Mathematics Learning Process with Science, Technology, Engineering, Mathematics (STEM) Approach in Indonesia

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Abstract. STEM approach has been widely applied in developed and developing countries. In Indonesia, the STEM approach has not been widely used. Application of STEM approach in each country is different according to the needs of the State itself. This study aims to describe the process of learning mathematics with STEM approach in Indonesia which includes the readiness of teachers before the learning process, implementation of learning, evaluation of learning and to describe the obstacles experienced by teachers during the learning process with STEM approach in Indonesia. This research is descriptive qualitative research. The subject of the research is the mathematics teacher. The technique used in taking the subject is purposive sampling. Methods of data collection is by observation and interview. Technique to validate data with time triangulation. Data analysis techniques used consist of data reduction, data presentation, and conclusion. The results of this study are the learning process of mathematics with STEM approach includes preparatory aspects before learning, learning implementation aspect consisting of preliminary, core and closing stage, and evaluation aspect. The obstacles experienced by teachers in applying STEM approach to learning mathematics is looking for real life and material practice on a material.

1. Introduction

Education is now expected to provide hard skill and soft skill to learners to form competent human resources so they can compete internationally. The existence of the ASEAN Economic Community presents a major challenge for developing countries such as Indonesia in improving the competitiveness of products and labor. Therefore, it takes a variety of efforts that can realize these expectations. The most important aspect in a country's development is education. Education which is needed nowadays is an education that is able to provide student learning experiences so that students have the ability to solve problems, think deeply, manage projects, and use various tools of technology and information.

In education, there are some subjects that are important to learn because they have many benefits both in real life and in integration with other subjects. One of the most important subjects to learn in the school is Mathematics. Mathematics is an important lesson because Mathematics is very useful in life. Mathematics also can be integrated with various disciplines such as Science, Social Studies, Art,
Health, Reading/Language Arts and Physical Education. The 21st century demands competent human resources in Science, Technology, Engineering design and Mathematics. With regard to economic growth of the 21st century, the workforce must have the skills of Science and Mathematics, creativity, expertise in information and communication technology, and the ability to solve complex problems [1].

In order to compete in the global economic system of the 21st century, a country must establish an education where students gain an understanding of Science, Mathematics, Engineering and computer (Technology), and Produce the product using the skills required in the field [2]. Furthermore, he also said that the recent Science and Technology education is a constructivism and investigation aimed at integration with other disciplines such as the use of effective technology (Engineering) and problem solving skills (Mathematics) in building the foundation of STEM education.

This is supported by research of Wijaya, Nila and Amalia that learning based STEM can train students' ability and talents to face 21st century problems [3]. In addition, the elementary school learning based on themes based STEM is expected to produce final output in the form of products and designs made by students related to the design. The development of STEM approach in education in developed countries shows that STEM needs to be for education in Indonesia because STEM (Science, Technology, Engineering, and Mathematics) is a paradigm that creates interdisciplinary learning and provides the achievement of Science, Mathematics, Engineering and Technology while doing so [2].

STEM implemented early in school will have a major impact on a country in facing global challenges, as Hidayah and Rohaida say that with the existence of information technology, economy based knowledge, mastery of Science and technology to students, schools must produce human resources who are knowledgeable and competent with the ability and creativity sufficient to lead the developed countries [4]. Through education based Science, Technology, Engineering and Mathematics (STEM), technological developments can be improved to meet global challenges.

The findings from the study of Sunyoung, Roslinda, Mary, and Robert showed that students at STEM PBL schools showed higher scores on materials geometry, probability, and problem solving than those in non-STEM PBL schools [5]. It shows that STEM is suitable to apply to most Mathematics materials. In learning mathematics, using STEM concept will make students more often apply the material in daily life so that students will be accustomed in solving mathematical problems in everyday life by thinking scientific, using technology to obtain various information, and data processing with engineering capability. As the opinion of Wang, Moore, Roehrig and Park that training students in this way (STEM paradigm) is considered beneficial because it is a multidisciplinary world that relies heavily on the concept of STEM, in which students must use to solve real-world problems [6].

Wang, Moore, Roehrig and Park explain that Multidisciplinary Integration requires students to connect components from different subjects taught in different classes at different times, whereas interdisciplinary integration can begin with real-world problems [6]. Jan B also says that real-world learning is very important in STEM subjects, therefore STEM learning should place more emphasis on investigation and authenticity [7]. Chew C M says that education based STEM is an interdisciplinary field of Mathematics that connects four disciplines namely Science, Technology, engineering and Mathematics [8]. The strength of workers in the field of STEM is considered as one of the indicators of the nation's ability to generate innovative ideas in several countries. This is because students who master STEM have many capabilities, such as the ability to identify, apply, and integrate concepts from Science, Technology, Engineering and Mathematics to understand complex issues and have the ability to innovate in solving problems.

The mathematics learning pattern with the STEM approach emphasizes the principles of practice, where in each student's learning is always facilitated to practice so that students gain an unforgettable learning experience as Chew C M research concludes that STEM should emphasize the students' learning experience in school. Integrated learning, the connections between subjects, the students' ability to solve problems, the method of thinking in depth, the ability to manage project types of tasks, understanding and skills regarding engineering design, as well as the use of various information and
technologies [8]. This is also supported by Hidayah and Rohaida which concludes that the practice of enhancing manipulative skills and student competence in manipulative skills can improve STEM education in Malaysia [4].

Some studies suggest that the learning approach that supports STEM is based learning based discovery or inquiry as research from Patrick B and J M Carfora which suggests that inquiry based learning (IBL) is currently being used in STEM programs [9]. The study strongly recommends IBL because IBL has great potential to improve and change teaching and learning. Education based STEM is recognized as the way to motivate children to love mathematics as Kamaleswaran, Rohaida and Rose increase education based STEM into a way of motivating young people to be more interested in Science and Mathematics [1], because mathematics knowledge is influential to the State's economy. Such as the opinion of Nasarudin, Lilia and Effandi that the entire state economy is concerned with mathematics, science, accounting, transportation, engineering, economics and geology so the primary responsibility as an educator is to instil the importance of STEM into the mathematics curriculum [10]. One way is to improve the problem solving ability of mathematics among school children.

In general, the way of teaching mathematics focuses on practice and remembering facts and procedures whereas the way does not encourage thinking and problem-solving because students do not learn the importance of mathematics in everyday life because it only becomes students who memorize math. Mathematical problem solving skills can be achieved by applying complex thinking through systematic awareness [10]. It reveals the importance of new innovations in mathematics learning that can provide students with in-depth knowledge to become competent resources in the 21st century. Based on some opinions on STEM education above, then offered approach STEM as approach of learning mathematics in century 21.

2. Method

This research is a qualitative descriptive research because it emphasizes to process and meaning. The purpose of this study is to describe the conditions and situations that existed at the time the study was conducted. The strategy used in this research is case study. The case study in this study is a single case study because it was conducted in one school. Research subject in this research is mathematics teacher. Sampling technique using purposive sampling method. The research was conducted at Sampoerna Academy Junior High School located on L’avenue Jalan Raya Pasar Minggu Kav. 16 Pancoran South Jakarta. Data collection techniques in this study using observation and interviews. The research procedure in this research follows Lexy J Moleong model which has three stages: pre-field stage, field work stage, and data analysis step. The pre-field stage includes the preparations that must be done before conducting the research, the field work stage includes things done at the time of research, the data analysis phase involves searching and finding patterns using time triangulation. Data analysis techniques used are Miles & Huberman techniques that include data reduction, data presentation, and conclusion or verification.

3. Result and Discussion

3.1. Mathematical Learning Process

Table 1 shows the results of the analysis of mathematical learning process with STEM approach in Indonesia. The data is derived from data taken from several time and resource which are then validated using triangulation of time and resource. The result validate data of mathematical learning process are presented in Table 1.

| No | Aspect | Indicator | Information |
|----|--------|-----------|-------------|
| 1  | Preparation | a. Prepare media and learning resources. | ✓ |
|    |         | b. Prepare RPP, syllabus, and activity sheet. | ✓ |
Table 1. Cont.

| 2 | Implementation of Learning | a. | Introduction |  |  |
|---|---------------------------|----|-------------|---|---|
|   |                           | 1) | Prepare students psychologically and physically | √ |   |
|   |                           |   | before the learning process. |   |   |
|   |                           | 2) | Asking questions about previous knowledge related to the material to be studied | √ |   |
|   |                           | 3) | Describe the learning objectives or basic competencies to be achieved |   |   |
|   |                           | 4) | Invite students to find problems then solve them |   |   |
|   |                           | 5) | Using the STEM approach in the lesson | √ |   |
|   |                           | b. | Content |   |   |
|   |                           | 1) | Using the Learning approach based inquiry | √ |   |
|   |                           | 2) | Linking matter with daily life | √ |   |
|   |                           | 3) | Practice | √ |   |
|   |                           | 4) | Involving students in practice | √ |   |
|   |                           | 5) | Students actively engage in classroom practice | √ |   |
|   |                           | 6) | Guiding students in practice | √ |   |
|   |                           | 7) | Utilizing technology (computers, internet) | √ |   |
|   |                           | 8) | Using Active Learning Strategy | √ |   |
|   |                           | 9) | Communicate actively to students during learning | √ |   |
|   |                           | 10) | Giving tasks in groups | √ |   |
|   |                           | 11) | Using Problem Solving learning method | √ |   |
|   |                           | 12) | Combining STEM in one subject (at least 2 STEM disciplines) | √ |   |
|   |                           | 13) | Students are motivated to like math | √ |   |
|   |                           | 14) | Develop teaching materials | √ |   |
|   |                           | 15) | Teach according to the field | √ |   |
|   |                           | 16) | There is no gap between learners | √ |   |
|   |                           | c. | Closing |   |   |
|   |                           | 1) | Conduct an assessment or reflection on what has been done | √ |   |
|   |                           | 2) | Provide feedback on the learning process and outcomes | √ |   |
|   |                           | 3) | There are products from the project | √ |   |
| 3 | Evaluation | a. | Informing a lesson plan at the next meeting | √ |   |
|   |                           | b. | Give an assessment in the form of a description | √ |   |
|   |                           | c. | Give an assessment based class or authentic assessment | √ |   |

Table 1 shows that from several indicators of learning with STEM approach, there are several indicators that are met in the process of learning mathematics with STEM approach in Indonesia as in the preparation stage before the learning there are 3 indicators that are fulfilled: preparing media and learning resources, preparing activity sheets, and Preparing tools and materials of practice. In the implementation stage of learning there are 22 indicators, namely the introduction there are 3 indicators that is preparing students psychologically and physically before the learning process, asking questions about previous knowledge related to the material to be studied, using STEM approach in the lesson. At
the core there are 16 indicators that are using an inquiry-based learning approach, linking the material with daily life, practicing, engaging students in practice, engaging students practice actively in classroom, guiding students in practice, utilizing technology (computer, internet), using active learning strategies, communicating actively to students at the time of learning, assigning tasks in groups, using problem solving learning methods, combining STEM in one subject (at least 2 STEM disciplines), motivated students to like mathematics, developing teaching materials, teaching according to their field, no gaps among learners. At the end there are 3 indicators that are assessed or reflected on the already implemented, providing feedback on the process and learning outcomes, there are products from the project. At the evaluation stage there are 3 indicators that are submitting the lesson plan at the next meeting, giving the assessment in the form of a description, giving a grade based assessment or authentic assessment.

Relating material to daily life as explained by the California Department of Education that STEM as a process of critical thinking, analysis, and collaboration where students integrate processes and concepts in real-world contexts as well as Arinillah opinion that STEM Is the integration of four disciplines of Science, Technology, Engineering, and Mathematics in an interdisciplinary approach and applied in a real-world context and problem-based learning [15]. Conduct practices based on Hidayah and Rohaida that through practice, students have the opportunity to investigate phenomena, draw conclusions, and practice scientific skills [4], as well as the opinion of Irma, Puji and Endah that engineering is a profession where knowledge of Science and Mathematics is obtained through studies, experiments, and practices applied by considering the development of ways to assemble materials and natural forces to meet human needs [12].

Utilizing technology as said by Hidayah and Rohaida that with the existence of information technology, economy based knowledge, mastery of Science and technology in students, the school must produce knowledgeable and competent human resources with the ability and creativity sufficient to lead the developed countries [4]. Through education based Science, Technology, Engineering and Mathematics (STEM), technological developments can be improved to meet global challenges. Using the STEM approach in learning as opinion of Breiner, Johnson, Harkness and Koehler that the STEM integrated approach is an approach that combines all STEM fields in a single subject of instruction [13]. Combining STEM in one subject (at least 2 STEM disciplines) as opinion of Breiner, Johnson, Harkness and Koehler that the STEM field is taught as if integrated into a single subject [13]. Integration can be done with at least two disciplines, but not limited to two disciplines. There is no gap among learners as stated by Indarjani that the benefits of STEM include: Addressing the gender gap, Addressing the gaps in student success/achievement and overcoming the gaps in skills through sustainable growth processes [14].

Indicators Prepare media and learning resources, Prepare activity sheet, Prepare tools and materials aims to know preparation before learning as proposed by Indarjani that the benefits of STEM include Improving the preparation of teachers in teaching [14]. There is a product of the project as Chew C M argues that STEM should emphasize the students’ learning experience in school as well as the ability to manage task-type projects [8]. Using an learning approach based inquiry as Jan B argues that real-world learning is very important in the STEM approach, therefore learning based STEM should place more emphasis on investigation and authenticity [7]. Students are motivated to like Mathematics as the Kamaleswaran, Rohaida and Rose suggest that the rise of education based STEM is a way of motivating young people to become more interested in Science and Mathematics [1]. Provide an assessment based class or authentic assessment as opinion Indarjani that the conditions to be considered in the application of STEM in Indonesia include the Class-based assessment with authentic assessment [14].

3.2. Mathematics Learning Process Obstacle
Table 2 shows the results of obstacle analysis experienced by teachers in the process of learning Mathematics with STEM approach in Indonesia. The data obtained from interviews conducted several times then validated by using time triangulation. Valid data is presented in table 2.

| Aspect               | Indicator                                | Information                                                                 |
|----------------------|------------------------------------------|-----------------------------------------------------------------------------|
| Obstacles            | a. Obstacle in the learning process.     | a. Looking for real life and preparing tools and materials of practice on a material |
|                      | b. Completion is done to deal with the   | b. Seeking information from various sources such as books from inside and outside the country and internet then developed and modified to fit the conditions in Indonesia. |
|                      | obstacles that occur.                    |                                                                             |

Table 2 is the result of an analysis of obstacles in the learning process of Mathematics with STEM approach in Indonesia. This data is obtained through interview and validated use triangulation of time. The data shows that the constraints experienced by teachers in the process of Mathematics learning with STEM approach is in the preparation stage is looking for real life of a material because not all material in mathematics can be concrete into real life and made a project. In addition, the obstacles faced are preparing tools and materials of practice because not all tools and materials are available so that teachers need to think about it before learning begins. The completion of the teacher to handle the constraints is to seek information from various sources such as books both from within and from abroad and the internet then the information is developed again and modified and adapted to the conditions in Indonesia to be appropriate and suitable to be applied.

4. Conclusion

Based on the results and discussion, it can be concluded that the process of learning mathematics with STEM approach in Indonesia is aspects of preparation include prepare media and learning resources, prepare activity sheet, prepare tools and materials of practice, aspects of learning implementation are introduction includes prepare students psychologically and physically before the learning process, asking questions about previous knowledge related to the material to be studied, using the STEM approach in the lesson, the content includes using the learning approach based inquiry, linking matter with daily life, practice, involving students in practice, students actively engage practice in classroom, guiding students in practice, utilizing technology (computers, internet), using active learning strategy, communicate actively to students during learning, giving tasks in groups, using problem solving learning method, combining STEM in one subject (at least 2 STEM disciplines), students are motivated to like mathematics, develop teaching materials, teach according to the field, there is no gap between learners. The closing includes conduct an assessment or reflection on what has been done, provide feedback on the learning process and outcomes, there are products from the project. Aspects of evaluation include informing a lesson plan at the next meeting, give an assessment in the form of a description, give an assessment based class or authentic assessment. The obstacle experienced by
teachers in the process of learning mathematics with STEM approach in Indonesia is looking for real life and prepare tools and materials of practice on a material. To solve these obstacles, the things done by the teacher is to seek information from various sources such as books from within and outside the country and the internet then developed and modified to fit the conditions in Indonesia.

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