Engaging Students in STEM Based Learning Through Media and Technology

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Abstract. Engaging students in physics learning is a challenge for teachers, since few students were interested in it. Therefore, STEM based learning that embedded scientific and engineering practice, was chosen to solve the problem. It has been developing in Indonesia since 2013 at secondary school level. The implementation evaluation showed that most of STEM based learning was conducted through media and technology. Therefore, these studies were analysed students response toward STEM based learning through media and technology. The media and technology was invited into electricity learning. 92 students were involved as samples of this study that came from two different classes. The analysis result showed that most of student enjoyed the lesson and eager to engage in other STEM based learning. Moreover, they agree that media and technology can help them in understanding the concept. It convinced by the students understanding improvement after the learning processes.

1. Introduction

21st century is the era of high science and technology development as symbols of modernization that stimulating the globalization. Regardless many opinion of 21st century’s definition, there are agreement that we need develop demanded human resource with required literacies to survive in this era. ISTE views the crucial technology literacy that needs highly skill labor with higher-order thinking skills and skills for digital citizenship to be effective lifelong learners and productive members of globalized society. ISTE standards include broad categories such as, the ability to demonstrate creativity and innovation, communicate and collaborate, conduct research and use information, think critically, solve problems, and make decisions, and use technology effectively and productively.

On the other hand, Bybee (2013) proposed STEM literacy that different from science, technology, engineering and mathematics literacy. This affects from US science education development that considering STEM (Science Technology Engineering and Mathematic) education as a crucial way to cope with the challenges and demands in this century. This literacy come from idea that as literate adults, individuals should be competent to understand STEM-related global issues; recognize scientific from other non-scientific explanations; make reasonable arguments based on evidence; and, very important, fulfill their civic duties at the local, national, and global levels [1].

STEM based learning that embedded scientific and engineering processes into learning activities, was proposed in order to develop STEM literate adults. The scientific process take place when students identify the introduced STEM issues or problems occur in daily life, and engineering processes is delivered through design, construct, and test its solution. Furthermore, media and technology is tools that assist the processes. There were several definitions of media. Media could be brought to the classroom through visuals, sounds, smell, and tastes. It could also be brought as technology or using technology. In this research, it was limited into the media as technology, where
the media in STEM based learning that focuses to complement students understanding by creating its media as prototype of the proposed solution. The term of technology were not limited only on communication tools such as computer or TV, but also other form of technologies that uses in constructing the media. Purpose of this research was to identify students’ response toward STEM based learning through media and technology.

2. Theoretical Framework

2.1. STEM Based Learning

Hays Blaine argue that science, technology, engineering and mathematics (STEM) education often has been called a meta-discipline, the “creation of a discipline based on the integration of other disciplinary knowledge into a new ‘whole’. This interdisciplinary bridging among discrete disciplines is now treated as an entity, known as STEM [2].” STEM education offers students one of the best opportunities to make sense of the world holistically, rather than in bits and pieces. STEM education removes the traditional barriers erected between the four disciplines, by integrating them into one cohesive teaching and learning paradigm. Morrison and others have referred to STEM as being an interdisciplinary approach. “STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy [3].

In addition, Bybee (2013) resume the definition of STEM education that already conducted by several educators. He wrote that STEM perspectives come in many ways not only as interdisciplin ary approach but also as other perspectives. He did not indicate which one is the true STEM perspective, he rather to help individuals, organizations, and agencies clarify different perspectives and give insights to those considering or engaged in education reform with a particular STEM perspective. He emphasizes to create STEM literate society, a deep technical workforce for a 21st-century knowledge economics, and an advanced research and development workforce focused on innovation.

The perspective that built and adopted on this research is describe in the figure 1. It illustrate that the STEM based learning is integrating two or three STEM discipline in lesson. A more complex model combines three of the four disciplines. Integrating science, technology, and math would be an example.

![Fig.1: STEM based learning perspective](image.jpg)

Learning process designed based on Next Generation Science Standards (NGSS) that emphasized science learning on scientific and engineering practice design. The term “engineering design” has replaced the older term “technological design,” consistent with the definition of engineering as a systematic practice for solving problems, and technology as the result of that practice. According to the Framework: “From a teaching and learning point of view, it is the iterative cycle of design that
offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices” [4]. The Framework recommends that students explicitly learn how to engage in engineering design practices to solve problems. The core idea of engineering design includes three component ideas:

1. **Defining and delimiting engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.
2. **Designing solutions to engineering problems** begins with generating a number of different possible solutions, and then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
3. **Optimizing the design solution** involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

### 2.2 Media and Technology

Reeves, G. T (1998)[5] defined media are the symbol systems that teacher and students use to represent knowledge, and technologies are the tools that allow them to share their knowledge representations with other. But he said that it is common to confound the meaning media and technology in education, indeed they are often used synonymously. For the purpose of this research, we defined media as miniature or prototype that build to represent students’ knowledge in solving non routine-problem. And technology is tools that use to explore students’ knowledge in order to trigger innovations and creation.

There are two major approach in using media and technology. Students can learn “with” media and technology, and “from” media and technology. This study describes these two approaches that embedded into STEM based learning. Learn “with” media and technology means that we bring technology and media to the classroom directly to be used by students in exploring their knowledge. For instance, we bring torch to the classroom to engage students in understanding electricity circuit concept. We asked them to explore how the torch work is and then challenge them to create innovation from it. Learn “from” media and technology occurs when students are challenged to solve non-routine problem then represent their solution through miniature or prototype that created use technologies.

Teaching using media and technology could help student in understanding the concept. Media has great impact on children; it affects on attention and other cognitive skills [5]. He argues that it is difficult within the context of his study to isolate the links between content and self-regulatory skills, but the findings clearly indicate that a media does not have an indiscriminate negative effect on intentional skills. In fact, several experiments have found that technology can teach specific attention skills and strategies. Furthermore, teaching with media is brain friendly since it occurs in environment that is positive and utilizes research based method in teaching and learning.

### 3. Methodology

This descriptive research was conducted at two classes of 92 senior high school students. It was divided into control and experiment class. Students in control group taking electricity lesson in conventional approach, and students in experiment group taking the lesson in STEM based approach using learning cycle 5E models that consist of 5 phases: engage, explore, explain, elaborate, and evaluate. The lesson was invited torch as technology to learn electricity concept, and students was challenged to create new torch from simple and used materials as media to show their concept understanding. At the first phase, students were engaged with the problem of two torches which one of torch is broken. Teacher leads students with question whether one torch is working and another one is not. In the second phase, students explore the torches to find the answer. After that they were asked to explain the answer by presenting it in front of the class. In the next phase, they were challenged to create a new innovative torch using simple and used materials. They were elaborate to define (D), develop (D), and optimize (O) as an engineering design processes. Finally, they evaluated the media by
questioning the reason of deciding the materials, the problems on creating it, and the solution to solve it. Data of students’ response toward learning processes were collected through an observation in each phase. And data of students’ concept understanding were collected before and after learning processes. It was analyzed statistically using N-gain to show their improvement.

4. Results and Discussion
Observation result showed that almost all students were enthusiast in learning activities. They interested and enjoyed in exploring, explaining the problem, and they were challenged to create innovation about the torch. It was describe in the table 1.

**Table 1. Students’ response toward the learning processes**

| Phase  | Students’ activity | Students’ Performance |
|--------|--------------------|-----------------------|
| Engage | Watching demonstration of two torch | Students enthusiast, answers all question from teacher |
| Explore | Explore the two torch by analyzing the systems | Students enthusiast in analyzing torch system  
Students prepare all the equipment by themselves.  
Students can identify the torch component successfully  
Students can draw the torch circuits.  
Students designed the torch well.  |
| Explain | Explain the reason why the torch is working and not working | Students conclude that the torch is working when the electric circuit is closed. They assumed that the current moves from positive to negative pole, and analyze that the iron plate will touch the lamp circuit by putting the switch at ‘on’ mode. It showed that they can explain correctly the torch work system.  |
| Elaborate | Define (D), Develop (D), and Optimize (O) the solution to solve the challenges | Students gave new torch design that different from the initial ones.  |
| Evaluate | Evaluate they did a self-assessment toward what they learned, what problem they faced, and what solution they had. They also gave opinion related to media and technology | Students gave evaluation of their learning processes by writing a journal.  |

Besides, enthusiast in learning process, they showed improvement on concept understanding related to electricity topic. The N-gain analysis concluded that it was on medium category (\( <g> = 0.49 \)). The detail analysis is showed in table 2.

**Table 2. Description of students’ understanding concept score of static electricity**

|                  | Experiment | Control |
|------------------|------------|---------|
|                  | Pre-test   | Post-test | \( <g> \) | Pre-test | Post-test | \( <g> \) |
| N student number | 46         | 46       | 46       | 46       | 46       | 46       |
| Average          | 30,1       | 70,8     | 0,58     | 30,0     | 65,3     | 0,49     |
| SD               | 7,9        | 12,1     | 17,05    | 7,0      | 9,9      | 16,34    |
Based on the pre-test, post test and <g> preview understanding of the concept in Table 2, it is known that the average score of the initial test of the experimental class is 30.1 (30% of the ideal score), while the average pre-test score of the control class is 30.0 (30% of ideal score), average post-test score of experiment class is 70.8 (71%) and control class is 65.3 (65.0%). Thus, the students in the experimental class experienced an average score increase of <g> of 0.58 and an increase in the average score of the control class by 0.49. The average of experimental class and control class is medium category. Generally, it showed that students’ concept understanding had improved. However, the experimental class was better than the control class. It could concluded that using media and technology in learning processes took essential role in increasing students’ motivation and understanding.

These findings support Cylan’s research that the implementation of STEM based learning could increase students’ achievement by 0.67. The results also support the findings [6] that the integration of STEM in learning can improve learning outcomes, motivation, and increase interest in science. Furthermore, It also convinced Ozel’s opinion that inviting media and technology can foster STEM learning [7].

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