

# CHAPTER I

## INTRODUCTION

### A. Background

In the 21<sup>st</sup> century, where globalization and modernization era occurred along with technology and science development, education also makes the great changes. Teaching and learning activity for example, is becoming more diversified and interesting which involve the advancement of technology in the entire school system. The scenario of 21<sup>st</sup> century learning should provide students with information acquisition skills through varied learning methods and media instead of directly delivering the information to students. It is in a way to prepare students to become skillful and knowledgeable individual in digital era. It is in line with Hasni (2011) whom stated that good education is not just preparing students' future, but through education students should be able to solve their real life problems through implementing skills and knowledge learned at school.

The 21<sup>st</sup> century is the century of technology and a digital era where everything relies on computer system. Many scholars argued that it is important to implement and evolve the integration of science, technology, engineering and mathematics (STEM) in school system which will give direct advantages for students, teachers, national economy and education institutions whom implement STEM in teaching and learning activity (Tseng, et al., 2013). It corresponds to Lou, et. al. (2011) whom concluded that science, technology, scientific studies, and technology engineering have relied heavily on each other and cannot be apart. Integrating Science, Technology, Engineering and Mathematics (STEM) gives advantages to students to connect relevant skills learned to the use of the skills in the real world application by providing valuable learning contexts and help students to develop relevant knowledge and conceptual understanding (Brophy et al., 2008). Conceptual understanding could be achieved by integrating science concepts and everyday life problems which is connected among the different science concepts in a discipline (Robertson, 2016).

STEM education was initiated by the concern of students who were doubt to prepare their future career which demanded skillful workers whom integrate technology. By implementing STEM in school education, researchers and scholars

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*DEVELOPING SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS (STEM)-BASED MODULE TO ENHANCE STUDENTS' STEM LITERACY*

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believed that it would be useful for students' future careers on engineering, science and technology by studying mathematics and science with the integration of technology and engineering (Decoito, 2014). Especially it is in Indonesia with the abundance of natural and human resources supposed to be a nation which implements technology development. However, the implementation of STEM education in Indonesia is still lack, not everyone recognizes it especially the research which proves the positive effects on implementing STEM at school.

In 2016, SEAMEO QITEP in Science did the research on the implementation of STEM in Indonesia to five schools in Bandung. The result shows that STEM-based learning has been implemented properly but there are several things need to be considered especially teacher's skills, lesson plan (RPP) and learning resources such as modules, worksheets and books. Learning materials play a vital role in teaching and learning process at various level of education, it provides the opportunities for children to broaden and deepen their knowledge and understanding through scientific explanations of real-world phenomena and provide students opportunities to develop explanations of phenomena which could enrich student's hard and soft skills (Brown & McIlroy, 2011; Kesidou & Roseman, 2002).

STEM literacy has close relation with the demands of 21<sup>st</sup> century competencies and skills which would make students to be able to compete in new economic era and modernization in line with the demand of 21<sup>st</sup> century working skills. STEM literacy on the other hand is a relatively new idea that has not been well defined in literature or practice. The achievements in STEM literacy should cover students' designing skill and all learning domains that refereed to STEM as a whole. However, to be able to solve complex problems creatively and innovatively, students are expected to have identification, applying and integration STEM concept skills which are known as STEM literacy (Balka, 2011). STEM literacy is characterized by the ability to use knowledge, skills and attitudes to solve contextual problem by applying various disciplines. In addition, engineering processes are also done by students to solve problems.

According to Zollman (2012) there are four main aspects to develop student's STEM literacy. First, STEM content is delivered in integrative way into a single

entity which can be seen as a discipline that integrates STEM knowledge without sorting it out. Secondly, content and pedagogy should blend, there must be a shift from learning that initially engages learning activities that demonstrate and prove concepts, into learning that is more focused on efforts to conduct investigations and analyze problems to obtain solutions (National Research Council, 2012). Thirdly, teachers should pay attention to student attitudes, beliefs, self-esteem, confidence and student motivation. Fourth, students operate technologies related to STEM independently and efficiently.

STEM Literacy is defined as the ability to identify, implement, and integrate concepts and contexts of Science, Technology, Engineering, and Mathematics (STEM) to understand and solve problems that cannot be solved using one scientific discipline but through innovative products. STEM Literacy can be measured by considering four aspects, namely context, knowledge, skill, and attitude. The context aspect has indicators of personal, social, and global. Meanwhile, indicator of knowledge aspect are presenting facts, concepts, and laws; as well as presenting theoretical hypotheses and models, asking students to remember and analyzing knowledge or information. Furthermore, the indicators of skill aspect are carrying out engineering processes, identifying scientific problems, explaining phenomena scientifically, using scientific evidence. Finally, indicators of attitude aspect are interest in the STEM field, supporting inquiry, responsibility for resources and environment. Students' STEM literacies are really important to be assessed in implementing STEM-based learning activity to create deeper understanding of science and mathematics concepts with the capability to cope real life problems through implementing skills.

Several studies have been conducted to test how to develop literacy in each STEM components, but these studies are still focused on developing one component of STEM literacy. For instance the research done by Robbinson & Kenny (2003) who conducted research on engineering literacy as a result of integrating science with the principles of engineering design in 9<sup>th</sup> grade students. Furthermore, Sulliman (2008) conducted research on the effect of robotics activities on science literacy both knowledge and skills aspects. Moreover, Afriana, et al. (2016) did research on the application of project-based learning in improving

students' scientific literacy. Thus, research that builds student's STEM literacy as a whole has not been done so far.

STEM education initiates students to become STEM literate which are those who are able; to use knowledge, skills and attitudes to solve contextual problems by applying various disciplines. However, the implementation of STEM education should be followed and supported by STEM-based teaching and learning materials. One of learning materials that is commonly used by teachers and schools are modules, the main function is usually helping students to cope with learning materials and to do some problems exercises related with the materials. Putra and Winarti (2014) stated that module is a kind of learning resources which is used to help students to understand specific materials learned at school by understanding the highlight and do the evaluation in a systematical structured to achieve the competency standard. Module is usually used by students to do the self-study because the guidelines, concepts and evaluations are presented in well-structured.

The main use of module possess some function such as minimizing teacher's role, initiating active learning process, enhancing the easiness of topic comprehension and making learning activity to becoming more efficient (Widowati, 2012). According to Widodo and Jasmadi (2013) that there are five characteristics of good module (1) self-instructional; (2) self-contained; (3) stand alone; (4) adaptive; (5) user friendly. Broadly speaking, module should be able to be used by students to learn independently in any condition easily and effectively whether at school or at home, thus students would have individual responsibility to achieve desired learning outcomes.

Moreover, Prastowo (2011) stated that good module contains at least learning instructions, content of subject matter, supporting information, exercises, work instruction, evaluation and respond of the evaluation results. Learning module should also able to accommodate relevancy in daily life as an integrated context that guided students to have concrete experience in learning science (Holbrook & Rannikmae, 2009; Lopes et al., 2011).

Nevertheless, although existing module meets the criteria of good module, but it fails to meet the characteristics of STEM-based learning material especially in enhancing student's STEM literacy because in average, existing module only meets

two from six characteristics of great STEM learning materials. According to Jolly (2014) there are six characteristics of great STEM based learning material (1) Focus on real world issues and problems; (2) Guided by engineering design process; (3) Immerse hands-on inquiry and open-ended exploration; (4) Involve productive teamwork; (5) Apply rigorous science and mathematics content; (6) Allow for multiple right answers.

The main difference of STEM based module and existing module is basically on problem exploration and designing process which encourage active learning activity and make students easier to comprehend the materials. STEM based module is guided by engineering process design where hands-on activity and problem exploration is the main part of student's activity which initiates active and meaningful learning process. According to English and King (2015) there is an important consideration in developing successful STEM learning materials. The first is the "E" stands for engineering as the driving force behind STEM which what makes STEM different from regular science, technology and mathematics learning material. A good STEM-based learning material puts a heavy focus on engineering design process (EDP) which leads to problem-solving approach. A framework of EDP based on basic technology education in Indonesia known as PDBU (*Pikir, Desain, Buat Uji*).

The implementation of STEM-based learning would be more precise if it is applied on secondary level study since science and mathematics subjects involve authentic problem solving activity in socio-cultural and functional context (Roberts, 2012). Firman (2015) stated that based on *Kurikulum* 2013 in secondary level, science and mathematics are the core subjects which are assumed as the foundation for students to enter STEM-based learning with the integration of technology. Science subject on *Kurikulum* 2013 in secondary level provides several concepts of daily real world problems, mathematics calculation and the use of technology, one of the concept that is closely related to human who is living on earth is earth's structure and its dynamics topic on 7<sup>th</sup> grade level which would be used as the main concept in developing STEM-based module since this topic relates closely with human life. Earth structure and its dynamic topic includes earth's layers, atmosphere, lithosphere, earthquake, volcanic eruption phenomenon, and

hydrosphere. By studying this topic, the students are expected to have understanding on how earth structure, layers and its characteristics are, how earth's movement can cause earthquake and volcanic eruption.

Regarding to the background that existing module fails to fully meet the criteria of great STEM based learning. Therefore, this research is focusing on producing STEM-based module on earth's structure and its dynamics topic which fulfills the criteria of both good module and great STEM learning materials to enhance students' STEM literacy.

## **B. Research Problem**

Based on the explained background above, the problem formulation of the research is "How is the characteristics of developed STEM-based module to enhance student's STEM literacy?"

## **C. Research Questions**

Elaborating the research problem, the research attempts to explore the following questions:

1. How is the characteristics of developed STEM-based module?
2. How is the validity and readability of STEM based module?
3. How is the enhancement of student's STEM literacies on knowledge aspect through the implementation STEM-based module?
4. How is the student's attitude towards STEM after implementing STEM-based module?
5. How is student's profile of STEM literacy process through the implementation of STEM-based module?
6. How is students' perception of STEM by implementing STEM-based module on earth's structure and its dynamics topic?

## **D. Limitation of Problem**

To avoid widening of problem on this research, then the research will be limited for the following things:

1. The topic is earth's structure and its dynamics in 7<sup>th</sup> grade of Junior High School that is limited by Core Competency No.3 and Basic Competence No 3.10 and 4.10 attached in *Kurikulum* 2013. Earth structure and its dynamic topic includes earth's layers, atmosphere, lithosphere, earthquake and volcanic eruption phenomenon, and hydrosphere.
2. The development of STEM-based module on this research is using a general approach of Design Development Research (DDR) method which is adopted from Richey dan Klein (2007) classified *Design and Development Research* as two categories namely (a) *product and tool research*, and (b) *model research*. Generally, there are six procedures to develop STEM-based module which based on Peffers et al. (2007) as follow:
  - a. Identify the problem
  - b. Describe the objectives
  - c. Design and develop product
  - d. Test the product
  - e. Evaluate testing result
  - f. Communicate testing result

#### **E. Research Objectives**

According to the problems that has been proposed the aim of this research is to produce STEM-based module on earth structure and its dynamics topic and analyse the effect on students' STEM literacy, furthermore this research is conducted to obtain some other information which is arranged and presented as follows:

1. To capture the characteristics of developed STEM-based module.
2. To capture the validity and readability of STEM based module.
3. To analyse the effectiveness of STEM-based module to enhance students' STEM literacies on knowledge aspect.
4. To analyse student's attitude towards STEM after implementing STEM based module.
5. To capture student's profile of STEM literacy through the implementation of STEM based module.

6. To gain information about students' perception on STEM after using STEM-based module on earth structure and its dynamic topic.

#### **F. Research Benefits**

The results of this research are expected to provide benefits as follow:

1. Students

For students by implementing STEM-based module, it is expected to provide meaningful learning experience which can improve students' technology and engineering skills, motivation and conceptual understanding.

2. Teachers

For teachers, as innovation to improve students' conceptual understanding and skills by selecting an appropriate learning module on implementing STEM-based approach at class.

3. Other researchers

For other researchers, this research can be used as a reference in order to develop learning materials for STEM-based approach. The information and discussion appeared due to this research can be evaluated as the way to have better ideas for the future research. Hopefully, there will be another research that could give valuable influences for better educational improvement.

#### **G. Organization Structure of Research Paper**

This thesis comprises five chapters that is started with introductory chapter which elaborates the background of the research followed by the problem proposed as well as its limitations. This chapter also contains the objectives of research, operational definition of how to do the research as well as the advantages of doing this research for other parties in the same field of study. It starts by focusing on the main goal of the educational system in 21st century that shows growing interest in STEM until STEM education has received growing attention nationwide. In implementing STEM education it is known that it has to be supported by learning materials such as module. However, existing science modules are found to only meet the criteria of good module, while it fails to meet the characteristics of STEM based module which facilitates students to become STEM literate. Therefore,



STEM based module is developed to produce STEM based module which meet the criteria of both good module and STEM learning material characteristics. In order to overcome this obstacle, the objectives of the study were determined, and subsequently some research questions were formulated.

The second chapter provides literature review of the study, this chapter started by focusing on theory of STEM education, STEM literacy, learning module and its characteristics, and earth's structure and its dynamics topic. Finally, STEM based module was implemented in this study for science teaching and learning process specifically on earth's structure and its dynamics topic that was discussed along with an attempt by the researcher to justify the research. The third chapter examines research methodology used which is Design and Development Research (DDR). The chapter begun by detailing the participant of the study and the time and location under which the various stages of research were carried out. Next, it dealt with the method and design of research, operational definition and data collection instruments. The fourth chapter presented data analysis and discussion. Calculation of normalized gain, effect size, tables and percentages were used in the data analysis and summaries. The results of both qualitative and quantitative data were presented by using tables and graph. The last chapter presented conclusion that was taken from the research and suggestion for further research.