Developing the STS electric and electric power unit for design based STEM activities

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Abstract. Recently, there is increasingly providing STEM learning activities in school setting. This paper aimed to clarify the developing STS electric and electric power unit for design based STEM activities. STEM education learning activities need to be developed through design based learning activities. The STS electric and electric power unit, therefore, was developed regarding on STS approach and structuring students’ ideas of designing for problem solving by providing the steps of engineering process design. The paper, then, clarify the details of STS electric and electric power unit. The unit will bring the social issues to the classroom in order to engage students’ identify the problem for solving. Then, the unit will suggest the engineering process design to students in order to scaffold students to design for developing the prototypes for solutions. This paper may have implication for providing design based STEM activities.

Keyword: Design based, STS, STEM education, electric

1. Introduction
The P21 Partnership for 21st century skills [16] provided framework definition of 21st century skills. The framework suggested what kinds of skills should be provided for preparing students in the 21st century. The elements described in this section as “21st century student outcomes” (represented by the rainbow) are the knowledge, skills and expertise students should master to succeed in work and life in the 21st century. This suggested that people in the 21st century not only held the crystalized knowledge but also soft skills. Those skills included learning and innovation skills; information, media and technology skills; life and career skills.

A Framework for K-12 Science Education [13] has also been provided as knowledge and skills for practicing in the real context. Based on the direction of the framework for K-12 science education, the National Research Council in the United States has released the Next Generation Science Standards [14]. The Next Generation Science Standards (NGSS) integrated engineering into science education and call for increasing engineering design as the same level of scientific inquiry in science classrooms. It describes a new vision of American science education for all [3] in which students’ science proficiency gains through the integration of practices with contents. These Standards release performance expectations that combine three dimensions (science and engineering practices, crosscutting concepts and disciplinary core ideas) in a manner that requires students to demonstrate knowledge in use-building and applying scientific knowledge [13]. This indicates that science
education focuses on STEM education. For example, a framework for K-12 science education [13] and the Next Generation Science Standards [14] describe “the integration of technology and engineering within science teaching, raising engineering design in the same level as scientific inquiry in classroom instruction”.

Regarding on the conceptions of STEM education, the literatures indicated that STEM teaching and learning involved the integrator is the engineering practices and engineering design of technologies as the context; the engineering design or engineering practices related to relevant technologies requires the use of scientific and mathematical concepts through design justification; and the context of instruction requires solving a real-world problem or task through teamwork [24], [25]. And, it should focuses on the design processes that are much diversity. The STEM teaching and learning should provide an inquiry approach that may begin with an environmental problem, a design approach may begin with a product, and a problem based approach may begin with a problem [20].

To develop some design-based STEM activities, the ASE suggested the revised SATIS (Science and Technology in Society) units in the UK for science teachers [20]. This could be viewed that the STS approach could be provided for scaffolding to inquiry of practicing STEM knowledge. Consequently, based on the second author research experiences on STS, he [23] suggested school science teachers provided STS teaching approach that consisted of 5 stages including (1) identification of social issues; (2) identification of potential solutions; (3) need for knowledge; (4) decision-making; and (5) socialization stage. Those science teachers, who followed Yuenyong [23]’s STS approach, had showed some results of enhancing students’ practicing knowledge in real world [20]. Some implementations of Yuenyong [23] STS approach gave students chance to apply their scientific and other knowledge for problem solving in context of entrepreneurship. It revealed that students not only apply science and mathematics knowledge for solving problem of social issues but also values, culture, designing/procedure knowledge, marketing, financial thing, commence, economic, law, and so on [1], [2], [5], [10], [15], [17], [19], [21], [22], [26].

Regarding on STEM education, the design-based tasks usually give chances for integration of technology and engineering within science teaching. Design-based tasks could give excellent chances for students to express creativity. The design-based tasks are the inquiry-based activities. It, therefore, need to provide feature strategies such as analyzing, synthesizing, evaluating, and design strategies (e.g. problem finding, question asking, manipulating and investigating objects, estimating, calculating, and sketching) [6], [7]. Pedagogy for design tasks should organize authentic and hands-on activities, chances of finding multiple solution pathways, student-centered, and higher-order work [6], [8]. To enhance inquiry skills for design tasks, the pedagogy need to foster using familiar and easy to work with materials and fabrication techniques, allowing for multiple design iterations to improve the work, and having clear links to science and engineering concepts [6]. However, many design-based tasks are considered to be ill-structured problem-solving tasks, which are complex, open ended, and more in line with real-world problems [4]. To scaffold students to structure their design-based tasks, the pedagogy may provide some engineering design process in order to enable students to make the task designing cognitively easier [11], [18].

According to literature above, this paper will clarify the developing STS electric and electric power unit for design based STEM activities. The structure for design based could follow the engineer process design. Enhancing students to work through engineering design process, they learn that it is not simply building things. Instead, it is a process through which structures are designed, through which clear identification and definition nine of the Identify need or problem, research, planning and brainstorming, testing and evaluation, and Communication are necessary. They also are engaged to practical application of math and science knowledge for developing a thing as solution. This study, adopted Hynes et al [9]’s engineering design process as scaffolding of students’ designing a thing. The Hynes et al [9]’s engineering design process, therefore, should be taken into account when teachers develop the STS learning unit. Then, the unit probably enhance students to apply engineering process design for solving problem.
2. Developing the STS electric and electric power unit for design based STEM activities

According to the Basic Education B.E. 2551 [12], teaching in the unit of electricity and power in the subject of science (additional) module must complete 2 plans with 4-hour teaching and another 2 extra hours, making it 6 hours in total. Based on Yuenyong [23], the 5-stage STS teaching consist of 1) identification of social issues, 2) identification of potential solutions, 3) need for knowledge, 4) decision-making, and 5) socialization. In order to suggest students to practice knowledge, the engineering process design was built in the 5 stages of STS teaching. Based on Hynes [9], the steps of engineering design process were provided. These included 1) identify need for problem, research need or problem, 3) develop possible solutions, 4) select best possible solution, 5) construct a prototype, 6) test and evaluate solution, 7) communicate the solution, resign, and 9) complete decision. Based on this idea, we could develop the STS electric and electric power unit for design based STEM activities. The unit probably enhance students to apply engineering process design for solving problem.

The engineering design process helps students seek more information during the need for knowledge in the 3rd stage and improves their decision-making process in the 4th stage of Yuenyong [23]’s STS approach more effectively as explained below.

1) Identification of social issues is the stage that the teacher encourages students to be aware of social issues by presenting situation of fire accidents occurred in a community in which the students live. Then, students identify social issues how science and technology can solve the issue using certain questions such as "what is the cause of the short circuit?" By doing this, it is expected that students will be appreciated that they are involved in helping to seek answers to that issue in order to build up their interests in the issues and in searching for knowledge to eliminate social issues by using their knowledge of science and technology.

2) Identification of potential solution is the stage that students check their potential solutions to find the answer to that social issue from students' perception of science in solving problems “what is the cause of the short circuit?” At this stage, students must plan how to acquire answers to the problem by examining their potential solutions by considering their own knowledge and aim to enhance with additional knowledge that will encourage students to be more active in searching for answers. Otherwise, they can search "guidelines, methods, or invent any devices to eliminate “short circuit protection" as well as explain the principles and reasons supporting the methods used in design of device invention. In addition, students can review previous knowledge among group members to assess what knowledge can be best used to solve problems while sharing ideas and answers some issues they have not known by searching more information, for example, how much is the amount of power used by the electrical appliances, how they affect the short circuit, what content of scientific knowledge used in designing devices, including the construction of short circuit protection devices. Therefore, teachers can add any content for students to expand their knowledge: “do you want to know more about anything apart from your friend's presentation?” If so, teachers must provide knowledge immediately. Then, teachers can proceed to the next step that is summarizing relevant knowledge of electricity and power related to the cause of short circuit, such as electrical equipment and appliances, and the excessive amount of electricity or electricity usage.

3) Need for knowledge is the stage that students must study additional science knowledge related to problems from several sources i.e. internet and textbooks, and then teachers and students discuss results of the gained information about the cause of the electric shock. The group discussion allows additional comments so that teachers can further explain about the relation of electricity and its power from the definition and the equation. Also, teacher should provide suggestion to students on which method, design, or equipment is needed for short circuit protection device.

4) Decision –making is the stage that students apply their existing knowledge and knowledge gained from additional studies and knowledge that the teachers provided to finalize the design, methods, or equipment needed in the protection of short circuit to be used in reality. In this stage students must consider whether the design and device invention are possible or not, what are the benefits and disadvantages. Then, students must present the detail of the device invention in accordance with the engineering design process regarding on 9 steps of Hynes [9].
Accordingly, in this study, the engineering design process is adjusted with 7 steps to be suitable for the students to reflect their concepts and behaviors that highlight the components of learning skills and innovations of the 21st century, consisting of the following 7 steps: (a) Identification of Problem or Need, (b) Data collection, (c) Method selection, (d) Design and Practice process, (e) Testing, (f) Revision, and (g) Evaluation.

5. Socialization is the stage that students review their concepts in solving the problems by presenting how they decision was made to design the fire prevention device. During this stage, students can exchange or recheck their ideas to be most suitable with other groups of students. From classmates’ presentation e.g. poster or online webpage, students can reflect their ideas of how they came up with the methods, or equipment for short-circuit protection to the public.

3. Conclusion
It could be viewed that this paper clarifies the ideas of organizing STS electric and electric power unit for design based STEM activities. According to the nature of STS teaching, the real world problem was brought to the classroom in order to motivate students to identify the problem. Five stages of Yuenyong [23] allowed teachers to flow the ideas of enhancing students to learn about electric through finding a solutions of electric related to society.

The Hynes [9]’s engineering design process probably give students’ ideas of the structure for designing problem solving of building things about electric and electric devices. Through the design-based about electric issues, students could be engaged to practical application of math and science knowledge for developing a thing as solution. The STS electric and electric power unit may give students chances for integration of technology and engineering within science teaching.

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