The Design Phase of the Development Of an Electrical Installation Prototype Kit as A Medium for The Stem Project of Junior High School Students

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Abstract. This research is the design phase of the research on the development of an electrical installation prototype as a STEM project for junior high school students. This simple electrical installation project requires students to apply the concepts and theories about electrical circuits they have learned. In carrying out this STEM project, students integrate STEM elements, namely science, technology, engineering, and mathematics. Therefore, this research stage aims to design a prototype kit in accordance with STEM requirements and determine the tools and materials needed for these purposes. Based on the recommendations of the analysis phase that we have carried out before, in this stage of research, we have successfully built a design for an electrical installation project kits. The design of this electrical installation kits are in the form of the overall project design, supporting components, and the flow of project work by students. We have designed the kit in such a way that it becomes a mini project in a real context that allows students to directly apply the electrical circuit concept they have learned. In this kit design, STEM education elements have been integrated, namely Science, Technology, Engineering, and Mathematics.

1. Introduction
Various surveys in the world have also shown that the quality of science education in our country is still not encouraging. This can be seen from the results of measuring the scientific ability of Indonesian students by TIMSS (Trends in International Mathematics and Science Survey) and PISA (Program for International Survey Assessment), which places the position of our students' scientific achievement is still low. The OECD 2019 reports that the mean score in science for Indonesia is 396, with a world average score of 489 [1]. Although differs slightly from year to year, in general the PISA survey measures the scientific literacy of students which includes: concepts scientific (scientific concept), scientific process (scientific process), and scientific applications (scientific application). This shows that the concept-application process is a science lesson that cannot be separated.

STEM education is a global movement in educational practice that integrates various integration patterns to develop the quality of human resources in accordance with the skills demands of the 21st century. STEM-based science learning as a form of STEM education is compatible with the current curriculum system in Indonesia [2]. Furthermore, combining PjBL with STEM can increase the effectiveness of learning, produce meaningful learning and influence student attitudes in pursuing future careers [3]. STEM education is manifested in certain situations when learning science or mathematics involves authentic problem solving activities in social, cultural, and functional contexts [4].

STEM application in learning: Science is a knowledge, Technology is used to design media such as computer software, thinking about design forms and manufacturing techniques are Engineering’s
activities, and calculating and measurements are Mathematical applications. The application of STEM can be supported by various learning methods. STEM which is integrative allows various learning methods to be used to support its application [5, 6]. Infusing HOTs through Thinking Based Learning can increase students' attention in STEM education [7].

The development of STEM education requires the participation of higher education academics, especially in designing the STEM media project. Furthermore, STEM media is confirmed to be effective in its implementation in school or outside school settings. Researchers in the field of education are expected to contribute to the development of STEM media projects whose effectiveness has been tested based on classroom-based scientific research. These researches include two important stages, namely the development stage and the field testing phase.

In the design phase of this electrical installation project prototype kit, the researcher formulated several research questions that were answered through this research. These questions are:

a) What is the general design of the electrical installation project kit as a STEM medium for junior high school students?
b) What are the tools and materials needed for the electrical installation project kit?

2. Method

Overall, this development research follows the ADDIE Model instructional design development pattern (Analysis, Design, Develop, Implement, and Evaluate) in producing electrical installation project kits as a medium for student STEM projects. ADDIE is a development model that is very effective in creating educational products and other learning resources [8].

The analysis phase we have carried out before this. We have also reported the findings in previous publications [9]. In this phase we identified the importance of STEM projects for students, especially students at the junior high school level, both in terms of the importance of the science curriculum according to the 2013 Curriculum, and according to student needs. The point is, students need learning that applies the concepts and theories they learn directly [9]. The analytical phase recommendations form the basis of this design phase. In this phase, we examine what are needed related to the design of the electrical installation prototype kit, and making the design intended by this student is also a concern for us.

In the design phase of the ADDIE model, we have designed a project that can apply the electrical circuit concept and it can integrate STEM elements. Therefore, the design of this STEM project prototype kit must meet several criteria, including: according to the applicable curriculum, integrating STEM elements, a project that is contextual, easy and fun for students, can be assembled and easily repackaged. For that purpose, we designed the whole electrical installation project, then designed the supporting components for the kit. In this design phase, we also identified the tools and materials needed to realize the prototype in the next research phase.

3. Result and Discussion

Assessment of the need to develop a learning product is the first very important thing in development research. This is because through an assessment of needs, learning products will be obtained that are in accordance with the circumstances and characteristics of students. There are 4 things that must be considered in conducting a needs analysis, namely (1) an analysis of instructional problems; (2) analysis of learners (audience analysis), (3) analysis of objectives (goal analysis); and (4) analysis of instructional setting analysis [10]. Based on the results of the study [9], it was found that, there is a need for STEM project-based learning for low school students in Pekanbaru.

In this phase, we have designed a set of STEM project prototype kits which are implemented as applications of the electrical concept. The most obvious application of the concept of electricity is to the electricity grid at home and on the streets. Therefore, we felt the need to design student projects related to electrical circuits. Electrical installation project is the name of the project which is considered appropriate as a medium that shows the application of electrical concepts and theories that they have learned. To produce a good STEM project media, several criteria became a reference for us starting from this design phase. Among these criteria are aspects of media or device function [11], elements of learning [12], ease of use [13], aesthetics and construction [14], and job security [14].
3.1. Overall STEM project kit design
Using this kit, students can design the installation scheme, assemble, and test the designed installation. Students can also learn to use electrical measuring instruments to measure current, voltage, and used electrical energy. Thus, all elements of STEM, science, technology, engineering and mathematics, have been integrated into this project. The design of the electrical installation project kit is shown in Figure 1.

![Figure 1](image1.png)

**Figure 1.** Design a prototype electrical installation project as a student STEM project

![Figure 2](image2.png)

**Figure 2.** Tools and design of supporting components for prototype electrical installation projects as student STEM projects

Figure 1 is a form of installation scheme that students can create. Students can create schemes in other forms. In this electrical installation STEM project assignment, students are challenged to make electrical installations that can turn on lights in the house, street lights, and lights in the yard. Here we want to strengthen the engineering element. To present a technological element, in this prototype, we provide measuring instruments in the form of a voltmeter, ammeter and a stopwatch. Using a voltmeter, ammeter and a stopwatch, students can calculate the current, voltage, and electrical energy used. The energy source in this prototype is two 9 volt dry batteries, and the lights used are various coloured LEDs with low electrical power. Electrical energy is calculated using scientific concepts, and the calculation uses mathematics. So, our prototype really is. For the street light poles, we used a small plastic pipe while for the garden lamp poles we used pen’s shaft. The electric pole stands are made using thicker acrylic.

To make the installation look more real, we provide houses. The mini house model is part of this prototype. This mini house model uses a collapsing system, similar to a puzzle at home. Students can install and dismantle houses, position houses, and install lights in the house. In the mini house, there are four rooms. Students can install lights and switches as needed. Students can integrate electrical installations in the house with the installation of garden lights or home yards. The parts of this mini house model, such as floors, walls, attic, and roof, are made using acrylic material. Apart from being stronger and more durable, the transparent nature of the material makes it easier for students to observe the circuit and the lights during installation testing.

3.2. Supporting components for prototype
To make it easier for students to connect cables, the kit is provided with cables with a connector system and alligator clips, as shown in Figure 2. The LED lamp holder, battery, and terminal are also designed to make it easier for students to assemble electrical circuits. Voltmeter, ammeter and timers are purchased items, also provided in the kit.

After implementing the project, students can package and rearrange their kits into storage boxes. The storage box design is shown in Figure 3. The storage box is designed in such a way that the
project components can be neatly arranged in the box. We use acrylic material as a kit box to make it transparent, so that the components of the kit are arranged inside can be seen from the outside.

![Image of storage box design](image1)

![Image of workflow design](image2)

**Figure 3.** Storage box design of electrical installation project kit components as a student STEM project

**Figure 4.** The design of the flow of electrical installation projects by students

3.3. **Workflow design for students in completing projects**

In this research phase, we also designed a flowchart of student work on projects. The flowchart designed is shown in Figure 4. Broadly speaking, student project work starts from building a house, designing an installation, assembling an electrical circuit, testing the system, and calculating the current, voltage, and used electrical energy. This work is carried out by students collaboratively in the classroom, schoolyard and in science laboratories. By involving the application of STEM knowledge, skills and values in solving real life problems in the context of everyday life will encourage students to ask questions and explore the environment through inquiry and problem solving related to real world situations to foster STEM practice [15] and implementation of STEM Project Based Learning can improve students' scientific work skills [16].

4. **Conclusion**

Efforts to improve the quality of science education must be continuously improved. Experimental activities and science projects are a necessity for science learning. Activities like these provide direct experience for students. Students will find their science learning to be interesting and useful. To carry out these scientific activities, science education must think and act creatively in preparing the necessary resources. This study has produced a learning media design for STEM education purposes in science learning. Electrical installation project prototype kits are considered important in applying electrical concepts and theories in the form of real products for students. In addition, this student project will integrate STEM elements: science, engineering, technology, and mathematics.

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