Development of simple science kits as dynamic electricity learning media for junior high school

S Saehana*, I K Werdhiana¹, N Tuljannah¹, and A Izzah¹

¹Sub-Department of Physics Education, of Faculty Teacher Training and Education, Universitas Tadulako, Jl. Soekarno Hatta KM. 9 Kampus Bumi Tadulako Tondo Palu-Central Sulawesi, Indonesia.

*Corresponding author: sahrulsaehana@gmail.com

Abstract. The aim of this study is to produce Simple IPA KIT as science learning media for dynamic electricity material. This Simple IPA KIT contains several puzzle blocks that could be set into several electrical circuits. The type of the study was Research and Development, which refers to the model of Puslitjaknov (a team in the Center for Policy and Inovation Studies). The five-scales Likert questionnaire were used to obtain the data. The product was assessed by the media and material experts, physics teachers and high school students. The result of media experts showed a percentage value of 85%, in "Very Good" category, while it was 80% in "Good" category for material expert assessment. Meanwhile, the responses of teachers and students showed 95.6% and 84%, respectively, with “Very Good” category. It indicates that the Simple KIT media is suitable for learning media.

1. Introduction

The abstract concepts in dynamic electrical topics make them challenging to be fully understood by students [1–3]. Moreover, teachers tend to use teacher-centered methods and textbooks in learning processes that drive students unmotivated [4]. These methods are ineffective, especially when teaching about physics concepts that are abstract concepts. For instance, when the researchers did observations at the preliminary research activities in some public schools in Central Sulawesi, teachers explained the concept of electricity as a part of dynamic electricity topic, while students only listened to the description of the definition of electricity, the electrical propagation, and electrical circuit.

IPA KIT-Media is an integrated laboratory instrument box for science experiments [5]. The integration of kits in science education does not only benefit the students [6,7], but also advantages the teachers [8]. It enables the teachers to create innovative and active learning environment because the kits allows the teachers to conduct a variety of learning activities [9]. The role of kits in science learning does not only help students understand the concepts, but also demonstrate how the concepts are applied through laboratory activities [10]. A study of Jones et al [11] found that students who learned consistently using kits in science learning are more likely to have scientific skills, such as designing and implementing laboratory investigations, results presentation, and data analysis. The use of kits, specifically in physics learning can help students in a complex and challenging concept, such as
electricity [12]. It improve students’ enthusiasm and motivation in learning because they consider learning as playing using the kits [13]. It was supported by a study of Miller [14] who found that children preferred to more creative and entertaining apps rather than pedagogical-based apps.

IPA KIT-Media for junior high school consists of 4 packages, namely KIT for Mechanics, KIT for Heat and Hydrostatic, KIT for Optics, and KIT for Magnetic Electricity. However, the integration of IPA KIT-Media in science learning is not very common. It is unfortunate since Simple KIT-based learning media was beneficial for students in learning dynamic electricity [8]. Teachers who were included in our preliminary activities, indicated that the use of IPA KIT-Media has not been optimal due to several reasons. Firstly, there is not enough equipment for certain electrical concepts or some components of an experiment are missing. Secondly, teachers admitted that they lack the ability to operate the tools. Thirdly, the KIT is quite expensive thus the teachers only could expect that the school will provide it. To solve these problems, researchers intended to provide innovation of the Simple IPA KIT that is affordable yet still beneficial for science learning.

If most research and development (R&D) studies in electricity concepts used only electrical components in their product (i.e [6, 9]), the developed kits in this study used puzzle blocks as the main material. Each of the puzzle blocks was designed by gluing a sheet of zinc on it and it serves as connectors that deliver currents from the source to the indicator to be measured. Students could use these puzzle blocks to set different types of electrical circuits such as Ohm’s Law Circuits, Series Electrical Circuits, Parallel Electrical Circuits, and Kirchhoff’s Law I circuits. Cardozo et al who conducted a study about the effect of puzzles in the learning process revealed that the activity with the puzzle assisted students to understand the topics better [10]. This research was also inspired by the results of a study of Stezik et al who found that students preferred to learn physics with the addition of puzzle games rather than lecture-only methods [11].

Accordingly, the objective of this research was to produce the Simple IPA KIT using the puzzle blocks. The product was expected to fulfil the limitation of science laboratory equipment in high schools, and eventually could improve students’ knowledge about dynamic electricity and their skills arranging electrical circuits [15]. The complete Simple KIT IPA contains several resistors, a switch, a battery, a simple indicator lamp (mini incandescent lamp), puzzle blocks, multimeters, and the guidebook in a box thus it is portable.

2. Methods
2.1 Type of Research
It was a Research and Development (R & D) study. It employed the procedures developed by Puslitjaknov [16] (the team in the Center for Policy and Innovation Studies) whose the stages were more efficient. This model belongs to the Borg & Gall and simplified by Puslitjaknov into five stages, namely analysis, early development product, expert validation and revision, limited field testing and revision, and big-scale field testing. However, this research only applied four stages, which excluded the big-scale field testing due to the limited time and cost. As the details of the research scheme can be observed in Figure 1.

2.2 Location and Subject of The Research
This research took place in SMP Negeri 19 Palu, Central Sulawesi for the limited field testing stage. The production process required a duration of 6 months. All the stage processes included one each of media and material experts, and ten physics teachers and ten ninth graders to assess the feasibility of the developed product.

2.3 Data Collection Techniques
Data were collected through interview and questionnaire distribution. Interview was conducted with the physics teacher to acquire the actual problems. Meanwhile, the questionnaire was used to assess the product from the perspective of media and material experts, teachers and students. The questionnaire was a 5-point Likert scale. Likert scale as a scaling technique is widely used primarily to measure
attitudes, opinions or perceptions about themselves or their group of people who are related to something [17]. This scale is often referred to as a summated scale which contains a number of statements with response categories. The data collected were analyzed into percentage [18], and converted into qualitative data based on categories in Table 1 [19].

Figure 1. The Simple IPA KIT development scheme

| Table 1. Likert Scale Category |
|-------------------------------|
| **Percentage** | **Scale** | **Category** |
| 0% - 20% | 1 | Very Poor |
| 21% - 40% | 2 | Poor |
| 41% - 60% | 3 | Enough |
| 61% - 80% | 4 | Good |
| 81% - 100% | 5 | Very Good |
3. Result and Discussion
In developing simple IPA KIT using puzzle blocks, researchers first create an initial design or sketch of the electrical circuit (see Figure 2a). Its working principle uses two 9V batteries as a voltage source, and the puzzle blocks as materials that allowed electric currents from the source to the multimeters. To make puzzle blocks work as connectors, researchers laid zinc sheets on them and then strengthened by wires. After that, the electrical circuit components such as resistors, switches, and socket cables were installed on puzzle blocks. The following Figure 2 represents the initial designs and examples of usable puzzle blocks.

![a) The initial product sketch](image1)

![b) Puzzle blocks with resistors](image2)

**Figure 2.** The initial designs of the product and the examples of usable puzzle blocks

Puzzle blocks that have been developed as presented in Figure 2b, were arranged into 4 types of electrical circuits such as Ohm’s Law Circuits, Series Electrical Circuits, Parallel Electrical Circuits, Combination Series-Parallel Circuits and Kirchoff's Law I circuits. The appearance of Simple IPA KIT for each circuit can be seen in Figure 3-6.

3.1 Ohm’s Law Circuits
This display was the process of examining the voltage on the resistor component of 100 ohms and the electric current.

![Figure 3. Puzzle blocks arrangement for Ohm’s Law circuit](image3)

3.2 Series and Parallel Electrical Circuit
This process determined the current and voltage used a resistor of 56 ohm and 100 ohm for series circuits as well as parallel circuits.
3.3 The Combination of Series and Parallel Electrical Circuits

The determination of current and voltage in this circuit was to parallel a resistor 47 ohm and 100 ohm then arranged in series with a resistor of 56 ohms.

3.4 Kirchoff's Law I Circuits

This display was an electrical circuit that aims to find out the amount of electric current that enters and exits.

Moreover, the guidebook was also provided. It consists of some parts such as instructions to measure the current (I) and the voltage (V), relevant information, components of practicum puzzles, experimental purposes, data processing, final questions and conclusions. All tools were further validated and revised by media and material experts. The responses were used as references to improve the quality of the product. The results of the validation tests are displayed on Figure 7.
Results from the media expert

Figure 7a shows that the average value of the overall aspects for media validation was in the “very good” category with the percentage of 85%. Meanwhile, the assessment for the contents obtained a “good” category with the percentage of 80%. These values show that The Simple IPA KIT was feasible to undergo field-testing. Revision was made in the puzzle blocks, including making the components permanently attached to the blocks, and giving clear instructions in the guidebook and worksheets for each experiment. According to Puslitjaknov, product trials are significant in research development. Product trials aim to find out the effectiveness of the product. In the limited field-test, data were obtained from physics teachers and students as the prospective product users. The results of the assessment can be seen in Figure 8.

Both the results of teachers and students’ responses were in the “very good” category, with the percentage of 95.6% and 84% respectively. There was no additional revision in this limited test. Students were very excited with the developed product. In the first trial of Ohm's Law, students needed about three minutes and 43 seconds to arrange the circuit. Meanwhile, they took 3.84 minutes for the series circuits, 05.27 minutes the parallel circuits, 3.40 minutes for Kirchoff’s Law I, and 2.56 minutes for the series-parallel circuits with the help of a guidebook only.

The final product of this research was similar to the product produced by Dwiokta and Desnita who developed a data logger-based practicum using almost the same electrical circuits [20]. However, their final product uses many puzzles and must be set separately, while this study only used a few puzzles that can be disassembled and rearranged according to the needs in the experiment. Another benefit of
the final product is its simple packaging. All components are fitted in a box including multimeters. The product is smaller in size and lighter thus it is very portable. It allows it to be carried anywhere thus the students even can do the hands-on activities outside the schools.

4. Conclusions
The simple IPA KIT as a science learning media consisting of circuit puzzles, multimeters, and guidebook in a toolbox has been developed. The assessments of the media and material experts as the validators, and physics teachers and students as the prospective users, show that the final product has met the criteria of feasibility of learning media. As a result, the product is feasible to be used in learning activities. However, the developed device still has one weakness which is the puzzle interblock connectors that were not very tight resulting in the instability when measuring the voltage (V) and current (I) in the multimeter. Further studies are also required to determine the effectiveness of this product to students’ learning outcome.

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