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The Effect of Learning Modelsand Mathematically Thinking Ability on Chemistry Learning Outcome in Stoichiometry

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ABSTRACT

This research aims to know the effect of learning models (Problem Based Learning and Direct Instruction) and mathematical thinking ability and interaction between learning models and mathematical thinking ability to student's chemistry learning outcome on stoichiometry subject.. The research was conducted in class X SMA N 20 Medan T. A. 2016/2017. The population in this research is all students of class X SMA N 20 Medan, which consists of 3 classes. The sample used in this study consisted of two classes taken by random sampling, is one class was experimental class I (using PBL model) and one more class as experiment II (using DImodel), which consists of 34 students each of the class. Instrument in this research is test instrument, in the form of matter - subject of stoichiometric to measure student's chemistry learning result (multiple choice) as many as 40 items that have fulfilled the requirement (validity, reliability, difficulty level, differentiator, distructor) and test instrument in the form of problem mathematical thinking related to calculation and logical reasoning to measure students' mathematical thinking ability of 30 eligible items (validity, reliability).Hypothesis test is done by Analysis of Varians / ANAVA 2 × 2. From the calculation result, obtained the value of Fcount (A) for learning models factor is 4,242 ; the value of Fcount (B) for mathematical thinking ability factor is 11,685; the value of Fcount (AB) for the interaction between learning models and mathematical thinking ability is 5,357 ; while the value of Ftable is 3,99. Thus, the results of research data indicate that the value of Fcount >Ftable, so it can be concluded that Ha is accepted, it means there is an effect of learning models and mathematical thinking ability to student's chemistry learning outcome, and there is an interaction between learning models and mathematical thinking ability to student's chemistry learning outcome.

Keywords: chemistrylearning outcomes, problem based learning model, direct instruction model, mathematically thinking ability

INTRODUCTION

Chemistry is a subject that must be mastered by students of Natural Science Majors because it entered into the national exam. However, at this time, the student's level mastery of chemistry lesson is still slow. Amiroh (2015), states thatchemistry includes a difficult lesson for many students, because chemistry is concerned with the structure of matter. In its study, chemistry combines many concepts, so it has an important role for the development of other science. One of the problems faced is the weakness of the learning process. In the learning process, children are less actively encouraged to develop their thinking skills. The learning process in the classroom is directed to child's ability to memorize information, the child's brain is forced to remember and hoard information without being required to connect it with daily life. Consequently, the students are theoretically smart, but poor applications (Sumar, 2016).

Stoichiometry is one of the chemical matter, in which there is a concept of the reaction's equation. This concept is a bridge to study the whole concept of chemistry. Stoichiometry is a study of quantitative relationships in chemical reactions (Winarni, 2013). Furthermore, Amiroh (2015) argues that stoichiometry is a science that studies the quantitative aspect or chemical formula that includes the concept of mole, chemical calculations, chemical reactions and others. Students also still have difficulty in studying stoichiometry because of its complexity of doing calculations requiring an understanding of the concept of moles, composing and balancing the equation of chemical reactions, algebraic skills, the interpretation of the word equation into steps that lead to the correct answer.

Correspondingly, Zulmividya (2016) reveals that stoichiometry is real and needs to combine understanding of concepts and applications. This material also requires good mathematical skills and understanding of concepts, as well as a logical reasoning in problem solving.Stoichiometry material also often makes students difficult to understand the concept that resulted in students can't apply it when answering questions.According to Isofiyah (2016), that stoichiometry learning is still often done with a teacher centered model and students are less involved, so students feel tired and less motivated to understand more personally about the material.

In solving the calculation questions on stoichiometry, students need to encourage their thinking skills, this is in line with the purpose of studying chemistry.One of ability possessed by a person is the ability to think mathematically. Mason (2010), mentions that mathematical thinking is about the process of mathematics, and not about any particular branch of mathematics. Furthermore, Devlin (2012) states that the ability to think mathematically is not the same as doing the math that usually involves the application of procedures and the task of symbolic manipulation. Instead, mathematical thinking is a specific way of thinking things that should not be about math, although certain parts of mathematics provide an ideal context about learning how to think. Mathematical thinking includes logical and analytical thinking as well as quantitative reasoning. This mathematical study is known as formal logic or mathematical logic.

The mathematical thinking (logical - mathematical) ability of a person can be categorized into high mathematical thinking and low mathematical thinking.In developing low mathematical thinking skills, direct instruction, proven to be very effective, and procedural.The research of Peterson and Fennema, in 1985 (in Ali, 2007) on mathematics learning, it is said that certain types of activities developed through direct instruction are more suitable for improving low-level thinking skills, while other learning activities developed through learning are not directly more successfully improve the ability of high-level mathematical thinking students.

According with the characteristics of stoichiometry material that has been described previously, it is necessary an effort to optimize the learning of chemistry in the classroom, so that students more actively encourage their ability to think and better understand and master the material by applying the model and the appropriate method of learning.One of the recommended learning models for use in the curriculum of 2013 is the Problem Based Learning (PBL) model.Istarani (2012), suggests that problem-based learning (Problem Based Instruction) is one of the learning models centered on the students by way of confronting the students with various problems faced in life.Then, Djamarah (in Istarani, 2012) argues that the problem-based learning model is not just a model of teaching, but also a model of thinking, because in solving problems can use other models that begin by looking for data to draw conclusions.

Based on researchby Siahaan (2014) on the application of learning model of Problem Based Learning with scientific approach, has been able to improve students' chemistry learning on stoichiometry subject of 83.94%. Another research is Aiga Elisa (2014) on the implementation of Cooperative Problem Based Learning model, can also improve students' chemical learning outcomes of 75, 15% as well as foster student communicative attitude.In improving learning, teachers can also use Direct Instruction (DI) model. Based on research by HMukarramah dkk (2012), that by using direct learning model (DI), can improve student's achievement of class X SMA PGRI Pekanbaru of 17.98% on the subject of hydrocarbons.Furthermore, Sofiyah (2010) also stated that using Direct Instruction (DI) model can improve student learning outcomes which is indicated by the acquisition of average post - test value is 63,7 then the average pre - test value is 53,6.

The description above, shows that this study aims to determine the effect of learning models and the ability to think mathematically on the students 'chemistry learning outcomes on the subject of stoichiometry and to know the interaction between the learning model and the ability to think mathematically on the students' chemistry learning on the subject of stoichiometry.

MATERIALS AND METHODS

This research was conducted in SMA N 20 Medan class X IPA even semester of academic year 2016/2017. Population in this research is all student of class X IPA SMA N 20 Medan. The sample used in this study, consisting of two classes taken by random sampling, one class is an experimental class I (using PBL model) and one more class as experiment II (using the DI model), each class consists of 34 students.The research design used is 2 × 2 factorial design. There are two factors studied, namely learning model factor (A) and mathematical thinking ability factor (B). Factor A has two levels, namely the learning model of Problem Based Learning and Direct Instruction. For factor B has two levels namely the ability to think mathematically high and low.

RESULTS AND DISCUSSION

The data collected in this study includes : data of mathematical thinking ability and student's chemical learning result. The data of students 'mathematical thinking ability are grouped into two categories: high mathematical thinking ability for students who have the value of mathematical thinking ability ≥ the average value of students' mathematical thinking ability.Then, the category of low mathematical thinking ability for students who have a value of mathematical thinking ability ≤ average score of students' mathematical thinking ability.

Data of students' chemistry learning result in this research is obtained from the test of learning result. For the students who were taught using PBL model with high mathematical thinking ability, the average of learning result (86,718 ± 5,455) was obtained, for the class that was learned using PBL model with low mathematical thinking ability, it was obtained the average of learning result (78,89 ± 4,22).For the class that is learned using the DI model with high mathematical thinking ability obtained by the average of learning result (80,5 ± 6,892). For the class that was learned using the DI model with low mathematical thinking ability, the average learning outcomes (79,21 ± 5,716) were obtained. The average details of the chemistry learning results obtained by the students for each treatment combination are presented in table below:

Table 1. Mean of Student Chemical Learning Outcomes Combined Treatment of Learning Models and Mathematical Thinking Abilities

Mathematically Thinking (B)	Model Pembelajaran (A)	
	PBL model with mathematical thinking (A_1)	DImodel with mathematical thinking (A_2)
High (B_1)	(86,718 ± 5,455)	(80,5 ± 6,892)
Low (B_2)	(78,89 ± 4,22)	(79,21 ± 5,716)

Hypothesis testing is done by Analysis of Variance (ANAVA) test at α = 0,05 with criterion if Fcount> Ftable, then Ho is rejected. Based on hypothesis test of data of student learning result, it can be concluded that there is interaction between learning model (A) with mathematical thinking ability (B) toward high school students' chemistry learning result. Anava list of high school student grades given the combination of learning model treatment and mathematical thinking ability is shown in table 4.

Table 2. List of ANAVA Student's Chemical Values Combined Treatment of Learning Models and Mathematical Thinking Abilities.

NO	Variable	Source of Variation	Manual			Explanation
			RK	F_{count}	F_{table}	
1	Learning Outcome	Between Column (A)	132,72	4,242	3,99	Real
		BetweenLines (B)	365,03	11,685	3,99	Real
		Interaction (AB)	167,64	5,357	3,99	Real
		RJKD/Eror : 31,287				

Hypothesis 1

F_{count} (A) > F (0,05)(1;64)where 4.242> 3.99 then Ho1 rejected, it means there is effect of learning model to student's chemistry learning on stoichiometry subject. Learning model used in this research is PBL and DI model. This effect indicates that the class that is taught by PBL learning model has mean of learning result value equal to 82,57 and with DI learning model equal to 79,77.Desriyanti (2016),suggests that the PBL model can improve students' understanding by providing students with learning experiences and can build a frame of mind, find problem solving, so that the success indicators of learning can be achieved.According to Yew (2016), that PBL is one effective learning model offers an active atmosphere of activity and gives the confidence to take a position in constructing an idea. On the other hand, Sofiyah (2010) suggests that the DI model gives a significant effect, because in its implementation, student's achievement is linked with time in learning, thus maximizing the use of student's learning time with teacher-oriented. Nelson (2015),added that the use of direct instruction model can be successful on learning outcomes with teacher explanations and guidance directly because it prioritizes students to comprehend a whole learning materials.

Average student learning outcomes using PBL models are much higher than students using DI models. Ajai (2013), states that the use of the PBL model can provide much higher learning outcomes than learning outcomes using conventional models or often called direct learning, PBL change models that train student activeness and student independence to discover and solve problems encountered in learning, so the ability of students can be much more developed.

Hypothesis2

F_{count} (A) > F (0,05)(1;64) where 11,685 > 3,99 then Ho_2 is rejected, it means there is effect of mathematical thinking ability to student's chemistry learning result on stoichiometry subject.The results showed that students who have high mathematical thinking ability to give higher average learning outcomes than students who have low mathematical thinking skills (average learning outcomes of students capable of high mathematical thinking is 83,71 while students with low mathematical thinking has an average value is 72,77). This is supported by Rohaeti's research (2010), that students who have high mathematical thinking ability have better learning outcomes than students who have low mathematical thinking ability. The ability to think mathematically or logically - mathematically very important and essential role and must be achieved by all students who learn about numbers and calculations involving mathematics.Correspondingly, Stockero (2017) states that one of the most important focus of teachers' attention is mathematical thinking, since the use of student ideas by teachers has been identified as an essential element of effective teaching. Widiada (2013), also shows that students with good mathematical thinking skills, have higher learning outcomes than students with low mathematical thinking skills. This mathematical thinking ability is indispensable in learning that requires the active involvement of students in construct and find new knowledge or to seek a conclusion.

Hypothesis 3

F_{count} (AB) > F (0,05)(1;64) where 5,357 > 3,99 then Ho_3 rejected, it means there is interaction between learning models and mathematical thinking ability to student's chemistry learning outcome on stoichiometry subject. Form of interaction between learning models and mathematical thinking ability to student's chemistry learning outcome on stoichiometry subject. Based on the form of interaction between learning models and mathematical thinking ability to student's chemistry learning outcome on stoichiometry subject, can be concluded that teaching using PBL model with high mathematical thinking ability, provides the highest learning outcome compared to high mathematical thinking ability using DI model. Average details are ; (86,718 ± 5,455) and (80,5 ± 6,892). This is in line with Widyatiningtyas (2015), who argues that PBL model is well taught to students who have a hugh mathematical ability compared to DI model.Jumaisyaroh (2014),states that using PBL model can provide an opportunity to improve their mathematical thinking.Birgili (2015) added that PBL modeltend to be challenging student to solveauthenticproblem in rich setting information. They can build their own solutions that contribute to the most effective experiences such as methods, process and epistemology of discipline.

While the use of PBLmodel tostudents with low mathematical thinking, provides lower learning outcome than students taught by DI model. Average details are : (78,889 ± 4,202) dan (79,236 ± 5,733). Application of PBL model to students who have low mathematical thinking ability, make students depressed in following lesson. Students are oriented to find ways to solve problems, from the decline of formulas, that discovery a concept and apply it in solving problems. Student centered learning to construct, find themselves and teacher only as facilitators, provide guidance and monitor student's activities. This causes students who have low mathematical thinking ability is difficult to learn and do not understand what is learned, so that the learning outcome are low. While, students who have low mathematical thinking ability are given a conventional learnig model, feel happy and understand about the material described by teachers accompanied by a discussion or structure questions. If students are happy with what they do, will motivate students to learn so that the results of learning can be better (Widiada, 2013).

CONCLUSIONS

From the overall data analysis that has been done, it can be drawn conclusion as follows : There is effect of learning model to the students' chemistry learning on the subject of stoichiometry. The application of PBL model to students who have high mathematical thinking ability gives high learning result of chemistry from application of DI model of student which gives lower learning result of chemistry. There is effect of mathematical thinking ability to student's chemistry learning result on stoichiometric subject. The application of PBL and DI models to students with high mathematical thinking ability provides high learning outcomes from students with low mathematical thinking skills. There is an interaction between the learning model and the mathematical thinking ability of the students' chemistry learning outcomes.

REFERENCES

[1] Ali, M., (2007), *Ilmu dan Aplikasi Pendidikan Bagian 3*, PT Imtima, Bandung
[2] Amiroh, Y., Yamtinah, S., Utomo, S.B., (2015), Penerapan Pembelajaran Numbered Heads Together (NHT) Disertai Media Kartu Soal Untuk Meningkatkan Aktivitas dan Prestasi Belajar

Pada Materi Pokok Stoikiometri Kelas X MIA, *Jurnal Pendidikan Kimia,* Vol. 4, No. 4, ISSN : 2337 – 9995.

[3] Arikunto, S., (2013), *Prosedur Penelitian*, Cet ke - 15, Rineka Cipta, Jakarta.

[4] Birgili, B., (2015), Creative and Critical Thinking Skills in Problem Based Learning Environments, *Journal of Gifted Education and Creativity,* Genc Bilge Publishing, Vol. 2, No. 2, pp. 71 – 80.

[5] Devlin, K., (2012), *Mathematical Thinking,* Palo Alto, USA.

[6] Elisa, A., (2014), Pengaruh Penerapan Model *Cooperatve Problem Based Learning* untuk Menumbuhkan Sikap Komunikatif dan Meningkatkan Hasil Belajar Siswa pada Materi Stoikiometri, *Skripsi,* FMIPA, UNIMED, Medan.

[7] Istarani, (2011), *58 Model Pembelajaran Inovatif*, Media Persada, Medan.

[8] Jumaisyaroh, T., Napitupulu E.E., Hasratuddin, (2014), Peningkatan kemampuan Berpikir Kritis Matematis dan Kemandirian Belajar Siswa SMP melalui Pembelajaran Berbasis Masalah, *Jurnal Kreano,* ISSN : 2086 – 2334, Vol. 5, No. 2.

[9] Mason, J., Burton, L., Stacey, K., (2010), *Thinking Mathematically*, Second Edition, ISBN : 978-0-273-72891-7, Pearson Education, England.

[10] Mukarrahmah, H.A., Erviyenni, Herdini, (2012), Penerapan Model Pembelajaran Langsung untuk Meningkatkan Prestasi Belajar Siswa Pada Pokok Bahasan Hidrokarbon Kelas X SMA PGRI Pekanbaru, *Skripsi,* FKIP, UNRI, Pekanbaru

[11] Siahaan, M.G., (2014), Penerapan Model *Problem Based Learning* dengan Pendekatan *Scientific* terhadap Peningkatan Hasil Belajar Siswa Kelas X SMA pada Materi Pokok Stoikiometri, *Skripsi,* FMIPA, UNIMED, Medan.

[12] Sofiyah, (2010), Pengaruh Model Pengajaran Langsung *(Direct Instruction)* terhadap Hasil Belajar Fisika Siswa, *Skripsi,* FMIPA, UIN Syarif Hidayatullah, Jakarta.

[13] Stockero, (2017), Learning to Notice Important Student Mathematical Thinking in Complex Classroom Interactions, *Journal of Mathematics Teacher Education,* Vol. 1, No.1

[14] Sumar, W.T., Razak, I.T., (2016), *Strategi Pembelajaran dalam Implementasi Kurikulum Berbasis Soft Skill*, Deepublish, Yogyakarta.

[15] Widiada. I.P.G., Candiasa, M., Natajaya, N., (2013), Penagruh Implementasi Model Pembelajaran Berbasis Masalah terhadap Hasil Belajar Matematika Ditinjau dari Kecerdasan Logis – Matematis pada Siswa Kelas X Akomodasi Perhotelan SMK PGRI Payangan, *Jurnal Program Pasca Sarjana,* Univ. Pendidikan Ganesha, Vol. 4.

[16] Widyatiningtyas, R., Kusumah, Y.S., Sumarmo, U., Sabandar, J., (2015), The Impact of Problem Based Learning Approach to Senior High School Students;s Mathematic Critical Thinking Ability, *Jurnal IndoMS – JME,*Vol. 6, No. 2, pp. 30 – 38.

[17] Yew, E.H.J., Goh, K.., (2016), Problem Based Learning : An Overview of Its Process and Impact on Learning, *Health Profession Education Journal,* Vol.2, ISSN 2452 – 3011, Singapore.