

# The Development of Physics Learning Materials Using Multimode Representation to Improve Cognitive Ability of High School Students

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## ABSTRACT

This research aims to determine the effect of physics learning materials using multimode representation to improve cognitive ability of high school students. The sample of this study was students grade X of a high school in Bandung. The sample was divided into experimental class and control class. The students of control class studied using usual physics learning material in the school while the experimental class studied using multimode representation of physics learning material. The sampling technique used was class random sampling. The instrument of this research was student's cognitive ability test on heat and temperature material. The result of this study show that physics learning materials using multimode representations on student learning processes were able to improve students' cognitive ability significantly

**KEYWORDS:** learning materials, multimode representation, cognitive ability, conceptual understanding, development

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## 1. INTRODUCTION

The learning process of students mainly occurs through interaction with other people and learning material. Therefore, learning materials becomes one of the important factors that influence student's learning. Learning materials can be interpreted as a book that contains knowledge and explained systematically and logically [1]. Learning materials also help students to achieve a basic competency in a coherent and systematic manner so that they can achieve all competencies accumulatively in their learning. Learning materials becomes an important tool used by students during their learning. Therefore, learning materials are expected to be able to fulfill the needs of students so their knowledge increase and the learning gained is more meaningful [2]. Learning materials that have been compiled in a systematic and simple way will help students to build their conceptual understanding and it will support to achieve the learning goals. Therefore, teaching books should be arranged systematically, fulfill standard writing rules, aspects of high readability, interesting, easy to understand, and based on students' needs and characteristics. The main purpose of learning materials is to make the learning process to become more effective, so that the teacher must choose the learning materials correctly or develop student learning materials by themselves [3]. The importance of the role of learning materials has been investigated previously by several researchers such as Ige who stated that learning materials make the learning process understood easily and real for students because of the application of concepts in daily life [4]. Other researchers who also stated that a good learning material is important in learning are Amodu [5], Emmanuel [6], Oladejo [7], and Aina [8].

From the results of interview with teachers and students in one of the high schools in Bandung obtained data about the characteristics of learning materials expected by students. They need a learning material that cover concepts with simple language and contain daily phenomena of physics. Students also hope to understand the application of the physics concepts they learned in school. But from the results of the analysis carried out on the physics learning materials used in the school, the learning materials only contains physics concepts and the explanations is not clear, does not contain the application of concepts in real life, and only use word representations. The problems have affects to the level of students' cognitive ability. Based on the results of the cognitive ability test conducted by researchers, it was found that students' cognitive ability were still in the low category.

The problem about student difficulties learning should be answered and overcome by the existence of learning materials in the learning process. Teachers as educators should know how to improve students' cognitive according to their learning abilities [9]. Learning materials include a lot of concepts that are difficult for students to learn because the material is complex and abstract. To overcome this problem, it is necessary to develop the right learning materials. The teacher as educator must be able to describe something abstract of the physics concept become clearer for the students by using a suitable learning materials. That consist words, charts, pictures, and schemes.

The ability to construct knowledge of each student is different so it is very possible if the students want to try various forms of representation to understand a concept and its application in life. Benner stated that a successful understanding concepts process depends on students skills tp representing concepts such as constructing representations in text, tables, graphs, solutions, equations, and symbol form [10]. Representation is a configuration (form or arrangement) that can describe, represent or symbolize something in a way. According to Rosengrant, representation is something that represents, describes or symbolizes objects and / or processes. So that a concept can be presented in various forms of representation (multi representation) [11]. Learning process that combines conceptual understanding through an integrated images and text called multimode representations. This learning has the ability to combine text / verbal, image, mathematical and graphical.

According to Lemke, science is not complete and not communicated only through verbal language. Scientists should combine, connect, and integrate verbal forms with mathematical forms, quantitative charts, diagrams, data tables, images, maps, and other visual representations [12]. With this integrated representation, students can be easier to understand the concept because if students do not understand one representation, the students will be helped by another representations that are still integrated. In this case, each student has a different representation ability so that conceptual understanding of learning cannot use one representation only.

The physics concept can be remembered well if it construct with text and pictures. This is explained by dual coding theory [13]. There are two types of human cognitive system called verbal system and image system (visual). Verbal systems usually process words and sentences (except for concrete material) while images are processed through the visual system or verbal system. So this dual coding system in memory are able to improve 'knowledge memory' if the concept explained by text and images.

Multimode representations has three functions in learning process. They are the function as complement, limiting interpretations and constructors of understanding [14]. As a complement, multimode representation used to help students to complete the cognitive process by providing representations that contain complementary information. The second function is as a limiting interpretation. One interpretation is used to limited the possibility of misinterpretation in using other representations. The third function is to build students' understanding, where representation is used to encourage students to build the conceptual understanding of a concept using one of representation form.

## 2. METHODOLOGY

This study aims to develop a physics learning materials using multimode representation so that the research method used is R and D (Research and Development). The process of developing this learning materials based on Borg and Gall stages, that are: research and initial information gathering, planning, initial product development, initial trials, initial revisions, field trials, product revisions, field tests, final revisions, dissemination and implementation [15-18]. This experiment using quasi-experimental methods with randomized control group pretest-posttest design. The population in this study was students grade X of a high schools in Bandung and 2 classes was chosen as the sample using random class technique [19]. The subjects of this study were divided into two classes, the experimental class and control class. The experimental class learn using physics multimodal representation and control class learn using learning materials usually used by students in their school. The research data was collected using a cognitive ability test instrument thar consist 35 multiple choice questions.

The learning process in both of class using the same learning method, namely PQ4R method (Preview, Question, Read, Reflecty, Recite, Review). This method aims to show that the treatment difference between control class and experimental class only focused in learning materials. In addition, the use of this method also aims to train students to learn independently with physics learning materials that researchers have developed.

Determination of increasing cognitive abilities as the effect of using learning materials was analyzed using normalized gain. The normalized gain is a standard measure that shows reporting score in student achievement after given with the treatment. The average N-gain values interpreted according to Hake's criteria in Table 1 [20]:

**Table 1. Criteria N-Gain Based On Hake**

Grade $\langle g \rangle$	Clasification
$\langle g \rangle \geq 0,7$	High
$0,7 > \langle g \rangle \geq 0,3$	Medium
$\langle g \rangle < 0,3$	Low

### 3. RESULTS AND DISCUSSION

Data of students' cognitive abilities on temperature and heat material obtained in the initial test (pretest), final test (posttest) and N-gain in experimental class and control class are presented in Table 2.

**Table 2. Data Of Students' Cognitive Ability**

	Experiment Class			Control Class		
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
Number of students	33	33	33	37	37	37
Average	49.78	79.48	0.54	42.30	60.19	0.31

Table 2 shows that the average test scores of students' cognitive abilities at the initial test for the control class was 42.30 and the experimental class was 49.78. The difference in the results of the initial test found that the experimental class was 7.48 higher than the control class. After the learning process has been completed, the final test is given to the students. The average value of students' cognitive ability tests in the final test obtained values for the experimental class was 79.48 and the control class was 60.19. The difference in the final test results of the experimental class was 19.29 higher than the control class. The N-gain calculation for the experimental class is 0.54 with medium category and the control class 0.30 with the low category. These results indicate that the value of cognitive abilities in the experimental class is higher than the control class so that it can be stated that students' cognitive abilities increase after the learning process using multimode representation.

After normality and homogeneity test, the results obtained that N-gain cognitive abilities of students are normally distributed and homogeneous so that the next step taken is to see the differences average score of increasing cognitive abilities of students between the experimental class and the control class. The test results with the t-test are presented in Table 3.

**Table 3. N-Gain Data of Students' Cognitive Ability**

Data	Class	Sig* (1-tailed)
N-gain	Experiment	0.000
	Control	

The data in Table 3 shows that the significance value of N-gain cognitive abilities of students between the experimental class and the control class is 0,000. This significance value is smaller than the value of  $\alpha$  (0,000 < 0,05) so  $H_0$  is accepted so that the conclusion that the application of physics learning materials using multimodal representation in student learning can significantly improve students' cognitive abilities compared to commonly used physics learning materials in school.

Learning materials has a very important role in improving cognitive abilities obtained in this study. This is consistent with what was expressed by Chambliss and Calfae that if the learning materials used by students are developed in accordance with the requirements of a good book, the level of students' cognitive abilities will be increase [21]. Sinaga states that there are conditions for a good learning materials, namely: a description of the concept must be true and clear, the sequence of discussion arranged inductively or deductively, the depth and breadth of content according to the level of development of students, integrating verbal and visual representation, the order of use of the mode of representation in according to students need so that the concept becomes clearer, it can encourage readers to read more about the learning materials willingly, and the use of punctuation according to the correct Indonesian grammar rules [22]. The requirements of a good learning materials have been fulfilled and have been tested to students. Therefore, physics learning materials using multimode representations oriented towards students' cognitive ability improvement have been improving students' cognitive abilities successfully.

The concepts presented in this learning materials are complete simple according to students' need and level of development of students at the high school level of grade X. The truth of the concepts presented in the book has been validated to expert lecturers and the conceptual clarity has been tested to students through a comprehension test and readability of paragraphs that show the results that students easily understand the concepts in the paragraphs presented. This finding shows that the concept is clear to students. This also helps students to get used to learning independently.

One of the causes of physics learning materials using multimode representations can further improve students' cognitive abilities because of multimode representations that help students understand the concepts of physics learning. Omosewo stated that teacher as educator will help students learn physics if the teacher can make the object or phenomena become real for the students but if it is not possible the teacher can use representation [23]. The experience can develop students' cognitive ability [24]. Each student has the ability to understand

different concepts so that if students have difficulty understanding concepts with one representation, their understanding must be supported using other representations. For example, when it is difficult to understand concepts with text representation, their understanding can be complemented by other representations that are easier to understand such as image representation, graphics, and mathematics. Fulfillment of the need for the ability to understand different concepts in students is very helpful to more quickly accept the physical concepts that want to be instilled during the learning process.

The findings of the importance of the role of multimode representations in learning materials are consistent with the statement of Richard Feynman in the Nobel lecture that something could be very simple if it could be explained in its entirety in various ways without immediately realizing that you were explaining something similar. The same was stated by Irwandani that multi-representation learning helps students who have multiple intelligences because different representations of objects can provide optimal learning opportunities for each type of intelligence [25].

The presentation of concepts in the developed learning materials also uses simple language that is easy for students to learn so that the concept is easier to understand. If the physics concepts in learning materials are compiled and explained simply, not only the cognitive abilities of students will increase but also the students will be able to learn the concepts independently.

#### 4. CONCLUSION

Data from research that has been done shows that if learning materials used for learning are developed according to the students needs in constructing their knowledge, students' cognitive abilities will increase. Using multimode representation in learning materials developed by researcher has succeeded in meeting the learning needs of students so students' cognitive abilities improve.

#### 5. SUGGESTION

Based on the results of the analysis, the author suggests some points to physics teachers about developing physics materials:

1. Physics teachers have to develop the physics materials according to students' character and needs. Using multimode representation in physics materials has been proven to improve students' cognitive abilities.
2. In developing physics materials, it is necessary to do a trial again to students after the first try out to show that the lack of books on the revised results of the initial tryout has been corrected,.

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