CHAPTER I
INTRODUCTION

A. Background

In the twenty-first century, along with the information explosion, computer systems and internet technologies have become more advanced. As a result, learning is becoming more diversified and interesting, and the learning environment is undergoing an upgrade in terms of individual autonomy and cooperation. With the rapid development of scientific studies and technology engineering, science, technology and engineering have relied heavily on each other (Lou, et. al. 2010). The 21st century is a century of technology, in which every country is implementing many policy reforms, related to scientific education (Lou, et. al. 2011). Thus, Science-Technology-Engineering-Mathematics (STEM) education has become educational reformation slogan in United States (US) to produce qualified human resources (STEM-workforce) to improve nation's economy, competitiveness and security. STEM education concept itself has been adapted and adopted by some developed and developing countries, including Indonesia.

The implementation of STEM education in Indonesia at this time is actually still in a form of concept and still lack of research result that prove if STEM can show some positive effects such as schools improvements, raising student achievement, or even advancing students' understanding of STEM competencies. Indonesia as a big country with abundance of natural and human resources supposed to be a nation that plays a big role on those technologies development, Amal -researcher of *Lembaga Ilmu Pengetahuan Indonesia* (LIPI)- on *Republika* Online (2015) said to actualize that matter, Indonesia should adapt the pattern of STEM education. He add that students that educated with STEM approach expected to master the hard skills complemented with some soft skills such as communication, collaboration, problem solving, creativity, decision making, and many other skills because the whole learning process are conducted with active learning method.

It should be considered that Indonesia nowadays has experience a free competition era started with the existence of ASEAN Economics Society that allow a tight competition between local and international brands or even human resources. To cope with the condition, Indonesian educational government should make a fast move to solve this 21st century challenges and should start from the very basic concept of curriculum. As stated on *Kerangka Dasar dan Struktur Kurikulum 2013 Jenjang Sekolah Menengah Pertama/ Madrasah Tsanawiyah* (Kemendikbud, 2013), that *Kurikulum 2013* has purpose to prepare Indonesian citizen to have some life skills such productive, religious, creative, innovative, manner, and can contribute on society's life. It also revealed that one of the paradigm that become the basic development of *Kurikulum 2013* is transforming a mono-discipline pattern to multi-discipline, those purpose and paradigm indicate that *Kurikulum 2013* still has some spaces to embed STEM education. Thus, the STEM curriculum design is actually allows learners to combine theories and practices in real situations in addition to integrating interdisciplinary courses. During the design process, students can examine and apply knowledge and skills not only to enhance their problem-solving ability but also to effectively integrate the comprehension and application of complicated knowledge in areas such as science, technology and mathematics (Lou, et.al, 2010).

The integration pattern in a form of embedded STEM is more precise if it is implemented on secondary level, since the STEM education will perform well in certain condition when learning science or mathematics involve authentic problem solving activity in socio-cultural and functional context (Roberts, 2012). Analyzing the structure and content of *Kurikulum 2013* in secondary level, science and mathematics are assumed as the best subject to be implemented by STEM education, because both subjects are the core subject on secondary level, and become a foundation for students to enter STEM-based carrier to improve innovation on technology and economical productivity (Firman, 2015). *Kurikulum 2013* in secondary level provides some science concepts which investigate daily real world problem and need some basic concept of mathematics calculation, one of them is lever system concept. According to basic competences of how lever

system is taught in junior secondary level is, it should correlated with human skeletal muscle system concept as stated on basic competence (*Kompetensi Dasar*) for grade 8th secondary level: 'To understand the concept of work, lever system, and its application in our daily life as well as its correlation with the work of muscle on human skeletal muscle system and presenting investigation result about the use of lever system in our daily life'. Therefore one of the most suitable multidiscipline concepts that are taught in secondary level is integration of lever system and human skeletal muscle system concept.

As known that embedding STEM education is quite new in Indonesia, therefore there is still lack of school that brave enough to apply this kind of method. Schools often approach STEM education in their own ways due to their own unique populations, challenges, and needs. No single school strategy has risen to the top. However, synthesizing lessons from many of those schools may begin to tell a story about how STEM education can be supported in this time of national education reform (Chiu, et.al, 2015). However it is not only school that has not ready with STEM implementation, but also the instructional materials. The instructional material is one of the most important components of how learning can occur well (Dick and Carey, 1990).

One of instructional materials that is commonly used by teachers and schools are worksheets, the main function is usually to help students in learning process and understanding the materials also to do some problems exercises related with the materials. However, empirically in a worksheet not include a work demands and work guideline furthermore a worksheet that available nowadays indicated not suitable with the rules of constructing a worksheet, mostly it is only consist of some fragments of the materials to answer the question sets (Suyantiningsih, 2013). Therefore, this research is focused on development of workbook where a complete materials, evaluations, guidelines, clues, and rules are included in it. A workbook in science learning is usually being used for experiment guide and practical activity (Kwan, N.P and Toon, T.Y, 2007). Therefore, a workbook is one of instructional materials that are match with implementation of STEM education, because it is suitable with hands-on learning

and students can work directly in their books, eliminating the need for loose-leaf and copying questions from a textbook and they are usually smaller and lighter than textbooks, and it can make the student easier to master the materials since they will be more guided during the learning process.

Furthermore, the use of workbook possess some function such as minimizing teacher's role and make the students to be more active, make the students easier to comprehend the materials, and make the learning activities become more efficient (Widowati, 2012). However, the existing workbook for science activity has not matched with the needs of STEM activity, where students have to explore problem and design the solution by their self not only proving a theory but more on applying theory, whereas the basis of science workbook is experiment and practical activity (Kwan, N.P and Toon, T.Y, 2007). So that, the exact structure of a STEM-based workbook has to be developed to be applied in all STEM activity.

To see the success of STEM-based workbook implementation, some students' achievements are necessary to be assessed, those achievements should cover students designing skill and all learning domains that refereed on STEM occupations in the future, and so-called as STEM competencies it is the set of cognitive knowledge, skills, and abilities that are associated with STEM occupations that includes non-cognitive work interests and work values associated with motivation and high performance in STEM occupations (Carnevale, 2015). Students' STEM competencies also really important to be assessed to create deeper understanding of the science and mathematics content, so they can live better lives and transition into technical (Fan, 2014).

Regarding to the background that has been represented and the needs of STEM learning implementation result in Indonesia, this research is focus on developing the structure STEM-based workbook to become a learning set to apply STEM in secondary level in Indonesia. Also, it will be use to analyze how the STEM-based workbook can cultivate students' STEM competencies on lever system in human body.

B. Research Questions

Regarded with the background which already explained, the problem formulation of this research is "How is the development of STEM-based workbook on lever system in human body in improving students' STEM competencies?" Furthermore the problem above is expanded through the following questions:

1. How does the structure of STEM-based workbook on lever system in human body being developed?

2. How is the improvement of students' STEM competencies through STEM-based workbook about lever system in human body?

3. How is the development of students' designing skill by implementing STEM-based workbook on lever system in human body?

4. How is students' perception on STEM by implementing STEM-based workbook on lever system in human body concept?

C. Limitation of Problem

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

1. The concept lever system in human body refers to *Kurikulum* 2013 on Basic Competence 3.3 (To understand the concept of work, lever system, and its application in our daily life as well as its correlation with the work of muscle on human skeletal muscle system and) and 4.3 (Presenting investigation result about the use of lever system in our daily life).

2. The development of STEM-based workbook on this research is using a general approach it is Research and Development (R & D) method which is adopted from Borg and Gall (1989) without including the last 3 steps of research and development method (operational field testing, final product revision, and dissemination and implementation). Therefore, the main procedure to develop the STEM-based workbook are:

    a. Research information collecting,

    b. Planning,

    c. Develop preliminary form of product,

    d. Preliminary field testing (validation, readability, sample testing),

    e. Main product revision,

    f. Main field implementation, and

    g. Operational product revision (final).

The model that is used for this R & D method is a descriptive model where it can portrays and describe each steps in achieving research purpose and the influences in each stages more actual (Gati & Asher, 2001).

D. Aim of Research

According to the problem that has been proposed the aim of this research is to develop a STEM-based workbook on lever system and skeletal muscle system concept and analyze the effect on students' STEM competencies and perceptions on STEM, furthermore this research is conducted to obtain some other information and arranged as follows:

1. To develop the structure of STEM-based workbook on lever system in human body that can enhance students' STEM competencies.

2. To analyze the effectiveness of STEM-based workbook on lever system in human body through the improvement of students' STEM competencies.

3. To analyze the development of students' designing skill, during the implementation of STEM-based workbook.

4. To gain information about students' perception on STEM after STEM-based workbook on lever system in human body being implemented.

E. Significance of Research

This research is important to be conducted because it is expected to provide some benefits to various sides including:

1. For students, providing a different learning experience by implementing STEM-based workbook, it is expected to raise students' motivation, to foster the spirit of cooperation, and responsibility within the group or individual in the learning process, and also expected to improve the mastery of designing skill and creating a technology product.

2. For teachers, as innovation to improve students' skills by selecting an appropriate workbook, varied, learning strategies and innovative ways to be applied in the learning process.

3. For other researcher with the same focus of study, as a reference to develop a STEM-based workbook for other science and mathematics concept, and become source to implement STEM-based science instruction.

4. For educational Indonesian government as a recommendation and consideration of applying STEM- based science instruction on secondary level in Indonesia.

F. Operational Definition

In order to conduct the research in accordance with the expected aims and avoid misunderstanding, therefore an operational definition need to be elaborated as follows:

1. The development of STEM-based workbook on this research is a process of constructing new product as instructional materials on lever system on human body concept, evaluate, and revise the workbook become a good product that can be used for refereed instructional materials and then being tested its effectiveness on N-gain score improvement, through repeated testing and revising, also from observation on the learning process and the workbook itself. The structure of STEM-based workbook is referred to learning goals from basic competence, workbook requirements, and STEM goals and practices for secondary level. It refers to NGSS science and engineering practices.

2. Students' STEM competencies the set of cognitive knowledge, skills, and abilities that are associated with STEM occupations also include and analyze non-cognitive work interests and work values associated with motivation and high performance in STEM occupations (Carnevale, A.P., et. al, 2015). For knowledge understanding it includes content domains about lever system in human body and will be gained from objective test in a form of multiple choices. Skills in this research is only problem solving that gained through

essay questions and abilities here is related with innovation that shown by the students during the whole process and analyzed through innovative abilities rubrics and from students' answer on the workbook, while work values that will be analyze is students' responsibility that also gained through observation rubrics.

3. Students' designing skill starts with divergence the deliberate attempt to expand the range of options rather than narrow them. It is a means to go beyond incremental changes and explore opportunities for breakthrough innovations (Carroll, 2015). The analysis of students' designing skill is analyzed through rubrics in terms of define, ideate, and prototype that refers to Stanford University: Taking Design Thinking to Schools (2011). It will also being analyzed based on Basic Technology Education that is applied in Indonesia where designing skill consists of functional analysis, industrial design, strength analysis, testability, product safety and liability, economic and market analysis. It will be measured from the students' answer on the workbook, the learning process, as well as the final product.

G. Organization Structure

This research paper is arranged based on its necessity. In order to get organized structure of paper, this research paper is arranged based on the following organization structure:

1. Chapter 1 : Introduction

   This chapter elaborates the background of the research followed by the problem proposed as well as its limitation. In this part also explain the aim of the research as well as operational definition of how to do the research and the benefit for other parties in the same field of study.

2. Chapter II : Literature Review

   It describes some literatures and basic theories of the research. This research is reviewing STEM education, STEM-based workbook, STEM competencies, designing skill and lever system in human body. Those theories are used to strengthen or support the data gained from the research in analysis part.

3. Chapter III : Methodology

   This chapter examines the step of research procedures, the type of research, how the data will be obtained, what is the object of the research, the instruments, and the research plot.

4. Chapter IV : Result and Discussion

   In this part, all of the data from the research will be interpreted as result of the research. The discussion of the result will be followed after it analyzes the result of research and the correlation between the result and the theories.

5. Chapter V : Conclusion and Recommendation

   As its title conclusion and recommendation, in this chapter all of research question will be answered based on the result. The difficulties and obstacles that found in this research will be discussed in recommendation part.