Developing Physics Learning Multimedia to Improve Graphic and Verbal Representation of High School Students

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Abstract. The purpose of this research are; (1) to develop the appropriate physics learning tool used to assist the learning process of learners, and (2) to know the ability of graphical and verbal representation of the learners. This development study refers to the 4D method, which includes: (1) defining, (2) development, (3) planning, and (4) deployment of devices. Learning tools developed include Teaching and learning plan (RPP), test of graphical and verbal representation and multimedia learning. This development product is validated by expert lecturers, physics teachers, and peer reviewer. The subject of empiric test consisted of 100 students. The limited test subjected consisted of 21 student. Field test subjects in the experimental class were as many as 32 students and the control class as many as 31 students. Data collection used interview guides, learning device assessment sheets and learning result test. Data analysis technique using MANOVA with 5% significance rate.

Keywords: Physics learning multimedia; Graphic and verbal representation; High school students.

1. Introduction

Physics learning on dynamic electrical materials is widely applied to everyday life. However, learners still have difficulty in solving problems in analyzing electrical circuits [1]. Learners still have difficulty understanding current and voltage concepts, understanding the meaning of charge, applying the concept of barriers, and interpreting and applying the relationship between current and voltage [2], [3]. One of the factors that influence the misunderstanding of learners is the ability to solve the problems of learners [4].

Solving problems is a complex process for learners, then it requires educators who have a strategy and efficient in solving problems. One efficient way is to use representation [5]. Using representations in physics teaching methods is helpful in improving the comprehension of learners [4]. Representation plays an important role in understanding the concepts of physics and stimulates the development of flexible and versatile thinking in solving problems [6]. Representation is a configuration that can represent something else in several ways, such as with objects, actions, images, symbols and words as well as with various representations can be used as communication and understand physics concepts, for example expressed in verbal form, diagrams, mathematics / symbolic, and graphics [4], [7]. Understanding the physics concepts of dynamic electrical material, especially on Ohm’s legal material and Kirchoff I law, allows learners to use verbal representations in explaining and describing problems related to graphs. The use of graphical representation will help learners more easily understand and solve problems in a mathematical way, as well as using verbal representation [8], [9] Technological
developments create new ways for educators to communicate with learners [10]. The use of mobile devices in learning called mobile learning (m-learning) is the delivery of electronic learning materials (e-learning) on mobile devices such as personal digital assistants (PDA), mobile phones, tablet PCs, pocket PCs, computers, laptops, [11]. Educators need to pay attention to the number of users (learners) of mobile phones, laptops or personal computers [12]. Educators can develop advanced technology-based multimedia learning such as utilizing mobile phones / laptops / computers to enhance learners' learning styles. By utilizing these technological advances, educators use as a teaching tool in delivering learning materials [11], [13].

Educators use instructional media as a tool for teaching and learning process. Selection of learning media adapted to the level of ability of learners, the interaction between learners with learning environments and the use of learning media aids can improve understanding of the science concept of learners [14]. Learning media is also useful for increasing interest in learning activities more interesting, and at the same time can provide real examples by displaying images, video animation, graphics, and images [15]. The media used by educators so far has been varied, there are modules, books, movies but still rarely use media that presents animation, video, text, music, images and photos integrated in a multimedia learning device [16].

The purpose of this study is to produce a learning tool that is feasible to use based on the assessment of some validators and know the improvement of graphic and verbal representation skills of high school students.

The rest of this paper is organized as follow: Section 2 describes literature review. Section 3 presents the proposed research method. Section 4 presents the obtained results and following by discussion. Finally, Section 5 concludes this work.

2. Related Works

Students have a negative perspective on physics [17]. This is because students do not get satisfactory results even though students have tried their best while studying physics. This phenomenon is caused by misunderstanding and lack of understanding of the concepts of physics, students tend to develop understanding, and less effective teaching strategies. Educators need new strategies to improve physics teaching and learning [18]. In addition, educators need to develop teaching materials to make teaching and learning activities more effective, save time, motivate and attract [19]. With the advent of technology, the number of tools aimed at facilitating educators and learners has grown, such information can be obtained through blogs, social networks, using the help of instructional media in the classroom and even in the virtual.

Learning media are useful to increase interest in learning activities more attractively, providing real examples by displaying images, videos, animations, graphics and images [16]. For example, on Ohm's legal materials, so that learners can see and understand the concept of Ohm's legal material. It takes a simulation or description that explains the concept of Ohm's legal material.

Cheng & Gilber explained the problem-solving ability depending on the quality of his educator strategy, both conceptually in acquiring science, studying the representation of the concept of science, and demonstrating the ability to understand representation [20]. Argues that learners who use representations such as graphics (e.g. arranging pictures, diagrams, and tables) or linguistics (eg natural language, logic, ideas) will help learners in solving problems as well as physics concepts [21]. McCoy, et al., (1996) states that in classroom learning, representation is not only used in one form and one way, but in several ways. For example, in the class of teachers presenting the problem of graphical representation, the teacher may ask the answer to the student by solving it using table representation, mathematically or by verbal representation [22].

Learners learn about complex concepts of physics, requiring interaction with various forms of representation such as diagrams, graphics, verbal and mathematical or equations. Interpretation graphics as an important component of IPA learning content, an important tool for analyzing data while performing knowledge, and essential visual aid when communicating and developing an understanding of the various scientific and economic factors in everyday life [22]. Barclay et al., Defines the graph as
the primary means of identification patterns and for understanding and communicating ideas in science [23]. The format of verbal representation is one way of explaining a concept in the study of physics. Verbal representation is used to help learners to solve problems in solving problems and to help learners to correct drawing errors or convey a concept completely.

3. Research Method

This development research refers to the 4D method, which includes: (1) defining, (2) development, (3) planning, and (4) deployment of devices [24]. At the defining stage an interview was conducted with one of the physics lecturers. Interviews were conducted to analyze problems, learners’ analysis, analysis of physics matter concepts, learning objectives analysis and analysis of problem solving skills of learners. In the planning stage carried out the validation to determine the feasibility of learning tools developed, including; RPP, test instrument of graphical representation and verbal learner and physics learning multimedia product. Assessment of feasibility tests conducted by expert lecturers, teachers, and peers. At the stage of development carried out the main research on two classes to determine the improvement of the ability of graphical representation and verbal learners. The experiment was conducted in experimental class using physics learning multimedia developed to assist teaching and learning process. The control class uses the help of the learning module to aid the learning process activities. At the dissemination stage, dissemination of multimedia learning products in the field of research or in some other schools.

Research subjects for empirical test instrument test consisted of 100 students in class XI IPA. Students tested have different cognitive levels, from low, moderate and high cognitive levels. Data analysis techniques on empirical test instrument using QUEST test. The empirical test aims to produce valid test instrument items. Research subjects on a limited test consist of 21 students in class XI IPA. The limited test aims to generate student responses to the developed product. Field test subjects for the experimental class were 32 students and control class of 31 students. Field test aims to determine the effectiveness of physics learning multimedia that is obtained from the value of the test result of the ability of graphical representation and verbal learners. Improved test of graphical and verbal representation ability of learners can be determined from analyzing the value of gain, with equation of formula;

$$g = \frac{s_f - s_i}{100 - s_i}$$

(1)

where $g$ as the describes gain value, $s_f$ as the final score obtained from the post-test, and $s_i$ as the initial score obtained from the pretest. Interpretation of each observed aspect can be done by looking at the criteria of value scores according to Hake [25], shown in Table 1.

| Table 1. Gain Value Criteria | Criteria |
|-------------------------------|----------|
| No | Gain Score | |
| 1 | $g \geq 0.70$ | High |
| 2 | $0.30 \leq g < 0.70$ | Medium |
| 3 | $g < 0.30$ | Low |

The result data of the gain value of the learner was analyzed by the prerequisite test using the MANUF 16.00 spss program. Data result significance value $< 0.05$, then $H_0$ rejected and $H_a$ accepted. The criterion for rejecting $H_0$ if significance is less than 0.05, and $H_a$ is accepted if there is an increase
in the result of graphical and verbal representation tests after learning to use physics learning multimedia on Ohm and Kirchoff I legal materials.

4. Results and Discussion

Physics learning multimedia products developed are applications created using Adobe Flash Professional CS6 program. The display of physics-learning multimedia displays more visualization (images, graphics and video animations) related to Ohm's and Kirchoff I's legal materials, summarizes examples of pressing questions on improving the students' graphic and verbal representational abilities and there is an evaluation test to test learners' abilities. The language used in multimedia learning products is easy to understand and read. Multimedia learning physics is packaged in the form of applications, so that students easily install in smartphone or laptop. Multimedia learning physics with the help of mobile devices enables learners to learn anywhere and at any time, as well as improve the success of learning effectively [26], [27], [28], [29]. Appearance of developed physics learning multimedia applications as seen in Figures 1 and 2.

![Figure 1. Multimedia Initial Display Physical learning](image1.png)

![Figure 2. Ohm's Law Menu Display](image2.png)

In the validation stage of the development of learning tools is done by two expert lecturers, two physics teachers and peers. Learning tools include RPP, test instrument of graphical representation and verbal learners, learning materials and physics learning multimedia. Result of feasibility assessment data of learning device is quantitative data using scale five, then data is converted to qualitative. The technique of data analysis assessment of learning devices using assessment criteria according to [31,32], shown in Table 2.
In the validation stage of the development of learning tools is done by expert lecturers, physics teachers and peers. Learning tools include RPP, test instrument of graphical representation and verbal learners, learning materials and physics learning multimedia. Result of feasibility assessment data of instructional device in the form of quantitative data by using scale five, then data are converted to qualitative type. The technique of data analysis of assessment of learning devices using assessment criteria is shown in Table 3.

| No | Score Range | Category  | Index |
|----|-------------|-----------|-------|
| 1  | $Mi + 1,80 Sdi < X \leq Mi + 3 Sdi$ | Very Good | 5     |
| 2  | $Mi + 0,60 Sdi < X \leq Mi + 1,80 Sdi$ | Good     | 4     |
| 3  | $Mi + 0,60 Sdi < X \leq Mi - 0,60 Sdi$ | Fair Good | 3     |
| 4  | $Mi - 1,80 Sdi < X \leq Mi - 0,60 Sdi$ | Not Good | 2     |
| 5  | $Mi - 1,80 Sdi < X \leq Mi - 3 Sdi$ | Very Less | 1     |

The feasibility test of RPP learning tool is conducted by two expert lecturers. Aspects assessed in the learning planning tool are subject identification, formulation of learning indicators, formulation of learning objectives, selection of materials, selection of learning methods, learning activities, selection of learning resources or learning media, assessment of learning outcomes and linguistics. The results of the data were analyzed using the average formula, and calculated the mean to the qualitative data referring to Table 3. The average result of the RPP feasibility assessment was 84.5, so that the RPP learning device was categorized as "good" and suitable for field research.

The validity assessment test of validation of the ability test of graphical and verbal representation of learners is done by two expert lecturers. Aspects that are assessed on the test of graphical and verbal representation are material, language and construction. The results of the data were analyzed using the average formula, and calculated the into qualitative data referring to Table 3. The average result of the assessment of the feasibility of the test of graphical and verbal representation is 74.5 so that the learning apparatus of the test of graphical and verbal representation is categorized as "good" and suitable for field research.

The feasibility assessment test of learning material validation is done by expert lecturer and two physics lecturer. Aspects that are assessed in the learning materials are the explanation of material concepts, and the use of language. The results of the data were analyzed using the average formula, and calculated the into qualitative data referring to Table 2. The average result of the assessment on the learning device of physics material is 39.66, so the learning material is categorized as "good" and suitable for field research. Assessment easibility in the multimedia of physics learning is done by two lecturers and colleagues (IT UGM). Aspects that are assessed in the multimedia of physics learning are the visual appearance, and the software counterpart. The results of the data were analyzed using the average formula, and calculated to qualitative data referring to Table 3. The average result of the RPP feasibility assessment is 76.5, so that the physics learning multimedia device is categorized as "good" and suitable for field research. The following table summarizes the results of the average assessment of the feasibility test of the physics-learning device that is floated from the validators of two expert lecturers, physics lecturers and peers.
Table 4. Results of Learning Device Assessment

| No | Learning Media | Average Feasibility | Category |
|----|----------------|---------------------|----------|
| 1. | RPP            | 84.5                | Good     |
| 2. | Material       | 39.66               | Good     |
| 3. | Instrument Test| 74.5                | Good     |
| 4. | Media          | 76.5                | Good     |

Trial item test is obtained through empirical test; the result of empirical test is processed by data result using Quest application. The results of the calculation with Quest application, 10 test questions the ability of graphical and verbal representation. Bond & Fox explained that if the sample number is between 30 to 300 learners, using a 5% error limit, so within the MNSQ range of INFIT ranges from -2.0 to +2.0 [30]. This stage of test questions into the category worthy of use as a field trial. The results of empirical test data are shown in Table 5 below.

Table 5. Empirical Test Results Graphic and Verbal Representation

| Item Test | INFT | MNSQ | Information |
|-----------|------|------|-------------|
| 1         | 1.06 | Valid|             |
| 2         | 1.01 | Valid|             |
| 3         | 0.82 | Valid|             |
| 4         | 0.71 | Valid|             |
| 5         | 0.70 | Valid|             |
| 6         | 1.09 | Valid|             |
| 7         | 1.00 | Valid|             |
| 8         | 0.96 | Valid|             |
| 9         | 1.33 | Valid|             |
| 10        | 1.10 | Valid|             |

Table 5 shows that the 10 item of test of the ability of graphical and verbal representation is included in valid categories. Based on the analysis of the results of the data that the test is feasible to be used as a field test for pre-test and post-test.

Limited trials were conducted to obtain a response assessment of physics learning by students. Learners are asked to fill out a questionnaire of qualitative data assessment on a scale of one to five. The results of the data are analyzed using the average formula, and calculated the mean to qualitative data referring to Table 3. Results of data from responses and suggestions of learners used as a reference for improving the product of multimedia learning physics. Aspects assessed are the clarity of the language, the display of multimedia-audio visualization, and learning materials. The result of the mean assessment data of the learner is 48.38. The results indicate that the response of learners to the multimedia learning of physics is "very good", so that the multimedia product of physics learning is feasible to be used for field test.

Field test obtained by the result of assessment of student ability test, that is pretest and post-test. Result of test data of graphic and verbal representation ability of learners obtained from control class and experiment class. Each result of a graphic and verbal representation test of learners from the control class as well as the experimental class is shown in Table 6 and Table 7.
The effectiveness of physics learning multimedia products is known from the test results of increasing the ability of graphical representation and verbal learners. The results of data obtained from students' pretest and post-test were analyzed using the score scores referenced in Table 3. Tables 8 and 9 show the mean value of gain in the ability of the students' verbal and graphical representation of the control class and experimental class.

### Table 6. Results of the Pretest & Post-test in Control Class

| Criteria          | Graphical Representation | Verbal Representation |
|-------------------|--------------------------|-----------------------|
|                   | Pre-test | Post-test | Pre-test | Post-test |
| Average           | 6.45     | 9.90      | 5.58     | 8.67      |
| Standard Deviation| 1.09     | 1.79      | 0.84     | 1.92      |
| Max                | 8        | 13        | 7        | 12        |
| Min                | 5        | 7         | 5        | 6         |

### Table 7. Result of the Pretest & Postests in Class Experimental

| Criteria          | Graphical Representation | Verbal Representation |
|-------------------|--------------------------|-----------------------|
|                   | Pre-test | Post-test | Pre-test | Post-test |
| Average           | 7.93     | 12.21     | 6.34     | 10.75     |
| Standard Deviation| 1.96     | 1.60      | 1.15     | 1.41      |
| Max                | 15       | 16        | 9        | 13        |
| Min                | 5        | 9         | 5        | 7         |

The results of the value data increase the ability test of graphical representation and verbal learner conducted prerequisite test analysis. The prerequisite test is performed to determine the normality and homogeneity of the data.
Table 10. One-Sample Kolmogorov-Smirnov Test

|       | Grafik | Verbal |
|-------|--------|--------|
| N     | 63     | 63     |
| Normal Parameters | Mean | .34 | .35 |
|        | Std. Deviation | .188 | .190 |
| Most Extreme Differences | Absolute | .111 | .130 |
|        | Positive | .111 | .098 |
|        | Negative | -.086 | -.130 |
| Kolmogorov-Smirnov Z | | .880 | 1.03 |
| Asymp. Sig. (2-tailed) | | .420 | .235 |

Table 10 shows the significance data for graphical representation ability is 0.420, the significance data for verbal representation ability is 0.235. The significance data is greater than 0.05, so it can be assumed that the gain value data of graphical and verbal representation ability is normally distributed.

Table 11. Levene's Test of Equality of Error Variances

|       | F     | df1 | df2 | Sig.  |
|-------|-------|-----|-----|-------|
| Grafik | .307  | 1   | 61  | .581  |
| Verbal | 1.214 | 1   | 61  | .275  |

Table 11 shows that the data of graphic and verbal representation ability using Levene test is homogeneous. The results of the data show that the significance data for graphical representation is 0.581, and the significance data for verbal representation is 0.275. It was concluded that the significance of the gain values for graphical and verbal representations is greater than 0.05.

Table 12. Multivariate Tests

| Effect     | Value | F     | Hypothesis df | Error df | Sig.  |
|------------|-------|-------|---------------|----------|-------|
| Intercept  |       |       |               |          |       |
| Pillai's Trace | .916  | 3.252E2 | 2.000 | 60.000 | .000  |
| Wilks' Lambda | .084  | 3.252E2 | 2.000 | 60.000 | .000  |
| Hotelling's Trace | 10.841 | 3.252E2 | 2.000 | 60.000 | .000  |
| Roy's Largest Root | 10.841 | 3.252E2 | 2.000 | 60.000 | .000  |

Kelas

| Effect     | Value | F     | Hypothesis df | Error df | Sig.  |
|------------|-------|-------|---------------|----------|-------|
| Intercept  |       |       |               |          |       |
| Pillai's Trace | .566  | 39.077 | 2.000 | 60.000 | .000  |
| Wilks' Lambda | .434  | 39.077 | 2.000 | 60.000 | .000  |
| Hotelling's Trace | 1.303 | 39.077 | 2.000 | 60.000 | .000  |
| Roy's Largest Root | 1.303 | 39.077 | 2.000 | 60.000 | .000  |
Table 12 explains that the significance data of the gain value of graphical and verbal representation is 0.00, then the result of the data on the Hotelling’s Trace test is smaller than 0.05 it can be concluded that there is a significant difference between the improvement of graphical representation and verbal ability of the learners in the experimental class with the control class. Based on this, then H₀ is rejected and H₁ is accepted.

5. Conclusion

Based on the assessment of validators consisting of expert lecturers, physics teachers, and peers learning tools developed include; RPP (Learning Implementation) test instrument of graphical and verbal representation, and physics learning multimedia have met the eligibility criteria. Physics learning multimedia tools that have been developed can affect the improvement of graphical and verbal representation capabilities of learners, it is known from the score of gain value in the experimental class for the ability of graphical representation test is 0.35, and for verbal representation test capability is 0.32. The score class score gain score for the graphical representation test capability is 0.25, and the verbal representation test is 0.21. These results, indicating that there is an increase in test skills of learners in the experimental class rather than in the control class.

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