Developing lesson plan of the biogas from animal’s dung
STEM education

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Abstract. The paper will clarify STEM education learning activity of designing biogas from animal’s dung. This activity was developed based on Sutaphan and Yuenyong [13] the context-based STEM education learning approach. The activity will start from identification of social issue of biogas that comes from animal dung and how to design biogas from animal’s dung. The possible solution will be introduced to the students to enhance them to develop the prototypes. Then, the lesson plan will provide activities regarding on the 7 stages of Sutaphan and Yuenyong [13] the context-based STEM education in order to scaffold students to practice knowledge for designing prototypes or products through engineer design process. The lesson plan will provide students to develop and use their integration of knowledge through biogas producing activity. For examples, physics (density of gases that lighter than air), biology (type of animal’s dung that fit and efficient for biogas), chemistry (composition of gas and dung), technology (design a tank that collect biogas from animal’s dung), engineering (how to make a gas separated by animal’s dung and flow it to the kitchen), mathematics (calculate the range of tank, pipe, and location to place the dung), financial issue (how to make an efficient biogas with a cheap cost). This paper may have implications for designing STEM education learning activities and adding value of local raw materials by using STEM education.

Keywords. STEM education, hydraulics, parking system

1. Introduction

STEM education begun in the US since the 1990s, the STEM definition is “pedagogical applications based design and engineering technology for teaching content and practice in science and mathematics education with the content and practice of educational technology and engineering with simultaneous” [1]. Moreover, STEM is a discipline that is related between sciences and technology or other subjects that involved with sciences knowledge. Technology and technique are the application of science which need mathematics as a data analysis tool and create innovation based on engineering. Thus, STEM learning needs to emphasize some aspects of learning [2], [3], [4], [5], [6] and give significant learning through the systematic integration of knowledge, concept, and skills to students. Furthermore, the advantages of STEM are enhancing students’ thinking such as problem-solving, critical thinking, analysis skills to prove their innovators, inventors, independent, logical thinker, and technological literacy [7], [8]. The 21st century has focused on globalization, information society, the competition in the economy, and the creative workforce. Thus, education should stimulate students to
become a well-educated resource such as critical thinkers, positive impact attitude, privacy management as well as motivation to be learned by themself [9].

Because the main goals of STEM education are to increase well-educated human resources, improve STEM literacy in all citizens and strengthen the STEM-related workforce [10], the lesson planning or curriculum development should show the connections between the variety disciplines and the real world issues. STEM education was defined as approaches focusing on integration or combination of two or more disciplines of STEM and/or other disciplines [11], [12]. Thus, the programs of teaching were designed confirmation by the connections all knowledge and skills to dealing with problems in real-life as well as find the solutions. However, STEM approach also known as disciplines bounded up with learning practices within contexts to enhance student learning [13]. Therefore, STEM programs can be more than thinking wherewith there is given many choices to design students’ intention and provide a relevant context for learning the exact contents.

Similar to other countries, STEM education is the dominant based field of the current Indonesian curriculum. The importance of providing students with knowledge also intends to be the technological and scientific citizens in next generation for globalization. The integration among science and other disciplines has been widely studied and discussed in Indonesia and produces good results in improving learners’ practicing knowledge. Therefore, this study investigated students’ apply a scientific principle, technology, engineering, and mathematics (STEM) by design biogas from animal’s dung, while the development of student skills through the application of integrated STEM.

2. Developing the biogas from animal’s dung learning activities
The developed lesson plan of the biogas from animal’s dung STEM education learning activities were developed based on Sutaphan and Yuenyong [14] the context-based STEM education learning approach. The context-based STEM education learning approach included (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage. The context of issue about natural gas for cooking will be provided in order to enhance students to make the prototypes or products of biogas. The integration of knowledge from different disciplines could be provided; for examples, physics (density of gases that lighter than air), biology (type of animal’s dung that fit and efficient for biogas), chemistry (composition of gas and dung), technology (design a tank that collect biogas from animal’s dung), engineering (how to make a gas separated by animal’s dung and flow it to the kitchen), mathematics (calculate the range of tank, pipe, and location to place the dung), financial issue (how to make an efficient biogas with a cheap cost). The students are encouraged to apply their integration of knowledge for problem solving in context of engineers, technology, or entrepreneurship [14]. The highlight of the biogas from animal’s dung STEM education learning activities is showed in the table 1.
Table 1: The highlight of the biogas from animal’s dung STEM education learning activities

| Stage                                      | Activity                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Identification of social issues        | Encourage the students to discuss about liquid petroleum gas for cooking in term of its properties and cost.                                                                                                                                                                                                                           |
|                                            | 1. Teacher challenges the students to make natural gas for cooking.  
2. Teacher tells students about biogas that comes from animal dung/feces. Teacher presents a problem “If the students are engineers, how to design biogas from animal’s dung?” .                                                                                             |
| 2. Identification of potential solutions  | Students create their possible designing based on Sciences (physics, biology, and chemistry), Technology, Engineering, and Mathematics. For examples,  
- Physics: Density of gases that lighter than air  
- Biology: Type of animal’s dung that fit and efficient for biogas  
- Chemistry: Composition of gas and dung  
- Technology: Design a tank that collect biogas from animal’s dung  
- Engineering: How to make a gas separated by animal’s dung and flow it to the kitchen  
- Mathematics: Calculate the range of tank, pipe, and location to place the dung  
- Financial: How to make an efficient biogas with a cheap cost                                                                                                                                                        |
| 3. Need for knowledge                      | 1. The teacher defined students to study multimedia about Biogas, which discusses processes and agriculture on the issue of energy generation from animal dung. This stage will lead students to know that the origin and outcome of Biogas including the conceptions of people on Biogas in order to connect their knowledge from previous steps with Biogas issues.  
2. Then the teacher distributed the knowledge about "Promoting biogas production" for students to search for information, discuss, explain and summarize technology or engineering of the Biogas process and the factors affecting the production of Biogas such as temperature, pH, Inhibitors and pollutants, etc. Moreover, the teacher gives some examples (Sweden with the world's first Biogas train) to students.  
3. Students work collaboratively searching for information of the types of animal’s dung, the composition of biogas, a tank gas, length and diameter of pipes, where to place the dung on the land, and design all component accurately although summarize knowledge about Biogas technology as well as the advantages and disadvantages which leads to impacts on humans and the environment. |
\textbf{Table 1:} (Continued)

| Stage                  | Activity                                                                                                                                 |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 4. Decision making     | 1. After students have the knowledge about all of capitals and learning activity, teachers assigned each group of students to design biogas from animal’s dung. Students may apply scientific principle, technology, engineering and mathematics.  
2. Students can make the design of biogas from animal’s dung in laptop. |
| 5. Development of prototype or product | Students create a prototype biogas from animal’s dung.  
Notes for consideration:  
✓ Proportion of animal’s dung with water  
✓ Location of the dung shelter  
✓ Size of the dung shelter  
✓ Length of the pipe  
✓ Number a biogas tank  
✓ Efficiency design and material’s cost |
| 6. Test and evaluation of solution | Students are asked to develop some ideas of how the prototype works.  
✓ Where the dung’s shelter should be located?  
✓ How far the dung’s shelter to house?  
✓ How many proportions between water and the dung?  
✓ How many pipes and tank to make biogas?  
✓ What size of the dung’s shelter should be made?  
✓ How the prototype could be explained as the real one? |
| 7 Socialization and completion decision | 1. Present and explain the miniature model or prototype of biogas from animal’s dung to the other group and teacher.  
2. Share what they learn from the comment and what they will revise for the completion solutions. |

3. Conclusion

This paper showed how to provide STEM education through Sutaphan and Yuenyong [14] context based STEM education learning approach. The issues of the natural gas for cooking will be discussed. The students are challenged to produce biogas that comes from animal dung for cooking. The possible design will be discussed through list some existing knowledge and requiring knowledge for further designing.

Then, classroom will move to the need for knowledge stage where students will investigate knowledge related to their possible designing the biogas from animal’s dung. Teacher may scaffold students to search for information related to the biogas. For examples, the type of animal’s dung, composition of biogas, a tank gas, length and diameter of pipes, where to place the dung on the land, and design all component accurately.

The students develop their prototypes based on the integration of STEM knowledge and skills. They need to explore the proportion of cow’s dung with water, location of the dung shelter, size of the dung shelter, length of the pipe, number a biogas tank, efficiency design and material’s cost. On development prototypes or products, students could not only apply various kinds of knowledge (physics, biology, chemistry, technology, engineering, mathematics, financial issue, and so on) but also fluid skills (cooperation, thinking skills, leadership, partnership and so on) to optimize their prototypes or products.

The test and evaluation of the solution stage, students’ prototypes of the biogas from animal’s dung through reflection of a distinguished panel of judges. The framework of evaluation for prototype work will be provided through some questions. These included where the dung’s shelter should be located, how far the dung’s shelter to house, how many proportions between water and the dung, how
many pipes and tank to make biogas, what size of the dung’s shelter should be made, and how the prototype could be explained as the real one.

In the socialization and completion decision stage, students have to present and explain the miniature model or prototype of biogas from animal’s dung to the other group and teacher. Then, students will get the comments from participants in order to revising their prototypes and products. Consequently, the biogas from animal’s dung STEM education learning activities may share some ideas of how to develop STEM education learning activities through context based. And, students will have also chance to apply their scientific and other knowledge for problem solving in context of engineers, technology, or entrepreneurship [14].

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