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Mathematical Representations Mapping of High School Students after using Multimedia Learning Modules Assisted by an Android Smartphone

Mathematical Representations Mapping of High School Students after using Multimedia Learning Modules Assisted by an Android Smartphone

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Abstract. Physics is one subject that has various applications in everyday life. However, many students assume that physics is a difficult lesson because physics is difficult to understand. One key to understanding physics is a mathematical representation. The purpose of this study is to map the mathematical representation of students after using a multimedia learning module assisted by an Android smartphone. The most prominent errors of mathematical representation ability of students learning after using a multimedia learning modules assisted by an android smartphone are solving problem involving arithmetic operation, changing the CGS unit to SI units and the proper use of units in writing the final results.

Keyword: Mapping; Mathematical representation; MLMs, Multimedia; Learning modules.

1. Introduction

The 4.0 industrial revolution has changed the style and outlook of human life in all aspects including education [1]. The result of this revolution is the use of technology in the education world [2]. The number of students who use smartphones and computers at school or university is one of the effects of the industrial revolution. Halaweh [3] states that schools allow the use of smartphones when learning has a good impact. The good impact is an increase in student learning abilities. Shi [4] also mentioned that the use of smartphones to learn practicum before the practicum was started greatly helped the course of the physics practicum. however, differences in gender and citizenship greatly affect the achievement of students using smartphones [5]. At present, smartphone has become a very useful tool as a link between students' understanding of physics concepts [6,7]. Another technology used to improve student learning abilities is digital media. Digital media is video, images, text and animation [8-10]. The combined form of digital media in learning such as Multimedia Learning Modules (MLMs). The research conducted by Sadaghiani [11-14] showed positive results. The study compares MLMs with books. The results show that the use of MLMs improves learning outcomes Illinois university students. the use of MLMs is also able to make learning more effective. Other studies have similarities with Sadaghiani's research. The study was conducted by Chen, *et al*. [15] where the results of this study have a positive impact on students' concept understanding. Further research conducted by Landau, Paez, Bordeianu & Haerer [16] which compiles teaching materials into a module so that it can contain various multimedia that can be read by various electronic devices. While the research of Ryan, *et al*. [17] stated that the application of learning using smartphone or computer media can increase the effectiveness of students' time and understanding. Furthermore Sigarchian, *et al*. [18] also stated that e-learning can become a new learning culture with various benefits. Although it must pay attention to the availability of devices to access e-learning.

This study investigates the mapping of students' mathematical representation after using Multimedia Learning Modules with an android assist on work and energy material. First of all, we introduce what MLMs are and their advantages in learning. Then, we explained in detail the methodology and explained the post test results data. Next, we evaluate the results of mapping based on students' mathematical representations of work and energy. Finally, we conclude the mapping of mathematical representations after the use of MLMs in learning. The results of the conclusions are students' difficulties on mathematical representation indicators. The difference between the existing research and the author's research is that the multimedia used by the author can only be accessed offline while the literature can be accessed online.

The rest of this paper is organized as follow: Section 2 describes the notions of MLM, mathematical representation and smart phones. Section 3 presents proposed research method. Section 4 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Rudimentary

This section describes the notions of MLM, mathematical representation and smart phones.

2.1. Multimedia Learning Module (MLM)

One of the technologies used in education is the use of multimedia in the form of computers and smartphones. Multimedia is a combination of several media such as text, images, videos and animations that are used to help convey information and can be controlled by users both used online and offline [19,20]. The learning module is a work unit or teaching material that contains learning materials such as skills and knowledge. Learning modules have properties such as self-instructional, self contained, stand alone, adaptive and user friendly. The learning module is structured and specialized with the aim that students are able to learn independently not limited to the module user time and space [21-23]. Each module must contain material, language and lesson design aspects. The learning module has 3 parts:

a. The opening section contains the Title, table of contents, information map, list of competency objectives, and initial test.
b. The core section contains an Introduction, relationships with other material, material descriptions, assignments and summaries.
c. The concluding section contains a list of terms, final tests and indices.

The MLMs were first created by Physics Education Research Group at the University of Ollinois. MLM introduces the concept of physics through video, images, text and animation. MLMs have a duration of 12-15 minutes. MLM can be paused and repeated according to the needs of students. Each MLM also has a play, pause, and fast-forward button that can be used by students to control speed [11-14]. The purpose of MLMs is to overcome the problem of students who are lazy to learn before class begins [13,15]. Besides containing material, MLMs also contain practice questions that students need to answer. After the question is answered, students will get feedback or responses directly [10-12]. MLMs can be tailored to the needs of students so that the use of representation, the type of media used and the content of the material can be adjusted by the teacher [11,14].

2.2. Mathematical Representation

Another impact of the industrial revolution is the target of education to be able to produce human resources who are ready to compete with the ability to think critically, problem solving, and entrepreneurship [2]. Understanding physics is closely related to problem solving abilities. One problem solving ability is the use of representation. According to Hall (2013) representation is the result of the meaning of concepts that are in one's mind through language. Mathematical representation is a representation that is often used in physics [24]. Mathematical representation is one of the strategies in solving problems and is also a strategy to help students understand the concept [25]. Mathematical representation is a form of someone's interpretation of a problem that uses the help of mathematical operations to find a solution [26]. Students who are able to use mathematical representations more easily understand physical material [27]. Mathematics is believed to be able to help students understand the concept of physics [28]. The ability of mathematical representation has several indicators. These indicators are shown in Table 1 [29-32].

Table 1. Indicator of mathematical representation

Indicator	Description
Obtain the appropriate data	Students can get the right and correct data to solve the problem
Using mathematical operations	Students can use physical concepts and mathematical operations correctly to solve problems
Write down the final results of calculations and units	Students can obtain and write the results of calculations and units correctly

After finishing assessing the results of the post-test using equation 1. We will get the results of each indicator from Table 2. Then the data for each indicator is collected based on the similarity of indicators. With this data we can find out many students about the value of each indicator. Then, data on the number of students on the value of each indicator is used to map mathematical representation indicators.

2.3. Smartphone

The role of smartphones today is very important. Many human activities are currently connected with smartphones. So that the smartphone becomes a mandatory item for today's society. Smartphones are not just a piece of hardware that is put together but at the same time a smartphone has software as a communication system. The use of smartphones today not only serves as a communication tool but a modern tool that has certain sensors that help student learning, especially physics. Today, smartphone use in education is very common. The use of smartphones in learning is often called mobile learning Mobile learning was defined as more than just learning delivered and supported by handheld, mobile computing devices but (b) learning that is both formal and informal and context aware and authentic for the learner [33-39].

3. Research Method

This section describes the proposed research method.

3.1. Proposed Method

This study uses a test questions to collect data. Test instruments in the form of essay questions that are used to assess the representation ability of students (see Figure 1). Before conducting the research, the researcher first analyzes the students, analyzes the competency of the high school physics curriculum, analyzes concepts and makes concept maps, arranges the planning stage, selects the model and learning media and designs an Learning Implementation Plan (RPP). Student analysis includes age, level of cognitive development, and students' abilities. Competency Analysis of the High School Physics Curriculum refers to the 2013 Curriculum document (K13). Material analysis is in the form of concept analysis which includes facts, concepts, principles, laws, and theories. The material taken in this study is work and energy in class X of high school. This study uses 1 class consisting of 29 class X students. This class is called modeling class. Students before participating in the learning process are given MLMs (Multimedia Learning Modules) first (see Figure 2). After the whole series of learning is complete, students are tested using posttest questions.

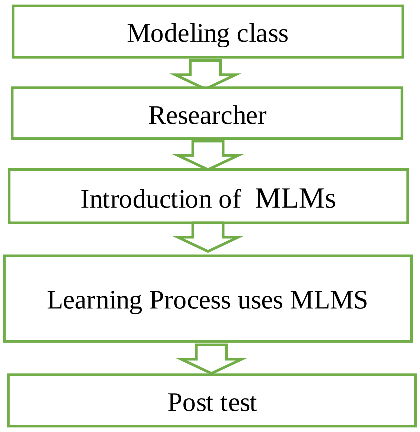


Figure 1. Research Flow Chart

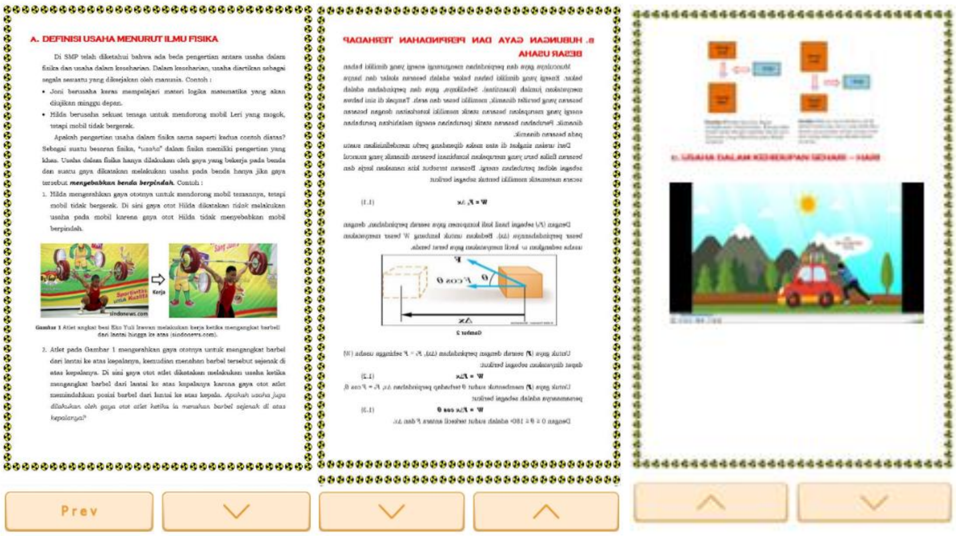


Figure 2. Main Content of Multimedia Learning Module

The questions used in the post-test are 4 essay questions with work material and energy. The maximum points for each question are 20. Maximum points are obtained from the indicator values in Table 2.

Table 2. Assessment of Mathematical Representations

Indicator	Maximum Score
Obtain the appropriate data	5
Using mathematical operations	10
Write down the final results of calculations and units	5

Data analysis techniques in this study were used to determine the scores of students' post test scores with the formula

$$Score = \frac{total\ score}{8}$$

4. Result dan Discussion

This section presents the obtained results and following by discussion.

4.1. Result

The results of the students' posttest values are shown in Figure 3.

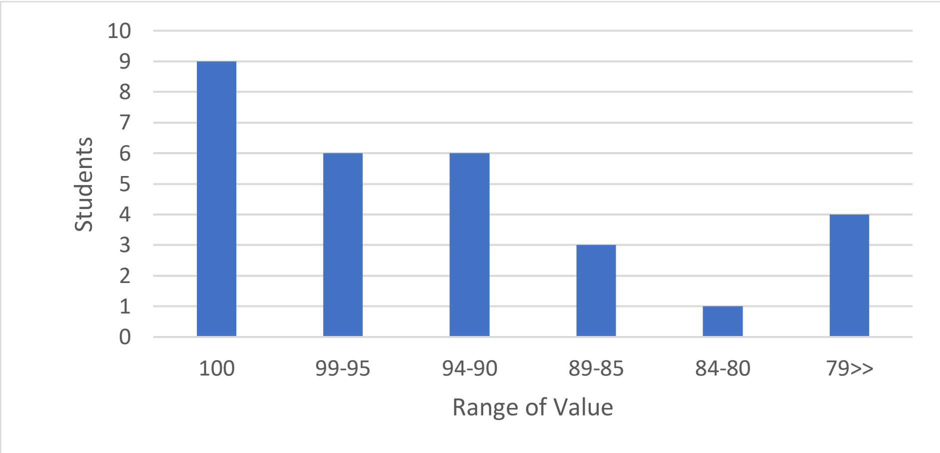


Figure 3. A comparison chart of many students for the range of values

Based on Figure 3, students who get a perfect score are 9. 12 Students have a range of values between 90 and 99. Furthermore, the number of students who have a range of grades 80 to 89 is 4 students and 4 students who get posttest results less than 80. With a minimum graduation value of 80, the data in figure 3 shows that 87% of students succeeded in achieving the graduation standard. The questions used as post-test questions totaled 4 questions. The post-test results were assessed using a mathematical representation indicator as in Table 2. Based on the indicators in Table 2, the results of the students' mathematical representation mapping were given in Figure 4 as follows:

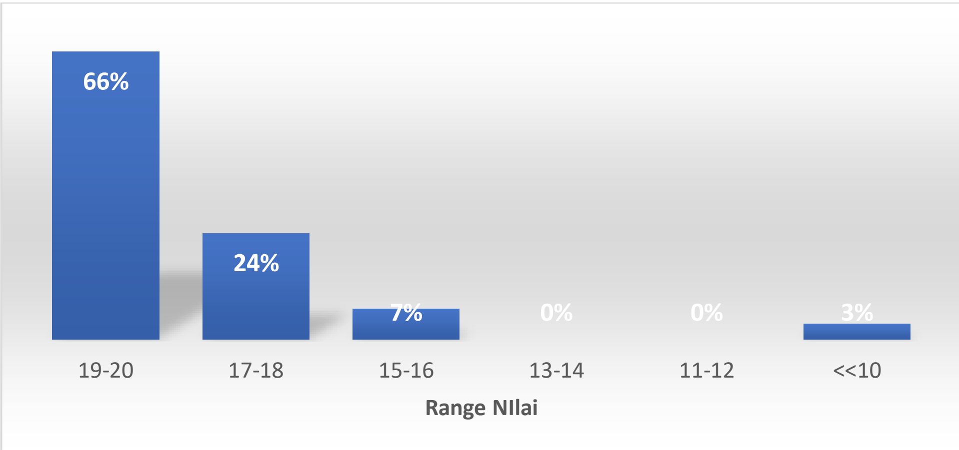
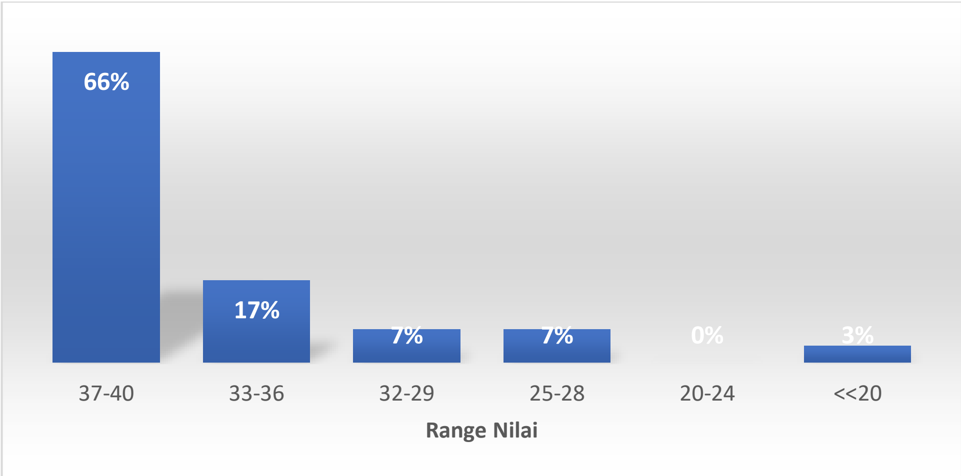


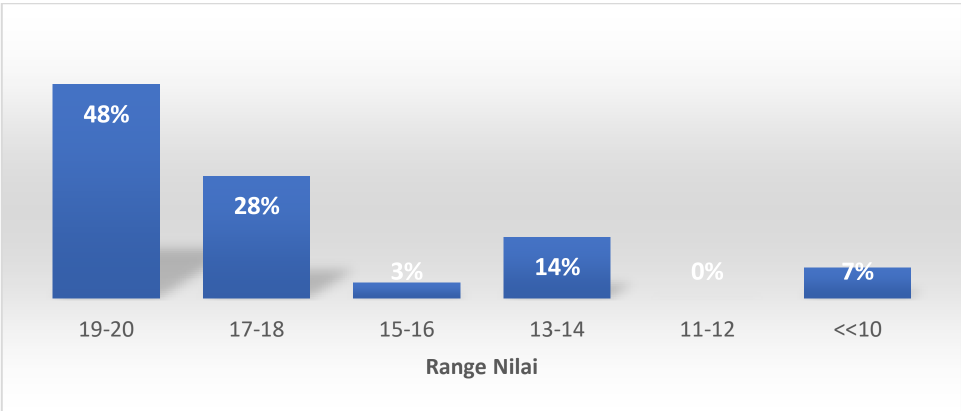
Figure 4. Indicator Obtain the appropriate data

Figure 4 shows the comparison between the range of indicator values to obtain data that is appropriate to the number of students. The range of values is the sum of all indicator values to obtain data from the questions used for the posttest. Figure 4 shows that there are around 66% or 20 students who get a perfect score on the indicator capable of obtaining appropriate data. While 24% or 7 students get an almost perfect score of 17 or 18 points. 3 other students, 7% or 2 students got a score of 15-16 points and 1 other student only got points less than 10. This shows only 20 students who understood how to obtain the appropriate data. Other students still face difficulties on this indicator.



Figures 5. Indicator Using Mathematical Operations

Based on Figure 5, we can see that only 66% of the total number of students or 20 students who get perfect points on the indicator using mathematical operations. In addition, only 17% of students were able to obtain a score of 33-36 from this indicator. Furthermore, based on Figure 5, it starts to show that students experience difficulties on indicators using mathematical operations. It is seen that almost half of the other students are divided into each range of values as shown in Figure 5. Whereas the highest score of a mathematical representation is in this indicator.



Figures 6. Indicator Write down the final results of calculations and units

Figure 6 shows the results of mapping the final results writing indicators and their units. Like the results of the indicator using mathematical operations only half of students or 48% of students are able to get perfect grades. The other half of the students are scattered in almost every range of values. this shows that half the number of students still face difficulties in writing the final results and their units.

4.2. Discussion

The limit value of the mastery of physics lessons used in the school is 80. If you see Figure 3, there are 4 students who did not graduate and 25 students graduated. If you look more in detail there are 4 students who have the potential to fail. This is because their achievements are very close to the limits of completeness. So only 21 students were said to be safe from the completeness limit. Figures 4 to 6 show the indicators that become weaknesses of students. Student weaknesses are outlined below

a. In the indicator obtaining the appropriate data from the problem or shown in Figure 4 only 66% of students are able to obtain perfect grades. While 34% of students have weaknesses in determining the appropriate data from the problem. Their weakness is the difficulty in changing the CGS unit to SI. Furthermore, there are some students who also have errors that do not include units of physical variables obtained.
b. On the indicator using mathematical operations shown in Figure 5. From figure 5, 34% of students were unable to obtain the indicator value of mathematical operations perfectly. This error is not related to formula errors but is more inability to use mathematical operations such as the use of angles sin, cos and tan. But there is something interesting from the results of the mathematical operation indicator. There are some students who are able to complete one of the post test questions using concepts outside of Business and Energy, the concept of GLBB.
c. The indicator to write down the results along with the exact unit shown in Figure 6. This indicator is closely related to mathematical operating indicators. Even though they are able to use mathematical operations perfectly, there are some students who do not get this indicator value perfectly. The reason is that students mistakenly use the right unit. Of course this is very risky if the problem faced by students is in the form of multiple choice questions and the question has an answer option in the form of different physical units.

Although not all students have the perfect mathematical representation ability, the use of multimedia learning modules in learning can be said to be successful. This can be seen from Figure 3 which shows the statistics of many students on the range of values. Statistics show that students who fail to meet the completeness limit value are only 4 students or 14% of the total number of students. 24 or 86% of students are able to get grades above 80 or are said to graduate from the applied limits

5. Conclusions

After successfully introducing and applying learning using multimedia learning modules to high school students, it was found that mathematical representation indicators were the point of students' mistakes. The indicators are 1. the use of mathematical operations; 2. changing the CGS unit to SI units; 3. and proper use of units in writing the final results. Although from this study there are still many students who have not mastered mathematical representations. The use of multimedia learning modules in learning to get good results. This is seen by many students who have graduated from the graduation limit. This research is not yet maximal because there are some drawbacks of this study such as comparative data. Comparative data on the use of non-MLMs media can be used further research as research determines the influence of multimedia learning modules on mathematical representations. In addition, this research can be developed such as the use of other representations such as vector representations, diagrams and verbal. These representations can be combined with mathematical representations..

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