 years.

Results and Discussion

Descriptive analysis

The descriptive analysis as in Table 2 was conducted according to the method described by [17] revealed that the attitude toward energy conserving had the highest mean score which averaging 8.64 with a standard deviation of 1.06, which falls under the "very high" category. This suggests that the respondents hold strongly favorable attitudes toward energy conservation which indicating a significant positive evaluation of the importance and benefits of conserving energy.

Overall, the high mean scores across all constructs reflect positive attitudes, strong intentions, and a sense of control over energy conservation behaviors among the students. The variability in environmental education may warrant further exploration to ensure more uniform exposure to energy-saving knowledge across the student population.

Table 2. The Average Mean of the Constructs

Construct	Average Mean	Std. Dev	Indicator
Attitude	8.64	1.06	Very high
Environment Education	6.77	1.99	High
ECB	7.27	1.57	High
Behavioral Intention	7.45	1.36	High
PBC	7.56	1.23	High

Confirmatory factor analysis result

For inferential analysis, this study utilizes structural equation modeling (SEM), with Confirmatory Factor Analysis (CFA) conducted prior to hypothesis model testing. Figure 2 depicts the measurement model utilized in the study, which met the criteria for construct validity as per the minimal fitness indices outlined by [18]. Further details on these indices are provided in Table 3. Table 4 presents factor loading values, Average Variance Extracted (AVE), and Composite Reliability (CR) for the measurement model, indicating that the requirement of unidimensional is satisfied [19].

Table 3. The Assessment of Fit for The Measurement Model

Category	Name of Index	Present model	Comment
Parsimonious Fit	Chisq/df	2.29	Min requirement < 3.0
Incremental fit	CFI	0.96	Min requirement > .85
	TLI	0.95	Min requirement > .85
Absolute fit	RMSEA	0.07	Min requirement < 0.1

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Table 4. Validity and Reliability Test of the Measurement Model

Construct	Item	Factor Loading	CR (> 0.6)	AVE (> 0.5)
Attitude	A1	0.89	0.85	0.66
	A2	0.87		
	A3	0.88		
	A4	0.85		
	A5	0.60		
Environment Education	EE1	0.92	0.89	0.68
	EE2	0.85		
	EE3	0.83		
	EE4	0.81		
	EE5	0.79		
	EE6	0.72		
ECB	ECB1	0.69	0.66	0.53
	ECB2	0.62		
	ECB3	0.77		
	ECB4	0.51		
Behavioral Intention	I1	0.84	0.62	0.61
	I2	0.86		
	I3	0.83		
	I4	0.88		
	I5	0.87		
	I6	0.84		
	I7	0.90		
	I8	0.80		
PBC	PBC1	0.88	0.61	0.60
	PBC2	0.90		
	PBC3	0.92		
	PBC4	0.45		

Moreover, the measurement model satisfies criteria for both convergent validity and reliability with CR and AVE values surpassing 0.6 and 0.5 respectively. Furthermore, correlations among the four study constructs were comparable but not identical suggesting varied relationships between constructs. These findings indicate the absence of multicollinearity as demonstrated by the fact that no correlation coefficient exceeded 0.90 affirming discriminant validity as depicted in Table 5.

Table 5. Summary of Discriminant Validity Indexes for the Pooled CFA Model

Construct	ECB	PBC	ATT	EE	Int
ECB	***0.65***				
PBC	0.22	***0.78***			
ATT	0.25	0.38	***0.83***		
EE	0.30	0.36	0.47	***0.82***	
Int	0.28	0.41	0.46	0.52	***0.85***

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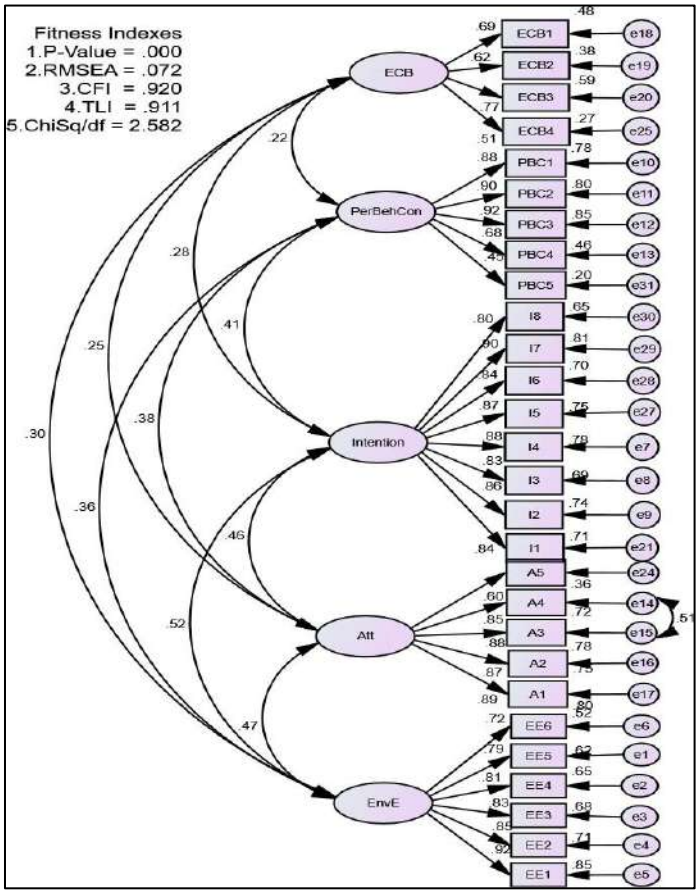

Figure 2. The Pooled-CFA Results to validate five constructs simultaneously

Model testing

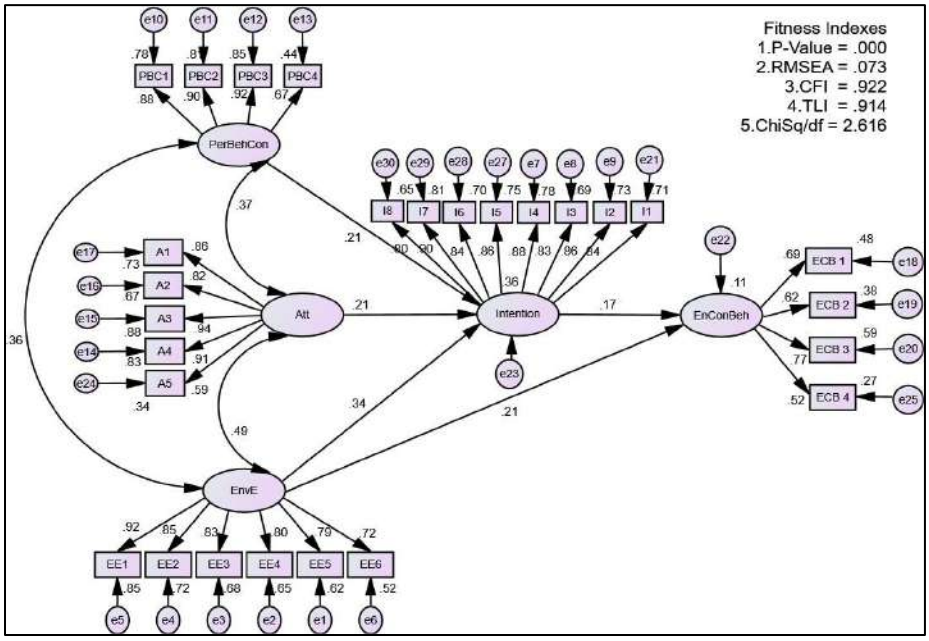

Figure 3. The Standardized Regression Path Coefficient among constructs in the model

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Table 6. The Regression Coefficient and Its Significance

Construct	Path	Construct	Std est.	*p*-value	Result
Intention	<---	Att	0.21	0.002	Significant
Intention	<---	PBC	0.21	0.002	Significant
Intention	<---	EE	0.34	0.001	Significant
ECB	<---	EE	0.21	0.001	Significant
ECB	<---	Intention	0.17	0.001	Significant

The structural equation model (SEM) provides significant insights into the determinants of energy conservation behaviors among university students in Malaysia with good model fit indices (P-value = .000, RMSEA = .073, CFI = .922, TLI = .914, and Chi-Square/df = 2.616). The relationships depicted in the model possibility the mediating role of Intention and the indirect effects of perceived behavioral control (PBC) and attitude on energy conservation behaviors. Not only that, this study contributes significantly to our understanding of how various psychological constructs namely perceived behavioral control (PBC), attitude (ATT), environmental education (EE), and intention (Int) interact to shape energy conservation behaviors among university students. While existing research has widely demonstrated the importance of these constructs individually [20] this study offers a more nuanced understanding by assessing their interrelationships through a hypothesis testing model.

The results from Figure 3 and Table 6 reveal complex relationships between the constructs with varying degrees of significant relationship. Notably, the low pathway value between PBC and ECB ($\beta = 0.21$) indicates that even though students may perceive they have control over their energy conservation behaviors, this perception does not strongly translate into actual behavior. This aligns with previous studies which suggest that perceived control while important, may be insufficient to drive actual behavioral changes in the context of environmental actions [21]. Thus, educators and policymakers might need to explore additional factors such as social norms or external incentives to bridge the gap between perceived control and actual behavior.

Both Perceived Behavioral Control (PBC) and Attitude influence Intention, but neither directly affects Energy conserving Behavior (ECB). Attitude positively affects Intention with a path coefficient of 0.21 indicating that students with more favorable views toward energy conservation are more likely to form strong intentions to engage in pro-environmental actions. However, neither Attitude nor PBC has a direct effect on ECB. Instead, their effects are fully mediated by Intention. This reinforces the idea that while positive attitudes and a sense of control are necessary for shaping intentions, these factors alone are insufficient to directly drive behavior. According to the Theory of Planned Behavior (TPB), Intention is the most immediate predictor of behavior and in this model, it has a positive effect on energy conserving behavior ($\beta = 0.17$). The relatively modest strength of this relationship suggests that although intentions are essential, additional factors may moderate the translation of intentions into actual behavior such as situational or external constraints.

In contrast, the higher correlation between Intention and Environmental Education ($\beta = 0.34$) underscores the importance of self-efficacy in shaping students' behavioral intentions. Students who believe they have the capability to successfully conserve energy are more likely to form strong intentions to act which is consistent with the principles of the Theory of Planned Behaviors (TPB) [9] and Social Cognitive Theory [22]. This finding suggests that fostering a sense of efficacy in students through educational interventions, campaigns, or practical demonstrations could be a critical lever for promoting sustainable energy behaviors.

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These findings carry significant implications for educators and university administrators aiming to foster energy conservation behaviors among students. Initiatives designed to improve attitudes toward energy conservation, strengthen students' sense of efficacy, and clarify their perceived control could collectively enhance students' intentions to act. Furthermore, by recognizing the distinct yet interrelated roles of these psychological factors, educational institutions can develop more targeted interventions that address the specific barriers students face in translating intention into action.

The lack of a strong relationship between PBC and ECB also signals the need for further research. While PBC is typically a strong predictor of behavior in many contexts, its weak relationship with ECB in this study suggests that additional factors may mediate or moderate this relationship. Future research could explore whether external variables, such as social influences or institutional support, play a role in enhancing the effect of PBC on actual behavior.

Conclusion

This study highlights the intricate relationships between Environmental Conservation Behaviors (ECB), Perceived Behavioral Control (PBC), Attitude (ATT), Environmental Education (EE), and Intention (Int) among university students. The findings underscore the pivotal roles of attitude, self-efficacy, and intention in driving energy conservation behaviors, while perceived behavioral control exhibited a weaker influence on actual behavior.

The significant correlation between Intention and Environmental Education suggests that fostering a sense of confidence in students' ability to conserve energy may enhance their intention to engage in such behaviors. Moreover, the strong associations between attitudes and both efficacy and intention emphasize the importance of shaping positive attitudes toward energy conservation as a foundation for promoting sustainable actions.

However, the weak link between PBC and ECB calls for further exploration of additional factors that may mediate or enhance the translation of perceived control into actual behavior. Future research could delve into the role of external influences, such as social norms or institutional support in strengthening this relationship.

From a practical perspective, educational leaders and policymakers should prioritize the development of programs aimed at improving students' attitudes, enhancing their sense of efficacy, and supporting their behavioral intentions. Such efforts could be instrumental in cultivating a culture of energy conservation within academic institutions. Overall, this research contributes to a deeper understanding of the psychological drivers behind energy conservation behaviors and provides a foundation for future interventions aimed at promoting sustainable practices among university students. Further studies, particularly those employing longitudinal or experimental designs will be needed to establish causal relationships and refine the strategies used to influence these behaviors in educational settings.

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Adoption of eco-friendly packaging for biodegradable sustainability: insights from non-premise food handlers in selangor

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Abstract. *Eco-friendly practices have become increasingly important with the growing emphasis on environmental protection and sustainable development. This study focuses on the awareness and knowledge of biodegradable sustainable food packaging amongst food handlers who are street stalls and food trucks operators. The objectives are to assess the awareness levels of licensed food handlers regarding biodegradable packaging, analyse factors influencing purchase intentions, and explore the relationship between purchase intention and behaviour. Data were collected through questionnaires that addressed the demographic information and seven key domains: environmental concern, awareness, community practice, perceived value, government support, purchase intention, and purchase behaviour. The findings indicated that factors, such as environmental concern, awareness, community practice, government support, perceived value, and purchase intention significantly influence the decision to purchase biodegradable packaging in Malaysia. Additionally, this study discusses on its contributions, and offers suggestions for future studies on the adoption of biodegradable sustainable food packaging amongst non-premise food handlers.*

Keywords: Biodegradable packaging, environmental awareness, food handlers, purchase intention, sustainable development.

Introduction

Malaysia is a global player in the plastics industry. Plastics are made from 2.26 million metric tonnes of resin, with total exports worth RM30 billion. As a result, environmental issues associated with plastic garbage have become a major concern in Malaysia, which ranks eighth amongst the top ten countries in the world in terms of uncontrolled plastic waste. Malaysia generates 0.94 million tonnes of incorrectly treated plastic garbage, with 0.14 to 0.37 million tonnes potentially washing into the ocean [1].

The Malaysian government has stated its strong commitment to increase sustainable consumption and production [2]. This is reflected in the 11th Malaysia Plan, which identifies green growth as one of the main strategic thrusts for staying ahead when confronted with environmental challenges. Green products use natural resources, which help to reduce pollution, whereas nonbiodegradable goods like ordinary plastics are nonrecyclable, whereby they will damage the environment over time. Furthermore, plastic-based items contribute to air, water, and soil pollution as well as endangering aquatic species in rivers and streams [3].

Biodegradable food packaging has the potential to reduce carbon emissions [4]. Traditional food packaging frequently entails the use of materials that emit considerable amounts of carbon

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dioxide (CO2) during the manufacturing process. These emissions can include those from raw material extraction, processing, and transportation as well as energy usage in manufacturing [5]. The Selangor state government has defined achievement indicators in the First Selangor Plan (RS-1) to achieve a 35% decrease in greenhouse gases (GHGs) emission intensity by 2025 under the Sustainability Agenda. Furthermore, the RS-1 specifies for Selangor to be a carbon-free state by as early as 2050.

Packaging is defined as the science and technology aimed at ensuring the quality, integrity, and safety of a product, including its technical-commercial functions [6]. [7] defined green packaging as "a packaging product that conserves resources or energy, is easy to recycle or reuse, and can be incinerated or degraded". Food packaging is growing rapidly in the scientific and industrial sectors. It is an important component in the food supply chain, and is a key process element in the food industry. This is due to the increase in the world's population and adherence to strict new food safety regulations [8]. Food packaging plays a fundamental role in the society and acts as an effective protective barrier. Therefore, it protects food from possible physical damage and deterioration, environmental pollution, and other external factors to ensure product quality, safety, and hygiene during its useful life [9]. Food packaging is essential to minimise food waste [10].

Recently, the government focused on the food handlers' willingness to use biodegradable food packaging and consumers' desire to pay for 'green' materials. Multiple studies have found that consumers are willing to pay more for green/sustainable packaging [7,11-12]. However, it should be emphasised that the terms 'green' and 'sustainable' are employed in a very wide sense, whereby the outcome may not necessarily reflect anything about consumers' understanding. Based on previous studies, it may be expected that most consumers take green/sustainable packaging to mean that it is biodegradable, recyclable, or reusable at the end of its life [13-14]. It has been shown that other attributes relating to raw materials, such as made from renewable resources or from recycled material, or the energy efficiency in production, although equally deserving of the title 'green packaging', are less often associated with the term [13]. [15] observed that there was a willingness to pay a premium for recyclable or biodegradable bioplastic for water bottles. Positive sentiment towards sustainable packaging is also demonstrated in a study by [16], who found that one-third of their respondents favoured environmentally friendly packaging, stating it as a key factor influencing product choice.

Therefore, the government through the Ministry of Environment and Water has taken the initiative to ban plastic bags and polystyrene food packaging in support of environmental sustainability and resilience. Awareness campaigns on the negative effects of plastic bags usage have been conducted extensively. Although many campaigns have been launched to preserve the environment, consumers' perception of eco-friendly products remain low [17], and most of them are not well aware of the benefits of green products [18]. This indicates that consumers have misconceptions about the product due to insufficient understanding and information. This is important in spreading awareness and helping to lead the community towards becoming more environmentally friendly. Furthermore, it is expected that by 2030 all plastic packaging placed in the Malaysian market will be reusable, or can be economically recyclable. This is one of the strategies as outlined in the Malaysian Roadmap Towards Zero Single-Use Plastics 2018-2030. To achieve this objective, it is necessary to adopt a circular economic strategy. The main challenge of the circular economy is to close the material cycle as well as keep it as small as possible to maintain the quality of the material needed to fulfil its original function. Therefore, this is important in spreading awareness to every layer of society for this roadmap to be entirely successful.

Street foods are typically ready-to-eat meals that are prepared, organised, and sold by various

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food vendors and hawkers, each representing diverse cultures and backgrounds [19]. Street food vendors can benefit from the use of biodegradable food packaging to enhance sustainability and reduce environmental impact. Biodegradable materials like polyhydroxyalkanoates (PHA), polyhydroxybutyrate (PHB), starch, cellulose, and their derivatives offer high mechanical properties, and can replace conventional plastics in food packaging [20]. These materials can improve the shelf life of highly perishable street food products, while being environmentally friendly and completely degradable [21]. The development of biodegradable food packaging from natural and renewable resources, such as plant extracts and polylactic acid grafted with plant fibre, can provide street food vendors with packaging solutions that decompose quickly and reduce environmental harm [22]. By utilising biodegradable packaging, street food vendors can contribute to a more sustainable food industry by reducing plastic waste and promoting eco-friendly practices.

In order to extend the applicability of Theory of Planned Behaviour (TPB) to this context, this study incorporates additional variables such as environmental concern, awareness, community practice, perceived value, and government support, which are hypothesized to influence consumers' purchase intentions towards biodegradable packaging. The TPB, proposed by Ajzen in 1985, is a widely used theoretical framework in psychology and social sciences for understanding and predicting human behaviour, such as purchase behaviour amongst customers [23]. TPB posits that behavioural intentions are the primary determinant of behaviour, and are influenced by three main constructs: attitudes, subjective norms, and perceived behavioural control [24]. The TPB provides a comprehensive framework for understanding human behaviour by considering the interplay between attitudes, subjective norms, and perceived behavioural control, which consequently influences purchase behaviour. The TPB has been widely applied across various domains or fields, including health psychology, environmental psychology, consumers' behaviour, and organisational behaviour amongst others, to predict and explain consumers' behavioural intention and purchase behaviour.

This study is aimed at achieving the following objectives: to determine the food handlers' awareness on biodegradable food packaging; to determine the relationship between environmental concern, awareness, community practice, perceived value, and government support for purchasing biodegradable food packaging; and to determine the relationship between purchase intention towards purchase behaviour.

Material and Methods

The current research employed data collection using a standardised closed-ended questionnaire. The information was gathered from a sample of 150 non-premise food handlers in Selangor, utilising a convenience sampling method because of the large number of non-premise eateries in the chosen study area.

Conceptual framework

The conceptual framework provides a theoretical foundation that helps researchers and practitioners understand the relationship between various concepts, variables, or factors. As a result, the research emphasises on the relationship of the independent variables (environmental concern, awareness, community practice, perceived value, and government support) towards purchase intention. Furthermore, the analysis will scrutinise the effect of purchase intention on purchase behaviour. The research framework is presented in Figure 1.

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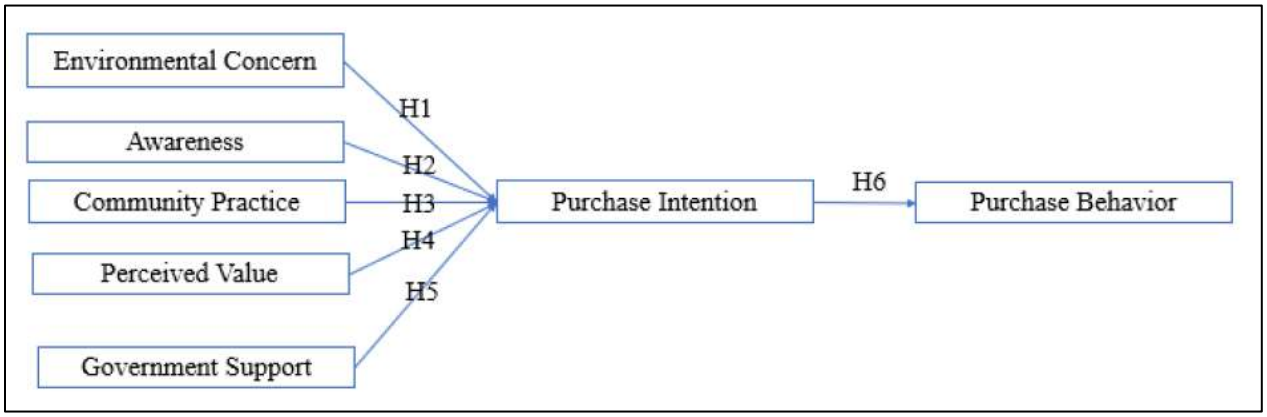

Figure 1. Research Framework

This leads to the development of the following research hypotheses:

H1: There is a correlation between environmental concern and purchase intention.

H2: There is a correlation between food handlers' awareness and purchase intention.

H3: There is a correlation between community practice and purchase intention.

H4: There is a correlation between food handlers' perceived value and purchase intention.

H5: There is a correlation between government support and purchase intention.

H6: There is a correlation between purchase intention and purchase behavior.

Instrument and Questionnaire

The questionnaire was divided into two parts: Part A and Part B, whereby each part contained a set of 43 questions. Part A comprised the demographic factors, such as age, race, education level, types of business, types of packaging materials used, and income per month. Part B covered the elements that influence utilisation, including level of awareness, environmental concern, community practice, perceived value, government support, purchase intention, and purchase behaviour. Furthermore, the questionnaire utilised the Likert scale with a five-point rating scale: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5).

Table 1 provides an overview of the number of items utilised for each construct, the sources of adapted questionnaire, and the scale intervals.

Table 1. Utilised Research Instruments

Construct	No of items	Adapted from	Scale
Environment concern (EC)	5	[25-27]	1 - 5
Awareness (A)	5		1 – 5
Community Practice (CP)	5		1 – 5
Perceived Value (PV)	6		1 – 5
Government Support (GS)	5		1 – 5
Purchase Intention (PI)	5		1 – 5
Purchase Behaviour (PB)	5		1 – 5

Reliability of Items

Reliability is the degree to which the outcome of a measurement, calculation, or specification can be relied on to be correct. Cronbach's alpha is a reliability coefficient that measures how well the elements in a collection are positively associated with one another. The questionnaire is

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acceptable and reliable if the Cronbach's alpha is 0.6 - 0.7, and 0.8 or higher is considered an extremely good reliability [28].

A pilot test was employed to evaluate a limited sample of participants prior to conducting a comprehensive study. By completing this test, it can ensure that the subsequent tests are conducted more smoothly, and that the study's output is improved. Table 2 shows the Cronbach's alpha score that is used to assess the reliability of the pilot test questionnaire.

Table 2. Cronbach's Alpha Scores

Construct	No of items	Cronbach's Alpha
Environment concern (EC)	5	0.883
Awareness (A)	5	0.773
Community Practice (CP)	5	0.929
Perceived Value (PV)	6	0.908
Government Support (GS)	5	0.912
Purchase Intention (PI)	5	0.890
Purchase Behaviour (PB)	5	0.881

As shown in Table 2, all the Cronbach's alpha scores were more than 0.7, indicating that all the items were regarded as having very good reliability.

Interpretation of Mean Score

The questionnaire applied the Likert scale to determine the level of agreement amongst the respondents regarding their adoption of eco-friendly packaging for biodegradable sustainability. Table 3 shows the interpretation of mean score with respect to their scale value that ranged from 1 to 5. Furthermore, the scale had four levels: low, moderately low, moderately high, and high. The interpretation of the mean score for this study follows the guidelines from previous studies [29-30].

Table 3. Interpretation of Mean Score

Mean Score	Interpretation
1.00 – 2.00	Low
2.01 – 3.00	Moderately low
3.01 – 4.00	Moderately high
4.01 – 5.00	High

Correlation Analysis

Relationship between the variable and its strength was analysed using the correlation analysis, which is a frequently used statistical method for data analysis and summarisation.

Table 4: Description of Correlation Analysis

Correlation Coefficient	Strength of Correlation
0.90 to 1.00 (-0.90 to 1.00)	Very high positive (negative correlation
0.70 to 0.90 (-0.70 to -0.90)	High positive (negative) correlation
0.50 to 0.70 (-0.50 to -0.70)	Moderate positive (negative) correlation
0.30 to 0.50 (-0.30 to -0.50)	Low positive (negative) correlation
0.00 to 0.30 (0.00 to -0.30)	Negligible correlation

The correlation coefficient values ranged from -1 to 1. The positive and negative values of the correlation coefficient indicate whether a variable has a positive or negative relationship with each other. The strength of the correlation coefficient is described in Table 4, based on a study by [31]. In this study, the Pearson correlation was utilised to examine whether there is a correlation between

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the adoption of eco-friendly packaging for biodegradable sustainability and factors influencing it.

Results and Discussion

A survey was conducted to gather information on the adoption of eco-friendly packaging for biodegradable sustainability amongst 150 non-premises food handlers. The respondents operate their businesses at street food stalls and food trucks. The samples indicated that the overall demographic was relatively young, with 63.3% of the respondents aged between 21 - 30 years, followed by 20.7% aged between 31 - 40 years. In terms of race, majority of the respondents were Malays (90.0%), followed by the Chinese (4.7%). Amongst the samples, 40.0% were SPM/STPM holders, followed by diploma holders at 40.0%. The distribution of annual income showed that 39.3% of the respondents had an income of below RM1,500, followed by 32.0% with an income of between RM1,500 and RM3,499. The types of packaging materials used included recyclable materials (25.3%), reusable materials (17.3%), eco-friendly materials (26.0%), and non-eco-friendly materials (29.3%). Only 18.0% of the respondents used biodegradable food packaging.

Mean Score for Factors Influencing Food Handlers' Intention

Table 5: Interpretation of mean score

Factors	N	Mean	Interpretation of Mean Score
Environment Concern	150	3.67	Moderately high
Awareness	150	3.57	Moderately high
Community Practice	150	3.36	Moderately high
Perceived Value	150	3.46	Moderately high
Government Support	150	3.34	Moderately high
Purchase Intention	150	3.43	Moderately high
Purchase Behaviour	150	3.69	Moderately high

The mean scores for factors influencing the food handlers' intention to adopt biodegradable food packaging (Table 5), provided valuable insights into the drivers behind this adoption. The interpretation of the mean scores follows the guidelines from studies by [29-30], categorising the scores into four levels: low (1.00 to 2.00), moderately low (2.01 to 3.00), moderately high (3.01 to 4.00), and high (4.01 to 5.00). All factors influencing the adoption intention scored at a moderately high level (3.01 to 4.00). This consistent pattern suggests that a range of factors are significantly contributing to the food handlers' intention to adopt biodegradable packaging. These factors are likely to include environmental concern, awareness, community practices, perceived value, and government support, as previously identified in the study.

Environmental Concern: The moderately high mean score for environmental concern indicated that the food handlers were aware and concerned about environmental issues. This aligns with earlier findings that show a strong environmental consciousness amongst the respondents, further emphasising the importance of ecological considerations in their decision-making process.

Awareness: Awareness of biodegradable food packaging also scored moderately high, suggesting that the food handlers were well-informed about the benefits and availability of such

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packaging. This high level of awareness is crucial, as it underpins their intention to make more sustainable choices.

Community Practice: The moderately high score for community practice highlighted the role of social norms and community involvement in influencing adoption intentions. The food handlers will most likely have a feeling of a sense of responsibility to align with community standards and practices that support sustainability

Perceived Value: The perceived value of biodegradable packaging received a moderately high score as well. This indicated that the food handlers recognise the benefits and advantages of using biodegradable packaging, not only for the environment but also potentially for their business, such as improving brand image and meeting consumers' demand.

Government Support: Government support also scored moderately high, suggesting that the food handlers value, and perhaps they rely on regulatory frameworks, incentives, and support systems provided by the government to facilitate the adoption of sustainable practices.

Assessing Level of Awareness

This section discusses the main factors contributing to the level of awareness amongst food handlers on the use of biodegradable food packaging (BFP). The results were categorised into three groups:

1 = Disagree (strongly disagree and disagree) with awareness regarding the use of BFP.

2 = Neutral with awareness regarding the use of BFP.

3 = Agree (agree and strongly agree) with awareness regarding the use of BFP.

Table 6. Main Factors Contributing to Level of Awareness Amongst Food Handlers in Using Biodegradable Food Packaging

No	Statement	1	2	3
			%	
1	Information about concerns regarding the Malaysian environment	18.5	35.6	45.9
2	Information about those who would like to be involved in environmental protection activities.	17.0	29.6	53.3
3	Information about improving environmental quality in Malaysia.	18.5	31.9	49.6
4	Information supporting the idea of imposing anti-pollution regulations in Malaysia.	20.7	40.0	39.3
5	Information about the preference for environmentally sustainable food packaging over traditional food packaging.	9.6	31.1	59.3

The findings from Table 6 reveal a strong environmental consciousness amongst the respondents, highlighting several key areas of concern and agreement regarding environmental protection in Malaysia. A significant portion of respondents (45.9%) expressed concerns about the Malaysian environment. This suggests that nearly half of the surveyed food handlers are aware and concerned about environmental issues, which could drive their motivation to support and engage in sustainable practices.

More than half of the respondents (53.3%) indicated their willingness to be involved in environmental protection activities. This high level of agreement reflects a proactive attitude towards environmental stewardship amongst the food handlers. Such involvement could range from participating in community clean-up events to adopting more sustainable business practices, indicating a readiness to contribute actively to environmental conservation. Almost half of the respondents (49.6%) agreed on the importance of improving environmental quality in Malaysia.

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This consensus underscores a broad recognition of the need for enhanced environmental efforts, suggesting that initiatives aimed at improving environmental conditions are likely to receive substantial support from the food handlers.

Furthermore, more than one-third of the respondents (39.3%) supported the idea of imposing anti-pollution regulations in Malaysia. While this indicates a significant level of support for regulatory measures, the slightly lower percentage compared to other areas might suggest some reservations about the potential impact of such regulations on their businesses. Nonetheless, this support is crucial for policymakers to consider when designing and implementing effective environmental policies.

The most notable finding was that 59% of respondents showed a preference for environmentally sustainable food packaging over traditional packaging. This strong preference indicates a market shift towards sustainable packaging solutions, driven by consumers' demand and environmental awareness. Food handlers are likely recognising the benefits of biodegradable and sustainable packaging not only for the environment, but also for meeting consumers' expectations and enhancing their market appeal.

These findings demonstrated a considerable level of environmental concern and a strong inclination towards sustainable practices amongst the food handlers in Malaysia. The support for environmental protection activities, improved environmental quality, anti-pollution regulations, and sustainable packaging suggests a favourable landscape for the adoption of eco-friendly initiatives. Policymakers and industry leaders should leverage this positive attitude by providing education, resources, and incentives to further promote and implement sustainable practices within the food industry. Future research could explore the specific barriers and facilitators in adopting these practices to develop more targeted and effective strategies.

Correlation

This section discusses on the correlations amongst environment concern, awareness, community practice, perceived value, government support, purchase intention, and purchase behaviour. Table 7 and Table 8 show the results of the correlation tests.

Table 7: Correlations Tests

		Purchase Intention
Environment Concern	Person Correlation	0.569**
	Sig. (2-tailed)	0.000
Awareness	Person Correlation	0.557**
	Sig. (2-tailed)	0.000
Community Practice	Person Correlation	0.366**
	Sig. (2-tailed)	0.000
Perceived Value	Person Correlation	0.560**
	Sig. (2-tailed)	0.000
Government Support	Person Correlation	0.555**
	Sig. (2-tailed)	0.000
	N	150

**Correlation is significant at the 0.01 level (2-tailed)

Table 7 demonstrates significant positive correlations between various factors and the purchase intention of biodegradable sustainable food packaging amongst the food handlers. Specifically, environmental concern ($r = 0.569$, $p < 0.000$), awareness ($r = 0.557$, $p < 0.000$), community practice ($r = 0.366$, $p < 0.000$), perceived value ($r = 0.560$, $p < 0.000$), and government support (r

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= 0.555, p < 0.000) showed positive correlations with purchase intention. These findings indicated that as the food handlers' concern for the environment, awareness of biodegradable packaging, community practices, perceived value of sustainable packaging, and government support increased, their intention to purchase such packaging also increases.

The strength of these correlations ranged from low to moderate levels, suggesting that while these factors are influential, they are not the sole determinants of purchase intention. Environmental concern, with the highest correlation (r = 0.569), highlighted the significant impact of ecological considerations on purchasing decisions.

Table 8: Correlation Amongst Purchase Intention and Purchase Behaviour

		Purchase Behavior
Purchase Intention	Person Correlation	0.573**
	Sig. (2-tailed)	0.000

This was further supported by Table 8, which showed a moderate positive correlation between purchase intention and purchase behavior (r = 0.573, p < 0.000). This indicated that higher purchase intention was translated into actual purchasing behaviour to a considerable extent.

The moderate correlation between perceived value and purchase intention (r = 0.560) suggested that food handlers, who recognised the benefits and worth of biodegradable packaging were more likely to purchase it. Similarly, government support (r = 0.555) played a crucial role, implying that policies and incentives could enhance the adoption of sustainable packaging practices. The relatively lower correlation between community practice and purchase intention (r = 0.366) might indicate that while community norms and practices influence purchasing decisions, they do so to a lesser extent than individual concerns and perceptions.

Overall, these findings underscored the multifaceted nature of purchase intention, influenced by both personal and external factors [32]. They highlighted the importance of increasing environmental awareness and providing strong governmental support to promote the adoption of biodegradable packaging. Future research can further explore these relationships, and identify additional factors that might strengthen the intention-behaviour link, contributing to more effective strategies for encouraging sustainable practices amongst the food handlers.

Conclusion

This study explores the attitudes, practices, and awareness of food handlers in Selangor on the usage of biodegradable food packaging, providing valuable insights into its adoption in Malaysia, and its implications for environmental sustainability. The key findings are as follows:

1. Level of Awareness: There is a variation in the knowledge amongst the food handlers in Selangor about biodegradable food packaging. While some exhibit good familiarity, others lack awareness.
2. Factors Influencing Purchase Intention: Food handlers' intention to purchase biodegradable packaging are significantly influenced by environmental concern, awareness, community practices, perceived value, and government support.
3. Relationship between Purchase Intention and Behaviour: There is a high correlation between the food handlers' purchase intention and their actual purchasing behaviour,

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indicating that positive attitudes towards biodegradable packaging translate into concrete actions.

These findings reveal substantial potential for encouraging the use of biodegradable food packaging amongst the food handlers in Selangor. However, to fully realise this potential, several opportunities and challenges need to be addressed.

Several recommendations are suggested based on the study's findings:

1. Education and Awareness Programmes: Implement targeted education and awareness campaigns to enhance the food handlers' understanding on biodegradable packaging. These programmes should emphasise on the environmental benefits, cost-effectiveness, and availability of biodegradable alternatives.
2. Government Support and Policy Implementation: The government should create and enforce regulations that promote the use of eco-friendly packaging materials. This can include offering tax incentives, financial support, or mandating the use of biodegradable alternatives through laws and regulations.
3. Industry Collaboration and Innovation: Foster collaboration amongst industry stakeholders, including food suppliers, packaging manufacturers, and governmental organisations, to drive innovation and develop more sustainable packaging solutions. Furthermore, to support research and development initiatives aimed at enhancing the flexibility, affordability, and quality of biodegradable packaging options.
4. Consumer Education and Engagement: Engage consumers through educational campaigns and marketing initiatives to raise awareness about the environmental benefits of biodegradable packaging. Highlight the role of biodegradable packaging in waste reduction and environmental conservation to boost consumers' demand for sustainable products.
5. Monitoring and Evaluation: Establish systems to monitor and evaluate the effectiveness of biodegradable packaging adoption efforts over time. This should include regular assessments of adoption rates, environmental impact evaluations, and feedback mechanisms to identify areas for improvement and refinement.

By addressing these recommendations, stakeholders can significantly advance the adoption of biodegradable food packaging, and thus contributing to environmental sustainability and enhancing the overall quality of life in Malaysia. Future research should continue to explore the barriers and facilitators to adoption, providing further insights for developing effective strategies.

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Media visual simulation (MSV) in the context of madura tourism: its benefits in improving critical thinking skills and understanding of science concepts

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Abstract. *Critical thinking skills and understanding of science concepts are critical to be taught to students. Critical thinking skills will stimulate students' cognitive reasoning in gaining knowledge. Various efforts have been made in multiple countries including Indonesia to improve students' critical thinking skills and understanding of science concepts. One of them is through the implementation of the Independent Curriculum. However, teachers as the determinants of success need to understand well the concept of critical thinking skills and understanding of concepts, as well as how to design science learning strategies that are oriented towards improving students' critical thinking skills. Media Visual Simulation (MSV) in the context of Madura tourism is one media that can be used in science learning. In addition to making science learning meaningful, the use of Media Visual Simulation (MSV) in the context of Madura tourism will support the achievement of improved critical thinking skills and understanding of concepts.*

Keywords: critical thinking skills, Independent Curriculum, Madura Tourism, Media Visual Simulation (MSV), understanding of science concepts.

Introduction

In general, educators' Knowledge of Natural Knowledge (IPA) or science recognizes that low motivation [1] and interest in students [2] to science learning is caused by the burden of material science curriculum [3] too lots for studied [4] and also targeted in exam end [5]. In addition, with the existing curriculum moment, it seems difficult for students to make the connection between scientific knowledge [6] with various problems in life they daily [7]. Therefore, very much needed to provide relevant context in science learning for relationships to the fulfilled [8].

Context in learning should built by the students themselves, including context physical and conceptual [9], with consideration of normative factors or potential values in pushing the involvement of students in science learning [10] so that understanding draft students increases or

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learning becomes meaningful [11]. Learning meaningful can happen thought students if there is no a separation between what is studied with what will understood in the environment [12]. Learning based on context describes an approach in science education that strives to make science learning meaningful for students [13].

One context learning that is lots in demand in science education in today's world is the utilization of Visual Simulation Media (MSV) with local wisdom context. As for the preservation of reserve culture on Madura local wisdom, then should present local wisdom to science learning through education [14]. Use local wisdom to science learning through education this is in line with the implementation Independent Curriculum [15]. Independent Curriculum directs students to explore issues current in activity project learning integrated as ethnoscience with integrate local wisdom in accordance characteristics area to in eye lessons. The importance of integration local wisdom based on studies of ethnoscience in science learning is explained by Luthfi *et al.,* [16] as theory constructivism Vygotsky's social. Vygotsky emphasized the concept of sociocultural which is the use of context social and interaction with students in learning. Vygotsky also believed that the learning process of students is not only in class but also in the middle public.

Science learning using Visual Simulation Media (MSV) with context Madura tourism stated as a powerful strategy to push interest students in Madura to critical thinking skills and understand science concepts [14]- [19]. Visual Simulation Media (MSV) contextualized Madura tourism is defined as a copycat job from the original object [20] tourism in Madura that can seen with eyes on related situations with science [21]. Several studies on MSV implementation have been done on several topics with the purpose of: making it easier for student to contextualize their world [22], developing knowledge/ scientific concepts [23], critical thinking skills [24], and understanding science concept [25]. Critical thinking skills required to analyze science problems up to with stage solve existing problems in context [26].

In general practical, benefits study is : (1) to be guidelines consideration in policy education and observer local wisdom, especially in developing science education teaching and learning based on local wisdom; (2) to be a recommendation for educators in science education and learning for developing character conservation reserve culture; (3) motivating other researchers to do study more carry on about MSV based development local wisdom.

Method

Types of research is a study qualitative descriptive. The article will restrict the discussion to a number of related matters with MSV namely understanding MSV, using MSV to increase understanding of science concepts and critical thinking skills, and correlation results contextual MSV study Madura tourism with draft science material.

A study was carried out in the District Camplong Sampang Regency. This area is located in Beach tourism in Madura, namely Camplong Beach. Research was also conducted at one of the Madrasah Aliyah in Sampang Regency to focus on studying science learning program design. The subject study is a contextual MSV Madura tourism. Subject as sample study obtained uses the technique of nonprobability sampling with purposive sampling with the average judgment of heterogeneous Madurese local wisdom. The object is a researcher & teacher at one of the Madrasah Aliyah in Sampang Regency. Research done September-November 2024.

Data was collected in the form of primary and secondary data. Primary data sources are obtained in a way right on time in the field through interview with source. The method used is an interview deep or observation field with the objective of knowing all related matters with research. The parties involved in primary data are the society in Camplong Beach location Sampang

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Regency. Secondary data sources are obtained from studies literature or documentation in the form of books, reports, internet references, etc. with problem research. The purpose is beneficial in enriching primary data sources. Secondary data is in the form of profile document Camplong Beach Sampang Regency, brochures, and information relevant to others.

Data collection techniques use observation, interviews, and documentation. Observation study is done to observe the existence of all objects on Camplong Beach tourism Sampang Regency. Interview structure used for science learning program design using MSV context Madura tourism, and contribution development character conservation reserve culture. Documentation used for documenting photos and make notes of field results related to observations and interviews with local wisdom results studies in science learning for develop character conservation reserve culture.

Research data analysis uses method analysis presented [27] in the form of data collection, data condensation, data presentation, data extraction conclusion, and verification. Data checking techniques using degrees of trust/credibility by (a) determining the time and schedule study until the appearance point boredom, (b) doing observation in a way consistent, (c) using method data/ source triangulation to test the correctness of the data collected with method compares the result data observation with the data obtained through an interview with the informant.

Result and Discussion

MSV Definition

The use of Visual Simulation Media (MSV) for learning Knowledge of Students' Natural Sciences (IPA) is still very rarely carried out. Visual Simulation Media is a media or tool to help teaching that contains messages of learning [28]. Visual Simulation Media (MSV) can visualize behavior macroscopic and microscopic a phenomenon so that can help students observe phenomena that are not can be observed in a way direct [29], and connect them with phenomena that can be observed in a way direct [30]. Use more visual simulation efficiently from aspect time and also the equipment needed [31]. Virtual simulation media can used with connected to the internet and need more equipment a little so that its use is more efficient from aspect time. Using virtual simulation, students can dig and construct the concept through appropriate observation with draft scientific [32].

MSV Usage Contextual Madura Tourism For Increased Understanding Of Science Concepts And Critical Thinking Skills

Visual Simulation Media is suitably applied as context in science-based learning inquiry and constructivism. Through inquiry/investigation, students will own profit in learning content of Madura tourism and at the same time skills to think critically as well as understanding science concepts. This is cause activity investigation students to Madura tourism provides a strong context in understanding of science concept as important aspects. With placing Visual Simulation Media or context Madura tourism [33], knowledge about understanding science concepts and critical thinking skills in a framework more context-wide, students will study the “what” in a discipline science (in matter this science) is associated with context around those give meaning [34]. For example, result research shows that student school medium studied with studies case experience improvement in understanding of science concept after they were involved in learning with context local wisdom about “Madura keris” [33].

Critical thinking skills is defined as abilities carried out by students so that students can learn methods to overcome problems in a way structured and creative so that they can find various alternative solutions [35]. Reviewed from level in general, there are five aspects of critical thinking

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skills which can implemented in science curriculum and learning. The fifth aspect is (1) to explain in a way simple, (2) determine base taking decision, (3) to conclude, (4) to provide an explanation continue, (5) to estimate and combine [36].

Understanding of science concepts is also used for understanding students about local wisdom and the results study support the need to use local wisdom as context study. Reviewed from the level in general, there are three aspects of understanding draft which can implemented in science learning using Visual Simulation Media context Madura tourism. Third aspect the is (1) translation, (2) interpretation, and (3) extrapolation.

Correlation Results In Contextual MSV Study Madura Tourism With Science Material

On the results contextualized Visual Simulation Media studies Madura tourism is available local wisdom showing load local area. Madura Tourism (in matter is Camplong Beach) was studied from the aspect of object load local and ingredients compiler (science). Madura Tourism (Camplong Beach) which was studied in local wisdom can also made into a learning source and learning media material/concept lessons, which is science. Study of local wisdom will bring up material Science learning through the process of scientific reconstruction (science concepts, laws, theories) from social science (opinions, perceptions, habits, and society). This is because of a number of local wisdom contain science concepts. The correlation results study ethnoscience of Camplong Beach with draft science material are listed in **Table 1** as follows.

Table 1. Correlation Result MSV In The Context of Madura Tourism with Science Material

<table>
<tr><th>Supporting Photos</th><th>Scientific Knowledge</th><th>Material Science</th></tr>
<tr><td rowspan="2">

Tree Shelf Mushroom
(Laetiporus sulfur)</td><td>Mushrooms are types of kingdom fungi that have characteristics that can grow in damp places. Fungi live to obtain food with a method to describe material organic which has dead. The characteristics of mold are no roots, stems, leaves, and chlorophyll. Taxonomic levels from this herbal medicine that is :
<table>
<tr><td>Kingdom</td><td>Fungi</td></tr>
<tr><td>Division</td><td>Basidiomycota</td></tr>
<tr><td>Class</td><td>Agaricomycates</td></tr>
<tr><td>Order</td><td>Polypores</td></tr>
<tr><td>Family</td><td>Fomitopsidaceae</td></tr>
<tr><td>Genus</td><td>Laetiporus</td></tr>
<tr><td>Species</td><td>Laetiporus sulfur</td></tr>
</table></td><td>Classification Living things</td></tr>
<tr><td>Mushrooms grow with spores. Spores are reproductive units cellular single result an organism multiply self or breed.</td><td>Growth and Development (Plant)</td></tr>
</table>

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	One of the contents of mold is natural toxicology or toxic. Toxic content is the result of reaction chemistry that occurs in the metabolism of mushrooms. Mushrooms are toxic Because can contain the compound aflatoxin or muscarine which causes poisoning. Usually, poisoning mold is marked with dizziness and nausea.	Reactions and Dynamics
	• Adaptations made mold For maintaining self from the environment is adaptation physiology. Adaptation This is a change function customized body with the environment. The toxic content found in mushrooms is from adaptation so as not to eat insects or animals. • Interaction mold with creature another life will happen symbiosis nature detrimental (commensalism), things the Because mold No can produce food Alone or nature heterotrophs. For example, the existence of fungi on plants mango besides that which causes trees Already No Can grow sprouting shoots.	Ecology and Biodiversity
 White Wood *(Melaleuca leucadendra)*	Plant wood white before becoming like the oil we know in the market. Plants the processed moreover formerly through method separator mixture that is distillation steam. The process is a method For separate oil essential oils in the leaves use water vapor. Oil leaf wood white entered into the tool distillation the steam underneath there is boiling water. Oil content astiri in the leaves will evaporate together water vapor which then through stage condensation so that the water vapor changed becomes a liquid called oil wood white.	Elements, Compounds and Mixtures

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American Dragon Tongue (Agave americana)	Plant American Dragon Tongue is plants that have bone leaf parallel (recliners). Function from existence bone leaf This is as support leaves to make bones strong. Leaf is a transport organ for the required substance plant in the process of growth and development	Structure and Function Living things
Bougainvillea Flower (Bougainvillea spectabilis)	The difference between cell plants and cell animals namely in chlorophyll. In plants, chlorophyll is located on the leaves that provide pigmentation color leaves. Chlorophyll is in chloroplasts that play a role important in the process of photosynthesis in plants.	Introduction to Cells

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Longitudinal Waves Wave Transfer Water Cycle	The waves generated from sea waves Can include transverse waves can also be including longitudinal waves. Transverse waves are formed when the water waves rise creating a different water level like the existence of hills and valleys. Called One wave when there is One hill and one valley in seawater waves. Longitudinal waves are found in bodies of water that form waves that create compression and expansion. On waves, This particle shifts parallel with direction waves. One longitudinal wave consists of One meeting and one stretch. Formula Vibration Frequency is the amount of vibration in One second (f) f=n/t f = frequency (Hertz) n = Number vibration t = time (seconds) The period is the time required To do One vibration (T) T=t/n T = Period (seconds) n = magnitude vibration t = time (seconds) Wavelength Formula $\lambda = v / f$ λ = length wave (lambda) v = is speed wave f = frequency wave	Vibrations, Waves, and Light
Souvenirs from Shell	Environmental Health can realized with 3R activities, namely reduce (reduce), reuse (use) return) and recycle (recycle) re). Processing return shell coral For decoration is capable reduce the emission of carbon from rubbish shell shellfish that can cause global warming.	Issues Environment

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Dust pan from Rusty Iron	One of the characteristics of iron is young and rusty. Iron can rusting process occurs due to several factors such as water and oxygen, substances impurities, electrolytes, temperature, pH, microbes, and surface metal. There is a reaction chemistry such as the pH of an acidic solution or the existence of contact metal with water or too much oxygen Lots will cause corrosion. Surface uneven metal makes existence the load that plays a role as the anode and cathode that trigger the presence of rust.	Reactions and The Dynamics

In **Table 1** above from results study local wisdom Madura tourism (Camplong Beach) is located various type of science material. Science material contained in Camplong Beach includes Classification Living things, Growth and Development (Plant), Reactions and Dynamics, Ecology and Biodiversity, Elements , Compounds and Mixtures, Structure and Function Living things, Introduction to Cells, Vibrations, Waves, and Light, Issues Environment. All drafts of the science material there is in Basic Competencies (KD) in the 2013 Curriculum and Achievements Learning (CP) in the Independent Curriculum in each level of education, from elementary school to high school/vocational school.

Science material from Camplong Beach to signify results study local wisdom Madura tourism actually can integrated to in Science learning. Function local wisdom will make it easier for students to dig into facts and phenomena that exist in society and are integrated with knowledge scientific [37]. Integration of results study Madura local wisdom context Camplong Beach to in science learning can help students understand the environment around them and what they learn at school in accordance with achievements and goals prescribed learning based on experience contextual [38]. This integration will provide a motivational stimulus for students to construct their knowledge by utilizing culture local to accommodate demands and needs in the learning process.

Conclusion

Contextual Visual Simulation Media Madura tourism uses related topics to science in general intentionally, not held or felt, but can seen from all directions in digital space. Topics the own element additional required moral reasoning or ethics. Utilization of context local wisdom in science learning will support the achievement of understanding of science concepts especially critical thinking skills and science learning becomes more meaningful. In particular, when local wisdom is designed and in a way effective, then students will own profit in matter increasing their understanding of science concepts, and critical thinking skills.

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Unlocking the potential of UNISEL's bird sanctuary lake: visitor perceptions and preferences for nature tourism development

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Abstract. *This study explores the perceptions and preferences of potential visitors to UNISEL's Bird Sanctuary Lake, with the aim of unlocking its potential for nature tourism. Located at Universiti Selangor, the sanctuary offers diverse bird species and scenic landscapes, making it a promising site for eco-tourism. A quantitative survey, using a Likert-scale questionnaire administered to 250 respondents through simple random sampling, was conducted to gather data. Analysis was performed using SPSS version 27, with descriptive statistics including frequencies, means, and standard deviations. The results revealed a high level of interest in nature-based activities such as bird watching, nature trails, and interactive educational programs. Safety and environmental conservation were identified as key factors influencing preferences, while younger respondents expressed greater enthusiasm for these activities. The findings indicate that UNISEL's Bird Sanctuary has significant potential to become a premier nature tourism destination, particularly if educational elements and guided tours are integrated into the visitor experience. Additionally, the sanctuary can contribute to biodiversity conservation and boost the local economy. To maximize its appeal, the study recommends enhancing visitor facilities, improving safety measures, and implementing targeted marketing strategies. These insights provide a foundation for the sustainable development of the Bird Sanctuary Lake as a major attraction for nature tourism.*

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Keywords: biodiversity, bird, sanctuary, eco-tourism, sustainability

Introduction

Nature-based tourism, defined as travel to natural areas for the purpose of enjoying the environment and wildlife, has grown in significance over the past decade [1][2]. This form of tourism not only promotes conservation but also provides economic opportunities for local communities [3]. Bird sanctuaries, in particular, serve as critical ecotourism destinations due to their role in biodiversity conservation and as educational platforms [4][5]. The concept of nature tourism has gained significant attention in recent years, as individuals increasingly seek to connect with the natural world and engage in eco- friendly activities [6]. One such initiative is the establishment of bird sanctuaries, which provide a unique opportunity for people to interact with and appreciate the beauty of nature [7]. Nature tourism has become a significant sector in the tourism industry, offering a unique and enriching experience for tourists [8]. This form of tourism involves visiting natural areas, such as parks, forests, and wildlife reserves, to appreciate and experience the natural environment [9].

UNISEL's Bird Sanctuary Lake, situated on the Bestari Jaya Campus, is home to diverse bird species and has the potential to attract both local and international tourists. Despite its inherent ecological and aesthetic value, the sanctuary remains underutilized. One crucial sign of the success and long-term sustainability of nature-based tourism is the ability to record and react to tourist opinions about a location and its resources [10]. Combining knowledge about nature-based tourism and visitor perceptions and preference towards the nature travel destinations can provide crucial insights for developing a successful nature-based tourism strategy in UNISEL's Bird Sanctuary Lake. Therefore, this research aims to explore the perceptions and preferences of potential visitors, focusing on the UNISEL community and other travellers across Malaysia. By identifying the elements that resonate most with visitors, this study seeks to provide actionable recommendations for developing the sanctuary into a premier nature tourism destination.

Method

Study area description

The Bird Sanctuary Lake at UNISEL is a semi-natural wetland ecosystem that harbors numerous bird species. Its location within the university campus makes it easily accessible to students, faculty, and tourists. The lake has an area of almost 1.5 million square meters, has a depth of 34 feet and the depth of the shallow area is 3 feet. The average depth of the entire lake is around 16 to 22 feet. This lake also becomes a rainwater catchment area if the rainfall exceeds the normal level and becomes the main location for the migration of various bird species.

Data collection

A quantitative research design was adopted, utilizing a structured questionnaire to collect data from a sample of 250 respondents. The survey was administered online using Google Forms and distributed via email and social media platforms targeting the UNISEL community and general travelers in Malaysia. The questionnaire was developed based on existing literature on nature tourism preferences and consisted of demographic questions, as well as items measured on a 7-point Likert scale.

Sample procedure

A simple random sampling technique was employed to ensure a representative sample of the UNISEL community and broader public. Before the full survey, a pilot study involving 50

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participants was conducted to refine the questionnaire and assess its reliability. The final survey was distributed to 250 participants, with responses analyzed using descriptive and inferential statistics.

Survey instrument

The questionnaire was divided into sixth sections: socio-demographic profile, interest in nature tourism, general perceptions of nature tourism destinations, perceptions of UNISEL's Bird Sanctuary Lake, preferences for nature-based activities, and general preferences of attractions and activities at UNISEL's Bird Sanctuary Lake. Apart from the socio-demographic profile and general preferences of attractions and activities at UNISEL's Bird Sanctuary Lake, all items were measured on a 7-point Likert-type scale that ranged from (1) 'strongly disagree' to (7) 'strongly agree'. The Items were designed to capture respondent attitudes towards nature tourism, such as their willingness to visit the sanctuary, activities of interest, and perceived barriers to visitation.

The interpretation of the mean score from Nunnaly and Bernstein (1994) was adopted which categorizes five levels: very low (mean score of 1.0 to 2.2), low (2.3 to 3.4), moderate (3.5 to 4.6), high (4.7 to 5.8), and very high (5.9 to 7.0). These levels were applied to explain respondents' perceptions and preferences regarding the Bird Sanctuary Lake's tourism potential, focusing on their interest in visiting, the attractiveness of the natural environment, and the overall satisfaction with the site's facilities and activities.

Data analysis

Data analysis was performed using SPSS version 26. Descriptive statistics, including frequencies, means, and standard deviations, were used to summarize the socio-demographic characteristics and overall responses. Reliability tests were conducted using Cronbach's alpha to assess the data's reliability and validate the quality of the dataset [12].

Results and Discussion

Respondents' socio-demographic profile

The demographic composition of the sample (n = 250) reflected diversity in gender, age, race, position, education level, and income (Table 1). Female respondents comprised 57% of the sample, while the majority of respondents were between 18-30 years old (51%). In terms of racial diversity, the respondents primarily consisted of Malays (58%), followed by Indians (38%), and a small percentage of Chinese and other races (2% each).

Table 1. Characteristics of Respondents (N=250)

Variables	Frequency	Percentage (%)
Gender		
Male	108	43
Female	142	57
Age		
18-30 years	127	51
31-50 years	107	43
51-60 years	16	6
61 years and above	0	0
Race		
Malay	147	58
Chinese	4	2

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Variables	Frequency	Percentage (%)
Indian	95	38
Others	4	2
Position		
UNISEL Student	95	38
Non-UNISEL Student	37	15
UNISEL Academic staff	61	24
UNISEL Non-Academic staff	19	8
Non-UNISEL Staff	38	15
Education/Level		
SPM/STPM	39	16
Foundation	11	4
Diploma	67	27
Degree	54	22
Master/PhD	79	32
Others	0	0
Income		
No income	94	38
<RM1500	17	7
RM1500-RM3499	55	22
RM3500-RM4999	31	12
RM5000-RM6499	32	13
>RM6500	21	8
Frequency of Visiting Nature Tourism Destinations		
Never	32	13
Rarely	91	36
Occasionally	104	42
Frequently	23	9

Most respondents were students (38%), and 32% held a Master's or PhD degree. Income levels varied, with 38% reporting no income, likely reflecting the large student population in the sample. The frequency of visiting nature tourism destinations varied, with occasional visits being the most common (42%), followed by rare visits (36%). Frequent visitors constituted 9%, while 13% reported never visiting such destinations. This variation in visitation patterns provides insight into the general behavior of the respondents regarding nature-based tourism.

Reliability test

To evaluate the overall internal consistency, Cronbach's alpha reliability coefficient was computed, with Cronbach's alpha (α) ranging from 0.939 to 0.967 for total of 29 indicators. The results demonstrate good internal consistency among the measurements. a Cronbach's alpha value above .70 is considered acceptable, indicating high levels of internal consistency. Therefore, the results demonstrate that the constructs in this study are reliable for all subsequent analyses [12].

Interest in nature travel destinations

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The scores of the overall interest in nature tourism are presented in descending order in Table 2. The results demonstrated a strong interest in nature-based travel, with respondents expressing a clear preference for destinations that provide tranquility and opportunities for outdoor recreation. The highest mean score (M = 5.61, SD = 1.50) was attributed to the desire for tranquility, closely followed by the contribution of natural landscapes to positive travel memories (M = 5.60, SD = 1.47). This aligns with the findings of Newsome et al. (2013), who emphasized the role of natural landscapes in enhancing visitor satisfaction. The analysis of respondents' interest in nature travel destinations, as reflected in Table2, reveals that these two elements—tranquility and memorable natural landscapes—were rated the highest, indicating a strong preference for destinations that offer peaceful environments and contribute positively to personal experiences. These high mean scores reflect a significant inclination towards peaceful and scenic travel experiences, underscoring the importance of tranquility and memorable landscapes in shaping the overall quality of nature tourism.

Conversely, lower mean scores were recorded for elements such as visiting biodiverse places (M = 5.13, SD = 1.57) and engaging in outdoor activities (M = 5.43, SD = 1.60), suggesting that while biodiversity and activity engagement are valued, they are not as critical as the emotional and experiential benefits associated with tranquility and scenic landscapes. This differential in ratings highlights that while environmental factors are important, the experiential and emotional benefits derived from nature tourism play a more central role in shaping visitor preferences.

Table 2. Interest in Nature Travel Destinations (N=250)

No	Nature tourism elements	Mean	Std. Deviation	Level
1.	Visiting biodiverse places is a priority in travel plans.	5.13	1.57	High
2.	Engaging in outdoor activities adds value to trips	5.43	1.60	High
3.	Taking part in adventure activities makes travel experience much more enjoyable.	5.46	1.58	High
4.	Being in nature enhances travel experience.	5.55	1.53	High
5.	Appreciate destinations prioritizing on environmental conservation efforts	5.59	1.53	High
6.	Natural landscapes contribute positively to travel memories	5.60	1.47	High
	Find tranquility in nature-oriented travel destinations	5.61	1.50	High
	Overall	5.48	1.47	High

Preferences for nature travel destinations

The analysis of preferences for nature travel destinations, as illustrated in Table 3, reveals significant trends among respondents. Notably, the highest mean score was recorded for the statement "Travel destinations that prioritize safety" (M = 5.70, SD = 1.60), indicating that safety is a paramount consideration for respondents when choosing nature travel destinations. This preference highlights the critical role of secure environments in enhancing overall travel experiences, suggesting that visitors are more likely to engage in nature tourism when they feel safe.

In contrast, the statement "Actively seek out travel experiences that immerse in natural surroundings" received the lowest mean score (M = 4.93, SD = 1.68). While this aspect still holds importance, it ranks lower compared to more practical factors such as safety and accessibility. The results indicate that although visitors appreciate immersive natural experiences, these preferences are often overshadowed by considerations related to security and logistical ease.'

This pattern underscores a nuanced perspective in which the desire for safety and accessibility

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takes precedence, potentially influencing travel decisions more than the depth of natural immersion. By prioritizing safety and convenience, tourism providers can enhance the attractiveness of nature travel destinations, ensuring that visitors feel comfortable and secure while enjoying the beauty of the natural world. Consequently, integrating measures that promote both safety and accessibility will be essential for attracting a wider audience to nature tourism offerings.

Table 3. Preferences for Nature Travel Destinations (N=250)

No	Nature tourism elements	Mean	St. Deviation	Level
1.	Actively seek out travel experiences that immerse in natural surrounding	4.93	1.68	High
2.	Visiting places with abundant wildlife	5.10	1.69	High
3.	Travel destinations that prioritize environmental conservation efforts.	5.16	1.63	High
4.	Unique ecosystems greatly affect choice of travel destination	5.32	1.61	High
5.	Prioritize easily accessible options when choosing nature travel destinations.	5.46	1.61	High
6.	Prioritize cost-effective options when choosing accommodations for nature travel destinations.	5.48	1.65	High
7.	Travel destinations that prioritize safety.	5.70	1.60	High
	Overall	5.31	1.60	High

Perceptions of the potential visitors towards UNISEL's bird sanctuary lake

Respondents generally had positive perceptions of UNISEL's Bird Sanctuary Lake, particularly in relation to its role in biodiversity conservation (Table 4). This was reflected in the highest mean score (M = 5.37, SD = 1.58), indicating a strong appreciation for the sanctuary's contributions to supporting local biodiversity. The high score underscores the sanctuary's success in positioning itself as a significant contributor to conservation efforts, making it an appealing destination for eco-conscious visitors. These findings suggest that respondents view the sanctuary's role in promoting sustainability and biodiversity as a central element of its attractiveness as a nature tourism destination.

However, the lowest mean score was for the statement "The ecological aspects of UNISEL's Bird Sanctuary Lake are well-known" (M = 4.86, SD = 1.64), revealing a gap in public awareness of the sanctuary's specific ecological significance. While respondents clearly value the sanctuary's contribution to conservation, this lower rating suggests that the broader public remains less informed about its ecological aspects. This finding highlights the need for improved communication and targeted marketing strategies to raise awareness about the sanctuary's environmental importance. Enhanced efforts to communicate the ecological value of the sanctuary could further bolster its appeal as a nature tourism destination, particularly among visitors seeking both recreational and educational experiences.

This contrast between high appreciation for biodiversity efforts and lower awareness of ecological details underscores the critical role of effective communication in shaping visitor perceptions, as supported by Calderón and Thompson [13], who stress the importance of public awareness in promoting nature tourism. The sanctuary's strong appeal as an eco-friendly destination is evident, but to maximize its potential, both conservation efforts and their public visibility must be emphasized to create a more comprehensive and engaging visitor experience.

Table 4. Perceptions Of Unisel's Bird Sanctuary Lake Destinations (N=250)

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No	Nature tourism elements	Mean	Std.Deviation	Level
1.	The ecological aspects of UNISEL's Bird Sanctuary Lake are well-known	4.86	1.64	High
2.	Information about UNISEL's Bird Sanctuary Lake, highlighting attractions for nature tourism, is effectively communicated	4.94	1.63	High
3.	The conservation efforts at UNISEL's Bird Sanctuary Lake plays a significant role in interesting visiting for nature tourism.	5.14	1.62	High
4.	UNISEL's Bird Sanctuary Lake aligns well with preferences for sustainable and responsible tourism practices	5.18	1.61	High
5.	The diverse birds at UNISEL's Bird Sanctuary Lake strongly shapes how I see it as a nature tourism destination.	5.18	1.62	High
6.	Perceive UNISEL's Bird Sanctuary Lake as an exciting and appealing nature tourism destination	5.20	1.57	High
7.	The promotion of UNISEL's Bird Sanctuary Lake as a nature tourism destination aligns with environmental sustainability.	5.34	1.56	High
8.	UNISEL's Bird Sanctuary Lake contributes positively to local biodiversity conservation efforts.	5.37	1.58	High
	Overall	5.15	1.56	High

Preference for UNISEL's bird sanctuary lake destinations

Preferences for activities at the Bird Sanctuary Lake revealed a strong interest in bird-watching, guided nature trails, and interactive educational programs (Table 5). The highest mean scores were observed for "Integrating nature experiences into UNISEL's curriculum" (M = 5.37, SD = 1.62), reflecting a desire for educational value in tourism offerings. This preference highlights the potential of the sanctuary as both an educational and recreational resource, aligning with previous research that emphasizes the educational and recreational benefits of bird sanctuaries [14].

Respondents also expressed a high level of interest in visiting the sanctuary for nature tourism (M = 5.37, SD = 1.68), with the availability of guided tours being another key factor that would enhance their experience (M = 5.37, SD = 1.55). These results suggest that incorporating guided tours and educational components into the visitor experience could significantly increase the sanctuary's appeal. The strong interest in these offerings highlights the sanctuary's potential to serve as both a nature tourism attraction and a platform for environmental education, making it a valuable resource for visitors seeking both leisure and learning opportunities.

In contrast, the lowest mean score was for "Willing to allocate a specific budget for a visit to UNISEL's Bird Sanctuary Lake" (M = 4.95, SD = 1.70), suggesting that while respondents value the educational and experiential aspects of the sanctuary, financial considerations play a less significant role in their decision-making process. This disparity underscores the need for strategic planning that prioritizes enhancing educational and visitor experiences while remaining mindful of potential budget constraints. Focusing on promoting the unique educational and recreational experiences available at the sanctuary, rather than emphasizing cost, could be key to attracting more visitors and maximizing the sanctuary's potential as a nature tourism destination.

Table 5. Preference for Unisel's Bird Sanctuary Lake Destinations (N=250)

No.	Nature tourism elements	Mean	Std. Deviation	Level
1.	Willing to allocate a specific budget for a visit to UNISEL's Bird Sanctuary Lake for nature tourism.	4.95	1.70	High
2.	Involved in activities related to environmental protection at UNISEL's Bird Sanctuary Lake.	5.17	1.65	High

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No.	Nature tourism elements	Mean	Std. Deviation	Level
3.	Believe that visiting UNISEL's Bird Sanctuary Lake would contribute positively to well-being.	5.17	1.65	High
4.	Recommend UNISEL's Bird Sanctuary Lake as a nature tourism destination to friends or family.	5.22	1.63	High
5.	The accessibility of UNISEL's Bird Sanctuary Lake would significantly impacts decision to visit.	5.34	1.60	High
6.	The availability of guided tours would enhance experience at UNISEL's Bird Sanctuary Lake.	5.37	1.55	High
7.	Integrating nature experiences at UNISEL's Bird Sanctuary Lake into the curriculum at UNISEL would enhance the educational experience.	5.37	1.62	High
	Overall	5.23	1.55	High

General preferences of attractions and activities at UNISEL's bird sanctuary lake

Figure 1 displays the survey responses regarding General Preferences of Attractions and Activities at UNISEL's Bird Sanctuary Lake of various attractions and activities. The results indicate a strong preference for attractions that emphasize interaction with nature and education. Guided bird-watching tours, bird conservation volunteer programs, and photography stations garnered the most support, with over 80% of respondents expressing interest in these activities. This aligns with the findings of Sekercioglu [15], who identified bird-watching and photography as significant drivers of nature-based tourism. These preferences, as shown in the survey results, underscore a clear trend towards blending educational, recreational, and interactive elements, which positions UNISEL's Bird Sanctuary Lake as a prime eco-tourism destination and an educational resource.

However, there was some noticeable disagreement among respondents regarding certain attractions. For instance, the bird-themed café and gift shop, while still highly favored with around 85% and 80% agreement respectively, also received a significant proportion of negative responses. Around 10-15% of respondents indicated they were not interested in these commercial aspects, suggesting that not all visitors prioritize amenities designed for revenue generation. This is consistent with Goodwin [16], who found that some segments of eco-tourists seek a more nature-focused experience, free from commercialization.

Another area of disagreement was observed in the bird-themed art installations or sculptures, where approximately 25% of respondents were not in favor. This might reflect a divide between those who prefer purely natural experiences and others who appreciate art as part of the wildlife sanctuary experience. Hvenegaard [17] noted that while art can enhance the aesthetic and educational value of eco-tourism sites, some visitors perceive it as detracting from the natural environment.

In terms of hands-on experiences, while bird feeding and interaction zones received around 80% agreement, there was a substantial minority (about 20%) who opposed these attractions. This may be due to concerns over ethical treatment of wildlife, as emphasized by Hughes et al [18], who warned that interactive wildlife activities can sometimes conflict with conservation ethics, especially when animals are overly exposed to human contact.

The canopy walkways and bird rehabilitation and rescue center were also areas where slight disagreement was observed. Although these attractions received about 78% and 77% agreement, approximately 22-23% of respondents were not in favor. This may stem from concerns about safety or a preference for more grounded, less immersive experiences. According to Ballantyne

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and Packer [19], while immersive experiences are generally well-received, they may not appeal to all demographics, particularly those who are less adventurous.

Despite these pockets of disagreement, the environmental education center (about 78% agreement) and informational signage about local bird species (around 80% agreement) remained popular, although about 20-22% of respondents expressed little interest. This suggests that while most visitors value educational content, a segment of the audience may prefer more leisurely activities rather than structured learning environments. This observation is consistent with Ryan et al. [20], who noted that not all nature tourists are motivated by educational opportunities, with some seeking purely recreational or relaxation-focused experiences.

The amphitheater for bird-related shows also highlighted some disagreement, with around 18% of respondents not supporting the idea despite 82% agreement. This opposition could be due to concerns about the appropriateness of performing shows within a sanctuary setting, as Buckley [7] discussed in his analysis of wildlife tourism, where entertainment-based attractions can sometimes conflict with conservation messaging.

Lastly, while bird observation points, guided nature trails, and aviaries showcasing diverse bird species enjoyed high approval rates (85%, 83%, and 85% agreement respectively), it is worth noting that 10-15% of respondents were not in favor of these activities. This could be explained by a preference for more relaxed, passive experiences, or by accessibility issues that deter some individuals from engaging in more active or immersive attractions. Balmford et al. [21] found that accessibility and visitor comfort are key considerations when designing nature-based experiences to cater to a broader audience.

Overall, bird-watching activities reached a notable 90% agreement, highlighting the sanctuary's strong potential to attract visitors through avian-related experiences. However, the disagreement across various attractions suggests that while the majority of visitors are enthusiastic about interactive and educational experiences, a significant minority prefers a more traditional, non-commercial, and less immersive approach to nature tourism. To fully meet the diverse preferences of its visitors, UNISEL's Bird Sanctuary Lake should balance conservation education, immersive activities, and passive recreation. By catering to both adventurous and leisure-oriented visitors, the sanctuary can enhance its appeal while promoting environmental stewardship and sustainable tourism practices.

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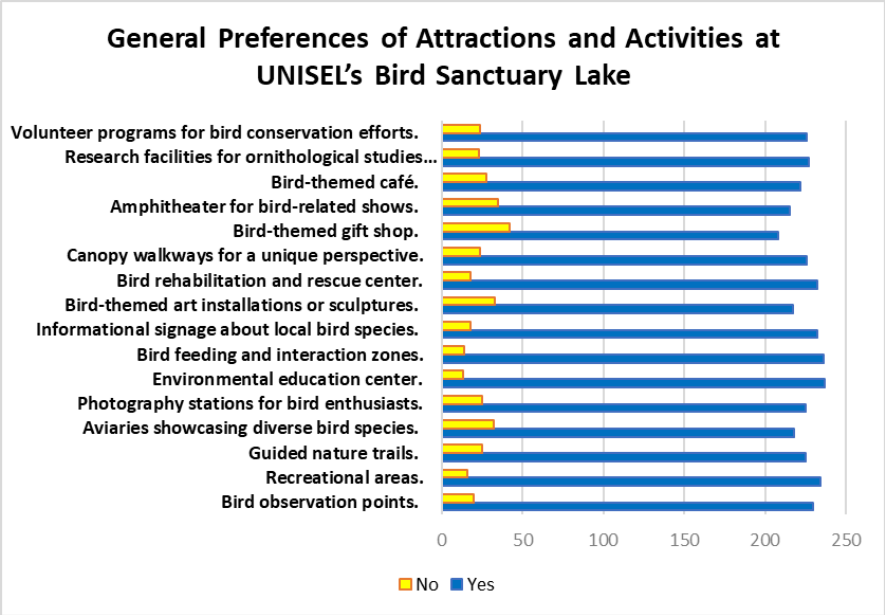

Figure 1. General Preferences of Attractions and Activities at Unisel's Bird Sanctuary Lake

Conclusion

This study provides valuable insights into the perceptions and preferences of potential visitors towards nature tourism at UNISEL's Bird Sanctuary Lake. The findings suggest a strong interest in educational and recreational activities, particularly bird-watching and nature trails. However, there is a need to raise awareness about the ecological significance of the sanctuary and to improve the accessibility of information to potential visitors. The study highlights the importance of aligning nature tourism offerings with visitor preferences to maximize the sanctuary's appeal. UNISEL can leverage these insights to position the Bird Sanctuary Lake as a premier nature tourism destination, contributing to both local conservation efforts and the university's sustainability goals. In fact, policymakers, conservationists, and tourism operators can also use these insights to craft strategies that ensure the ecological integrity of the UNISEL's Bird Sanctuary Lake is preserved while maximizing its tourism potential.

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