The development of lesson plan of the water pressure booster pump STEM education

Supriono Koes-H¹, Ika Khoirun Nisa¹, Elok Faiqatul H.¹, Tri Wahyuni¹, Chokchai Yuenyong²,³, Sukanya Sutaphan², and Jirakan Yuenyong²*

¹Department of Physics, State University of Malang, Malang, East Java, Indonesia
²Faculty of Education, Khon Kaen University, Thailand
³ASEAN Research Network for STEM education (ARN-STEM), Khon Kaen University, Thailand, email: ychok@kku.ac.th

Abstract. The paper will clarify STEM education learning activity of designing the simple the water pressure booster pump. The STEM education learning activity will be developed based on Sutaphan and Yuenyong [12] the context-based STEM education learning approach. The activity will start from identification of social issue of the drought often occurs during the dry season in various regions in Indonesia. The possible solution as the designing simple water pump 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 [12] the context-based STEM education in order to scaffold students to practice knowledge for designing some technology prototypes or products through engineer design process. For making the simple water pressure booster pump, the lesson plan will provide students chance to practice integration of knowledge. That knowledge includes physics (e.g. basic measurement skills, object motion, dynamic fluid, gravitational force, energy, etc.), math (e.g. measurement, unit conversion), art (e.g. an impressive form of water pressure booster pump), and economy (e.g. save money and be able to use natural resources). This paper may have implications for designing STEM education learning activities.

Keywords: STEM education, water pressure booster pump, energy, electromagnetics, measurement

1. Introduction
The term of STEM stands for Science Technology Engineering and Mathematics. It was first used by the National Science Foundation (NSF) to refer to a science-engineering program and mathematics. However, STEM does not have a wide definition that make resulting in being used in a variety of contexts by referring to occupations related to science, technology, engineering, and mathematics, etc. In the field of STEM Education, there is beginning to be widely taught in that university, college, and school will be an integrated study by using both scientific knowledge, technology, and engineering processes and math succeed to connect and use to solve various problems as well as developing new processes to create the innovation. It is an extension of the existing curriculum to be able to be used to improve the quality of life in various fields efficiently. In addition, stem studies are designed to reach
students who have never been interested in the courses in STEM before, turn to become more interested in learning in this field [1].

Indonesia paradigm is putting STEM forward to the education that produces interdisciplinary learning and provides effective results Indonesia began to integrate a STEM-based learning model through collaboration with science learning and teaching. It has been recognized that STEM education can be push students in creating innovative and creative masterminds with active problem-solving skills who are shaping up to be informed and empowered citizens. The solution ways are required the whole approach that includes skills and are not limited to STEM subjects to prepare students for an innovative and uncertain future [2]. This paper we focused on project-based learning (PBL) which is learning and teaching by using the project as the base. It is a process aimed at pupils connect real-life experiences, find answers by inquiry real investigated, PBL is not only an experiment in a lab but also performing tasks for students in real-life systematically. Furthermore, there are given students the opportunity to have direct experiences such as problem-solving, planning, teamwork, and systematic critical thinking by focusing on the ability to integrate various fields to deal the projects. In the process of developing the project, students must use a variety of disciplines in order to develop a good product. The teaching and learning process in STEM realizes through blended unilaterally or one filed may be the dominant base field. Therefore, the elucidations of its exact meaning very broadly. These range from very specific (e.g., mathematics, physics, chemistry, biology, information sciences, and engineering) [3], [4], [5], [6], [7], [8]. STEM knowledge can develop if it is linked the environment to realize a study that presents a real-life experience for students in their daily life activities [9], [10], [11].

This study focused on developing STEM teaching strategies in school setting. The paper clarified actions and conceptions of STEM education should be provided for students as well as suggested STEM education teaching in aspect of practicing knowledge in the real-world through project-based learning that enhancing students’ applying scientific and other knowledge for designing the solutions in real-world problems.

2. Developing the water pressure booster pump STEM Education learning activities

The developed lesson plan of the water pressure booster pump STEM education learning activities will be developed based on Sutaphan and Yuenyong [12] the context-based STEM education learning approach. The context of drought often occurs during the dry season in various regions in Indonesia will be provided in order to enhance students to identify the problem for making the prototypes or products of simple water pressure booster pump.

Sutaphan and Yuenyong [12] the context-based STEM education learning approach consists of 7 stages. These 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 7 stages of context based STEM education teaching approach, the activities may motivate students to practice knowledge for designing prototypes of simple water pressure booster pump. The integration of knowledge could be provided; for examples, include physics (e.g. basic measurement skills, object motion, dynamic fluid, gravitational force, energy, etc.), math (e.g. measurement, unit conversion), art (e.g. an impressive form of water pressure booster pump), and economy (e.g. save money and be able to use natural resources). The highlight of learning activities could be viewed as showed in the table 1.
**Table 1:** Highlight of the water pressure booster pump STEM education learning activities

| Stage | Activity |
|-------|----------|
| 1. Identification of social issues | 1. Social Problems: Drought often occurs during the dry season in various regions in Indonesia. Most droughts occur in the highlands/mountain areas. Residents have to go to lower places and take water for their daily needs.  
2. The teacher raises the problem, "How can you help the residents/government to overcome this drought problem?"  
3. Products: simple water pressure booster pump, students will design a simple water pressure booster pump prototype. |
| 2. Identification of potential solution | 1. Students and teachers will share a cost analysis in their simple water pressure booster pump design.  
2. Students will discuss the possibilities of their water pressure booster pump design. There are five aspects considered: physical, financial, social/technological, human, and natural.  
Physical - Aesthetic value of water pressure booster pumps  
Finance - Use local materials that are good and affordable  
Social/Technology - Selection of suitable materials ingredients and finding ways to solve the problems  
Humans - Safety of use  
Natural - The use of natural materials |
| 3. Need For Knowledge | 1. Project-Based Learning (PBL). Each group will have 4 to 5 members  
2. Students need to collect related information to make the right product.  
3. Students can ask for help from experts/technicians to create an efficient prototype water pressure booster pump.  
4. Students can research more information on the internet. Based on the information collected, students have many considerations to build a simple water pressure booster pump prototype. For examples [13];  
4.1 Gravitational potential energy will be studied. Gravity either drives or slows water flow. The higher the elevation where water must be delivered, the lower the water pressure. This happens because the weight of water - one gallon of water weighs over 8 pounds. If water travels uphill or up several floors, gravity wants to send it right back down. The high places require a large booster pump to move water up.  
4.2 How does a booster pump work? Core components of a booster pump include motor, impellers, inlet and outlet, and pressure or flow sensing device. Booster pumps have an impeller that moves water that comes in through the inlet and exits through the outlet. A motor makes the impellers spin. Booster pumps differ according to how they suck water in and push it out. Pumps with oscillating diaphragms propel water using two oscillating or rotating plates—one with cups and one with indentations. As the plates roll together, they compress the cups and force the water out. As the plates roll open, more water is sucked in. |
Table 1: (Continued)

| Stage                                      | Activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4.3                                        | To find the right size booster pump for your specific, students may consider the following issues:  
  - The highlands/mountain areas need the larger size of water booster pump because when the water must travel uphill, then the flow rate is slower and the pressure from the pump is higher.  
  - What is my water flow rate? Calculate how many gallons of water you get per minute, taking all fixtures into consideration.  
  - How much water do I need? Consider how much water your household or business uses.  
  - Is the water source above or below the pump? Think about whether or not your water must travel uphill or up several stories.  
  - How much pressure do I need? Many people prefer high water pressure when taking a shower, but pressure that's too high can destroy plumbing, fittings, and appliances. Most homes have a pressure reducing valve where the water line enters the house to maintain the water pressure. Pressure over 60 psi wears the household plumbing system.  
  
  Knowledge used:  
  Physics: basic measurement skills, object motion, dynamic fluid, gravitational force, energy, etc.  
  Math - measurement, unit conversion  
  Art - an impressive form of water pressure booster pump  
  Economy - Save money and be able to use natural resources. |
| 5. Development of prototype or product  | Students make a simple water pressure booster pump at school during Physics lesson schedule. Required documentation (Photos and videos) in each step of their experiment.  
  Students will be guided by the following questions during their activity:  
  1. What materials did you use in making simple water pressure booster pumps?  
  2. Mention the ratio and the amount of material you used!  
  3. What is the prediction of the success rate of the water pressure booster pump that you have made? Why is prediction like that?  
  4. What values have you learned from the activity? |
Table 1: (Continued)

| Stage                                      | Activity                                                                 |
|--------------------------------------------|--------------------------------------------------------------------------|
| 6. Test and Evaluation of the solution     | An open forum will start, so students will use this information to improve their products further. |
|                                            | - How high will water be brought up?                                    |
|                                            | - How much pressure do the water booster pumps produce?                 |
|                                            | - How is the attractive designing of the water booster pumps?            |
|                                            | - How much is the cost of making the water booster pumps?               |
| 7. Socialization and completion decision    | Each group of students will ask to create a vlog about their final product and publish it on social media. They can also display the results at school. |

3. Conclusion

It could be seen that the paper clarified how to provide STEM education through Sutaphan and Yuenyong [12] context based STEM education learning approach. The local issue of drought often occurs during the dry season in various regions in Indonesia will be provided. The activity will start from identification of social issue of how students could solve the problem of droughts occur in the Indonesia highlands/mountain areas where residents have to go to lower places and take water for their daily needs. The possible solution as the designing simple water pressure booster pump will be introduced to the students to enhance them to develop the prototypes.

Then, classroom will move to the need for knowledge stage where students will investigate ecosystem and other knowledge related to their possible designing the simple water pressure booster pump. Teacher may scaffold students to read the literatures related to the simple water pressure booster pump. Teacher may also ask for helping from expertise or technicians to extend students’ way of seeing and skills for practice knowledge of making the simple water pressure booster pump. Those knowledge included physics (e.g. basic measurement skills, object motion, dynamic fluid, gravitational force, energy, etc.), math (e.g. measurement, unit conversion), art (e.g. an impressive form of water pressure booster pump), and economy (e.g. save money and be able to use natural resources).

After students learn some more related knowledge, they could develop their prototypes or products which concurrent through knowledge based that could be provided on the decision making and development of prototype or product stage. The questions as scaffolding of students’ making the prototypes of simple water pressure booster pump will be provided in the development of prototype or product stage. Students will be guided by the following questions during their activity. These scaffolding include; for examples, what materials should be used for making simple water pressure booster pumps, what the ratio and the amount of material should be provided, what the success rate of the water pressure booster pump should be made, what students learn from the activity and so on. Through the scaffolding, students could not only apply various kinds of knowledge (e.g. science, math, economic, law, values, culture 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 water booster pump through reflection of a forum. The framework of evaluation relates to practice ideas and knowledge for how high water will be brought up, how much water pressure will be provided, what attractive the water booster pump look like, how much cost of making the water booster pumps, and so on. In the socialization and completion decision stage, students have to make a vlog on their final product and publish it on social media (e.g., Instagram and Youtube). Then, students will get the comments from their social media (Instagram and Youtube) in order to revising their prototypes and products. And, students will have also chance to apply their scientific and other knowledge for problem solving in context of engineers, technology, or entrepreneurship [12].

References

[1] Suwono H, Fachrunnisa R, Yuenyong C, & Hapsari L 2019 Indonesian Students’ Attitude and Interest in STEM: An Outlook on The Gender Stereotypes in The STEM Field. *Journal of Physics: Conference Series*, 1340 (1), 012079

[2] Kärkkäinen and Vincent-Lancrin 2013 Spearking Innovation in STEM Education with Technology and Collaboration: A Case Study of the HP Catalyst Initiative *OECD Education Working Papers* 91

[3] Gonzalez H B and Kuenzi J J 2012 Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer (Washington, DC: Library of Congress Congressional Research Service)

[4] Koes-H S, Putri FS, Purwaningsih E, & Salim AY 2020 The influence of flipped classroom in inquiry to student’s critical thinking skills in impulse and momentum. AIP Conference Proceedings, 2215 (1), 050008

[5] Linh NQ, Duc NM, & Yuenyong C 2019 Developing critical thinking of students through STEM educational orientation program in Vietnam. *Journal of Physics: Conference Series*, 1340 (1), 012025

[6] Mordeno IC, Sabac AM, Rouillo J, Bendong HD, Buan A & Yuenyong C 2019 Developing the Garbage Problem in Iligan City STEM Education Lesson Through Team Teaching. *Journal of Physics: Conference Series*, 1340 (1), 012046

[7] Villaruz EJ, Cardona MCF, Buan AT, Barquilla MB, & Yuenyong C 2019 Ice Cream STEM Education Learning Activity: Inquiry from the Context. *Journal of Physics: Conference Series*, 1340 (1), 012092

[8] Wongsila S. & Yuenyong C. 2019. Enhancing Grade 12 Students’ Critical Thinking and Problem-Solving Ability in Learning of the STS Genetics and DNA Technology Unit. *Journal for the Education of Gifted Young Scientists*, 7(2), 215-235

[9] Çakici Y and Türkmen N 2013 An Investigation of the Effect of Project-Based Learning Approach on Children’s Achievement and Attitude in Science *TOJSAT: The Online Journal of Science and Technology* 2(3) pp 9-17 [pdf]. Available at:<https://www.tojsat.net/journals/tojsat/articles/v03i02/v03i02-02.pdf>

[10] Bilgin Y A and Karakuyu Y 2015 The Effects of Project Based Learning on Undergraduate Students’ Achievement and Self-Efficacy Beliefs Towards Science Teaching *Eurasia Journal of Mathematics, Science and Technology Education* 11(3) pp 469-477

[11] Yuenyong C 2017 Enhancing Thai Students’ Thinking Skills about Energy issues: Influence of Local Values. *Chemistry: Bulgarian Journal of Science Education*, 26 (3): 363 – 376

[12] Sutaphan, S &Yuenyong C 2019. STEM Education Teaching approach: Inquiry from the Context Based. *Journal of Physics: Conference Series*, 1340 (1), 012003

[13] Fresh water.com 2019 Retrieved from: https://www.freshwatersystems.com/blogs/blog/what-is-a-water-booster-pump-and-how-does-it-work