THE 6th ANNUAL INTERNATIONAL SEMINAR ON TRENDS IN SCIENCE AND SCIENCE EDUCATION 2017 State University of Medan November 14th - 15th Grand Mercure Hotel. Jl. Sutomo. No. 1. Medan. Indonesia

Teachers' Readiness towards the Implementation of Science, Technology, Engineering, and Mathematics (STEM) Education in West Java

Tati Setiawati, Septian Karyana, Dian Purnama, Heri Setiadi, and Lintang Ratri Prastika

SEAMEO Regional Centre for QITEP in Science, Jalan Diponegoro 12 Bandung, West Java, Indonesia

ABSTRACT

The aim of the study was to gather information regarding teachers' readiness towards the implementation of STEM education in primary, secondary, and vocational schools. The main focus of the study was to investigate teachers' understanding towards STEM education and students' understanding towards materials given by their teachers who have participated in a STEM education workshop. The descriptive method is applied in conducting the present study. We examined teachers' consistency in implementing STEM based learning by reviewing lesson plans and observing their implementation. The impacts of the implementation towards the students were also investigated by conducting interviews and distributing surveys to the students. The research subjects of the study were 7 out of 23 teachers who have taken STEM education training and implemented the training at their schools. Instruments used in this study were STEM education observation guidelines, questionnaire responses of teachers and students towards STEM education, and teacher and student interview guidelines. The data obtained were analyzed by employing qualitative and quantitative methods. The results showed teachers' understanding on the importance role of STEM education implementation in improving students' thinking skills, interests and motivation in learning processes, teachers' readiness in STEM education implementation, as well as students' opinion on the role of STEM education in building their academic capacity.

Keywords: Teachers' readiness, STEM education, motivation, thinking skills

Corresponding Author: Tati Setiawati, SEAMEO Regional Centre for QITEP in Science, Jalan Diponegoro 12 Bandung, West Java, Indonesia. E-mail: setiawati58@gmail.com

INTRODUCTION

Southeast Asian Ministers of Education Organization (SEAMEO) Regional Centre for Quality Improvement of Teachers and Education Personnel (QITEP) in Science (SEAQIS) is one of the SEAMEO center which attempts to improve science teachers' and educators' quality in Southeast Asia through various activities. One of the programs organized by SEAQIS is training and workshop for teachers and educators regarding STEM education which combines science, technology, engineering, and mathematics. All of the events held in SEAMEO Centre refer to "The Seven Priority Areas of SEAMEO 2015-2035" and one of them is Adopting a 21st Century Curriculum. This priority aims to make a radical change concerning systemic knowledge analysis, skills, and important values to effectively respond to the changes in global context, particularly in the increase of complexity in economy, socio-culture, and political environment, development of teachers' competencies which is imbued with ASEAN values in establishing Southeast Asia community. STEM education gives students chances to develop their 21st century skills such as communication, collaboration

and solving complex problems. Therefore, STEM education is able to fulfill the seventh priority of SEAMEO program which is Adopting a 21st Century Curriculum.

In order to conduct a study regarding the development of STEM education in Indonesia, an analysis of the needs related to STEM education development have to be done. In this case, it is necessary to conduct a preliminary study which can show teachers' readiness in implementing STEM education in Indonesia. This preliminary study is conducted in West Java as a pilot project. SEAQIS has organized STEM education training in West Java. Based on the result of its implementation, teachers' readiness in implementing STEM education is then investigated. The following sessions report our investigation.

STEM Education: The term STEM was first used by the National Science Foundation (NSF) in the 1990s as an acronym of science, technology, engineering, and mathematics which is the theme of the educational reform movement in all four disciplines to foster the labor force of STEM fields, as well as developing the color of a country that is STEM literate, as well as enhancing the global competitiveness of US in science and technology innovation [1].

STEM education is an interdisciplinary subject which integrates some concepts and principles in science, technology, engineering, and mathematics by using real-world applications approach and an active learning [2]. STEM education appears to be a solution to the decrease of the number of students who are interested on STEM education in higher education or people who want to work in a STEM field [3], [4], [5], [6], [7]. Through the implementation of STEM education, students learn to be a problem solver, innovator, creator, and collaborator so that later they are able to support the invention of new products and creative processes which are needed by the market in order to increase people's s prosperity [8], [9].

Characteristics of STEM education are focusing on real-world issues and problems, guided by the engineering design process, immersing students in hands-on inquiry and open-ended exploration, involving students in a productive teamwork, applying rigorous math and science content that students have learnt, allowing for multiple right answers and reframing failure as a necessary part of learning [10].

Another explanation regarding the characteristics of STEM education is stated by Hansel [11]. STEM education can be applied at schools by adjusting it with students' thinking skills at elementary, middle, and high school levels.The application of STEM education at each level of education is as follows

- Elementary school — STEM education focuses on the introductory level STEM courses, as well as awareness of the STEM fields and occupations. This initial step provides standards-based structured inquiry-based and real-world problem-based learning, connecting all four of the STEM subjects. The goal is to pique students' interest into them

wanting to pursue the courses, not because they have to. There is also an emphasis placed on bridging in-school and out-of-school STEM learning opportunities.

- Middle school — at this stage, the courses become more rigorous and challenging. Student awareness of STEM fields and occupations is still pursued, as well as the academic requirements of such fields. Student exploration of STEM related careers begins at this level, particularly for underrepresented populations.
- High school — the program of study focuses on the application of the subjects in a challenging and rigorous manner. Courses and pathways are now available in STEM fields and occupations, as well as preparation for post-secondary education and employment. More emphasis is placed on bridging in-school and out-of-school STEM opportunities.

STEM education has to involve students actively with up-to-date issues; students are given opportunities to develop their thinking skills in solving a problem. It necessary to be noted that STEM education does not only attempt to get a result of a particular process, but more importantly attempts to understand the process itself so it will make students are able to think critically, be creative and innovative.

So, STEM education can provide opportunities for students to develop their 21st century skills such as critical thinking, creativity, communication, and collaboration. With these skills, when entering in the society, students will meet with global job demands. Therefore, STEM education prepares students to work in a technologically advanced world. This is vital for national competitiveness in the global economy.

MATERIAL AND METHODS

The study employs descriptive method with some step as shown on the Fig. 1. At the planning stage, an exam outline and a specification table of research instruments are created by inviting experts from Indonesia University of Education (UPI). The instruments later are examined in terms of their content and construction validity through applying logical validity with some experts involved. Then, coaching towards all observers needs to be conducted to maintain the internal validity of the data.

This study is done by observing teachers' performance in the class and by analyzing their lesson plans. The teachers involved are those that have participated in the training on STEM education held prior to the stages described in the Fig. 1. Teachers' and students' questionnaires are also used to see their readiness and problems regarding the implementation of STEM education. To enrich the data, interviews with the students have also been done. So that, the instruments used are teachers' performance on STEM education observation sheet, STEM education questionnaire for teachers and students, and teachers and students interview guidelines.

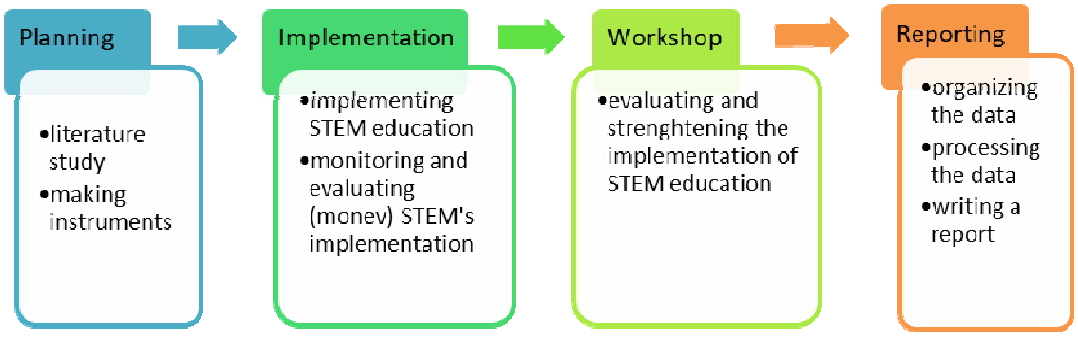

FIGURE 1. Steps in Conducting the Stu*dy*

At the implementation stage which occurred from October to November 2016, 16 out of 23 teachers (who have attended STEM education training) from 16 schools in West Java were involved in this research as the study subject. Among these 16 schools, seven schools have implemented while the rest are planning to implement STEM education. Table 1 shows the list of the schools.

Table 1. Respondents' Data

School levels	Schools which have implemented STEM education	Schools which are going to implement STEM education
Elementary	SD Pertiwi SDN Cibaduyut 3 SDN Margahayuraya	SD Darul Hikam Bdg
Junior High	SMPN 52 Bandung	SMP Krida Utama SMPN 32 Bandung SMPN 47 Bandung SMPN 9 Bandung
Senior High	SMA Plus PGRI Cibinong SMAN 1 Parongpong	SMA BPI 1 Bandung SMAN 11 Bandung SMAN 23 Bandung
Vocational	SMKN 13 Bandung	SMKN 9 Bandung

After that, the workshop was held as an evaluation and reinforcement for the sample teachers after implementing STEM education in the classroom. On the final stage, the obtained data is analyzed by using quantitative and qualitative method. Descriptive statistics is used in quantitative analysis to present percentage, average, and chart. Qualitative analysis is employed in the form of descriptions and qualification achievements of teachers' readiness in implementing STEM education.

RESULT AND DISCUSSION

Teacher observation: In general, the assessment of teachers when implementing STEM-based learning has been well viewed from the way to open the learning. However, as seen from Fig. 2, the teachers still need strengthening in the mastery of science contents within the STEM-based subject matter as well as how to relate them with everyday life. In addition, the teachers also need strengthening in assessment of based-STEM learning.

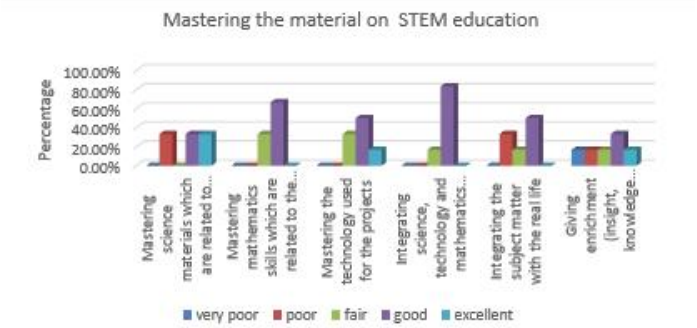

Figure 2. Mastering the material on STEM Education

Teachers' responses to STEM learning can be seen in Fig.3. The figure shows that most of the teachers agree that STEM learning can increase student participation in learning of STEM disciplines and therefore it is understandable that, even though with a little bit lesser in percentage, they have motivated in implementing STEM education in their schools.

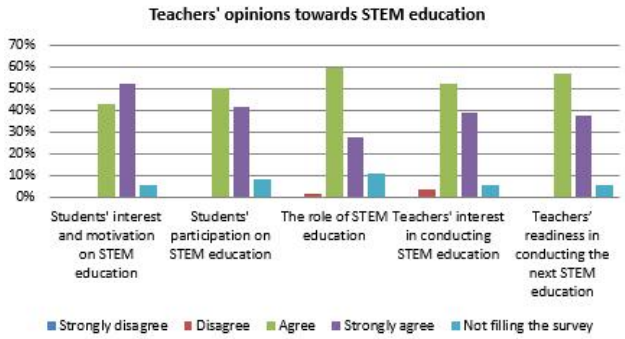

Figure 3. Teachers' responses to STEM education

High motivation of the teachers in conducting STEM education as described above is inline the data as shown in Fig. 4. The data describe the teachers' willingness in developing their competencies in STEM education through literature study, making a plan of STEM education approach and inserting the plan in the learning processes, as well as in conducting student evaluation on STEM education based learning.

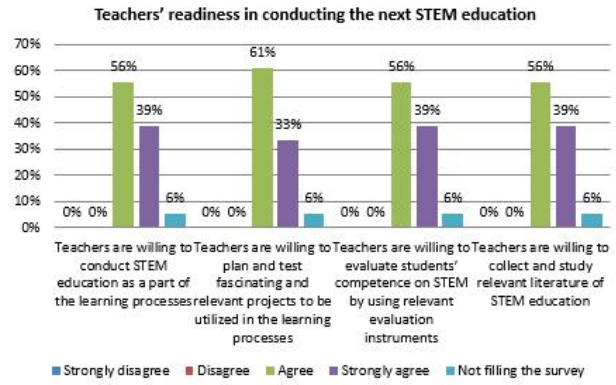

Figure 4. Percentage of teachers' readiness in conducting the next STEM education

The difficulties encountered by the teachers: During the implementation of STEM-based learning there were still many obstacles in the planning, implementation, and evaluation of STEM learning. In the planning process, the difficulties are in the preparation of lesson plan, in the case of arrangement evaluation tool, in determining of the media, approaches and models / learning methods that are in accordance with the topic of STEM, in determining the source of learning and in designing of learning steps in accordance with the indicators / learning objectives. The next constraint felt by the teachers is in planning STEM projects when looking for literature and testing STEM learning projects, whereas in STEM project management the obstacles are in applying technology for STEM project and in trouble shooting if technology used in STEM learning is not working properly. In the case of implementation of STEM-based learning the teachers have difficulty in managing the time and in managing STEM learning stages. In delivering the STEM material, the teachers have obstacles in integrating science, technology, and mathematics as a whole on STEM learning, and in mastering the technology used.

From the survey that has been conducted, the respondents were asked to give responses to the eight types of difficulty in STEM education. The following is the description of the respondents' responses concerning each of the difficulty.

Table 2. Dificulty of Implementing STEM Education

The Difficulty in	Aspect
Compiling STEM based Lesson Plan	Designing an evaluation to assess student competence on STEM
Planning STEM Projects	Piloting project on STEM education in planning, designing, and testing of STEM project
Motivating Students on STEM education	motivating students' interest on the on-progress project is not considered as a difficulty
Managing STEM Education	time management for STEM education and managing STEM learning steps
Delivering the STEM material	integrating science, technology, and mathematics in STEM education
Giving Training on Technology and Mathematics Skills in STEM	Giving training related to mathematics skills and technology skill
Managing Projects of STEM Education	encounter a technical technology problem, where they cannot find the solution if the technology does not work properly and operating the technology used in STEM projects
Giving Feedback on STEM Education	designing the instrument of STEM evaluation.

Students' questionnaire: The result of student's questionnaire analysis on STEM learning stated that in relation to the role of STEM learning, respondents stated that STEM learning can improve students' understanding on science and mathematical skills and students' ability in using technology. Few (about 6%) of the students, find it difficult in understanding STEM-based learning expressed. We also obtained that after learning STEM, the majority of the students have positive perceptions on STEM-based learning, even though there were about 6% whom the students disagreed with the usefulness of STEM learning for their life.

CONCLUSION

Generally, the teachers are ready to utilize STEM. Training programs that are held by SEAMEO QITEP in Science has successfully increased teachers' readiness in implementing STEM although some teachers' skills need to be strengthened and improved. The teachers give positive responses to STEM education because they think it can improve students' comprehension on science and students' skills on mathematics and technology. However, there are a number of issues in planning, conducting, and evaluating the STEM-based learning that should be considered. STEM education receives positive responses from the students because the projects challenge them in studying the materials. Furthermore, STEM education inspires the students about the importance of technology in solving problems. Strengthening in designing the lesson plan, compiling the workbook, designing STEM-based evaluation instrument, and integrating relevant materials is also required.

ACKNOWLEDGMENT

I would like to extend the greatest sincere and gratitude to SEAMEO Regional Centre for QITEP in Science, Ministries of Education of SEAMEO member countries, and SEAMEO Secretariat, as well as to the teacher and principal of the concerned schools involved in in this research.

REFERENCES

[1] Hanover Research. *K-12 STEM Education Overview*.(2011)

[2] Laboy-Rush, D., *Integrated STEM Education through Project Based Learning*, (2013). [Online]. Available: http://www.nsta.org/publications.

[3] Hudson, P., English, L.D., Dawes, L., King, D., Baker, S., "Linking pedagogical knowledge practices and student outcomes in STEM education for primary schools", *STEM 2014 Conference*, (2014).

[4] Hudson, Peter B., English, Lyn D., Dawes, Les, King, Donna T., & Baker, Steve, "Exploring Links between Pedagogical Knowledge Practices and Student Outcomes in STEM Education for Primary Schools", *Australian Journal of Teacher Education*, Vol 40 issue 6, article 8,(2015).

[5] Ling He, Lee Murphy, and Jiebo Luo, *Using Social Media to Promote STEM Education: Matching College Students with Role Models*, arXiv:1607.00405v1 [cs.CY] (1 Jul 2016).

[6] Roberts, A., A Justification for STEM Education, *TECHNOLOGY AND ENGINEERING TEACHERe*, (May/June 2012).

[7] Wy□els, F., · Van de Steene, W., Roets, J., Ciocci, M.C., Carbajal, J.P., *Building ArtBots to Attract Students into STEM Learning*, arXiv:1608.03405v1 [cs.CY] (11 Aug 2016).

[8] Jayarajah Kamaleswaran,cs, A Review of Science, Technology, Engineering and Mathematics (STEM) educations Research from 1999-2013: *A Malaysian Perspective, Eurasia Journal of Mathematics, Science & Technology Education*, (2014), 10(3), 155-163, (2013).

[9] Srivastava M., *Introduction of Intellectual Property Courses in the STEM Curriculum,* 3rd IEEE Integrated STEM Education Conference, (2013).

[10] Jolly, A., Six Characteristics of a Great STEM Lesson, Education Week: Teachers-, (17 June 2014) http://www.edweek.org/tm/articles/2014/06/17/ctq_jolly_stem.html,

[11] Hansel, M., *Characteristics of Schools Successful in STEM-Evidence from Two States' Longitudinal Data,* National Center for Analysis of Longitudinal Data in Education Research, (2013).