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The Effect Size of Implementing Physics Textbook Using Multimodal Representations

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ABSTRACT

This study aims to determine the effect size of implementing a physics textbook developed using multimodal representations to enhance the cognitive abilities and problem-solving skills of students. The research was conducted in one of the high schools in Bandung city with a sample size of 69 students. The sampling technique used was the class random technique. The sample was divided into two groups: the control group and the experimental group. In the control group, students learned using their regular textbooks, while in the experimental group, they used the textbook developed using multimodal representations and the Rosengrant problem-solving stages. The implementation of the textbooks in both the control and experimental groups was conducted using the PQ4R method (Preview, Question, Read, Reflect, Recite, Review) to focus the results solely on the influence of the textbooks. The results obtained indicate that the implementation of the developed textbook in this study had a significant impact on the cognitive abilities and problem-solving skills of the students.

Keywords: *effect size, PQ4R, cognitive abilities, problem-solving skills*

1. INTRODUCTION

The learning process within an educational environment involves a complex interaction among three main elements: students, teachers, and learning resources. Each element plays a crucial role in creating an effective and meaningful learning environment [1]. Learning in the classroom greatly requires learning resources that can be utilized by students. One of the commonly used learning resources is the textbook. Textbooks have a significant influence on students' learning. A textbook is a standard book used in a specific field of study, compiled by experts in the field for instructional purposes, equipped with teaching aids that are easily understood by users in schools and higher education institutions to support a teaching program [2].

The main objective of a textbook is to provide quality and structured learning resources in a specific field of study. Textbooks are designed to support the learning process with specific goals. With its primary focus on progress and facilitating learning, textbooks become essential tools in supporting the educational process and helping students achieve better learning outcomes. A textbook is designed to help students

comprehend the concepts being taught. Therefore, Teachers need to enhance creativity in developing teaching materials. By increasing creativity, teachers can create textbooks that are more engaging, innovative, and tailored to students' characteristics and needs [3].

As one of the key components in the learning interaction, teachers have the responsibility not only to deliver the subject matter but also to conduct meaningful and facilitative learning experiences. According to Gunawan et al., (2016), effective learning outcomes can be achieved when the learning process is designed in accordance with the characteristics and needs of the students. Therefore, teachers are expected to possess a creative and innovative attitude in developing textbooks that align with the characteristics and needs of their students.

Textbooks often contain a variety of materials that can be challenging for students to learn or for teachers to teach [5]. These difficulties may arise due to the abstract, complex, or unfamiliar nature of the material. The best way to assist students in understanding abstract concepts is to directly expose them to objects or phenomena related to the concepts being studied. When real-life objects are not feasible, alternatives such as

representations can be used. These representations aid in delivering learning in a more effective and meaningful manner to students, allowing them to receive, understand, retain, and apply their learning experiences to achieve overall educational goals.

The representations commonly used in presenting physics concepts are images, words, mathematical equations, freehand diagrams, tables, and graphs. Students have different abilities to comprehend physics concepts. Therefore, when a student is unable to understand a concept effectively through one representation, they may benefit from another representation [6]. Consequently, a good textbook should include multimodal representations, utilizing multiple different representations that are integrated to explain a concept. The goal is to ensure that the representations complement each other instead of conflicting, as each student has varying abilities to understand different types of representations. By incorporating multimodal representations, a good textbook caters to the diverse learning styles and preferences of students, enhancing their understanding and engagement in the learning process.

The design of this developed textbook includes everyday life phenomena and the problems related to these phenomena are solved using a step-by-step problem-solving approach. When presenting problems in the textbook, students are guided and trained to solve the problems through four stages, which are: 1) Drawing and interpreting the given problem, 2) Simplifying the problem, 3) Representing the physical form, 4) Representing the mathematical form [6].

The four stages are used both in solving everyday life problems and numerical problems. This approach greatly supports training students to familiarize themselves with solving problems using correct physics concepts. After students are guided in solving problems, they are given independent exercises to test their understanding and acclimate them to following the steps to find solutions to the problems.

Once the textbook is developed according to the characteristics and needs, it is essential to test its impact on students' cognitive abilities and problem-solving skills. This impact measurement will provide information about the success level of the developed textbook in enhancing students' cognitive abilities and problem-solving skills. Evaluating the impact will help ensure that the textbook is effective in achieving its intended educational goals.

2. RESEARCH METHODS

This research aims to determine the effect size of a physics textbook developed using multimodal representations to enhance students' cognitive abilities and problem-solving skills. The study was conducted in

one of the high schools in Bandung, with a sample size of 69 students. The sample was selected using the class random techniqueS. The implementation of the developed textbook will be conducted using a quasi-experimental method, which typically investigates practical situations where it is not feasible to control all relevant variables [7].

In the control group, students learn using their regular textbooks, while in the experimental group, they use the textbook developed with multimodal representations and the Rosengrant problem-solving stages. The implementation of the textbook in both groups will follow the PQ4R method (Preview, Question, Read, Reflect, Recite, Review).

The research design employed in this study is a randomized control group pretest-posttest design. In this design, the research subjects are divided into two groups: the experimental group and the control group. The experimental group uses the textbook developed by the researcher, while the control group uses the regular textbook used by students in their learning activities. The research design is shown in Table 1:

Tabel 1 Research Design

Class	Pretest	Treatment	Posttest
Experiment	O ₁ , O ₂	X ₁ , Y ₁	O ₁ , O ₂
Control	O ₁ , O ₂	X ₂ , Y ₁	O ₁ , O ₂

O1: Pretest of students' cognitive abilities.

O2: Pretest of students' problem-solving skills.

X1: Learning with the developed textbook (Experimental Group).

X2: Learning physics with the regular textbook used in the class (Control Group).

Y1: PQ4R method (Preview, Question, Read, Reflect, Recite, Review).

3. RESULTS AND DISCUSSIONS

3.1. The Impact Measurement on the Improvement of Students' Cognitive Abilities

The results obtained in this study indicate that the physics textbook using multimodal representations can significantly improve students' cognitive abilities. To determine the extent of the impact of using this physics textbook on students' cognitive abilities, the Effect Size can be calculated. The data regarding the effect size are shown in Table 2.

Tabel 2. Effect Size Values of Cognitive Ability Improvement

M _E	M _K	SD _E	SD _K	D	Kriteria
0,54	0,31	0,10	0,06	0,81	large effect

The effect size is used to determine the effect size of using the physics textbook with multimodal representations. This effect size can be calculated from the difference in N-gain between the experimental group and the control group. The result of the calculation shows that the effect size of students' cognitive abilities is 0.81, categorized as a large effect. This finding implies that the physics textbook using multimodal representations has a significant impact on improving students' cognitive abilities compared to the use of the regular textbook in schools.

The reason behind the significant influence of the physics textbook using multimodal representations developed by the author in enhancing students' cognitive abilities lies in the comprehensive and in-depth presentation of concepts in the book. This textbook explains concepts by starting with physical phenomena related to everyday life, making the learning more meaningful. Integrated learning helps students acquire meaningful learning and motivates them in the learning process [8].

The attractive presentation of concepts is also one of the reasons why students are interested in reading this physics textbook using multimodal representations because learning with interest helps students understand the concepts better. The student's learning source must be able to motivate them in their learning, as mentioned by Lestari, (2013), that the student's textbook can help improve their learning outcomes in the learning process due to the presentation of interesting examples, illustrations, or pictures in the material, thus reducing student boredom in learning.

The use of multimodal representations in explaining concepts also helps students understand the concepts better. Multimodal representations have three main functions: first, to provide complementary information or assist in completing cognitive processes. Second, one representation is used to limit misinterpretation errors when using another representation. Third, it can encourage students to build a deeper understanding of the situation. The various representations used in the author's developed textbook in explaining a concept greatly help students understand the concept better because when students have difficulty understanding a concept with one representation, they can comprehend it through another representation [10].

Various studies have been conducted on students' learning outcomes through interpreting and constructing different modes of representation, including in primary education and at the secondary school level, with the use of multiple forms of representation. The results show that students' conceptual understanding improves when they are assigned to translate different modes of representation into a coherent concept in their lessons [11]. If the textbook used by students is well-developed, the level of students' cognitive abilities will increase.

This is because the concepts in the students' minds have been well-formed, allowing for further analysis and deeper understanding to take place.

3.2. *The Impact Measurement on the Improvement of Students' Problem-Solving Abilities*

The results obtained in this study indicate that this physics textbook can significantly improve students' problem-solving abilities. To determine the extent of the impact of using this physics textbook on students' problem-solving abilities, the effect size can be calculated. The data regarding the effect size are shown in Table 3.

Table 3. Effect Size Values of the Textbook on Students' Problem-Solving Abilities

M_E	M_K	SD_E	SD_K	D	Criteria
0,71	0,18	0,12	0,08	1,67	<i>Large effect</i>

Effect Size is used to determine the magnitude of the impact of using the physics textbook with multimodal representations on students' problem-solving abilities. It quantifies the difference or effect of the intervention (using the multimodal representation textbook) on the students' problem-solving skills. The calculation resulted in an effect size of 1.67, categorized as a large effect, indicating that the physics textbook using multimodal representations developed by the author has a significant impact on improving students' problem-solving abilities.

One of the main reasons for the substantial impact of the physics textbook with multimodal representations is the contextual and relatable presentation of problems that are close to students' lives. This makes the given problems simple and easily understandable for the students.

Furthermore, the textbook systematically trains students in the Rosengrant problem-solving stages. The practice of problem-solving through various example problems greatly helps students in familiarizing themselves with solving physics problems correctly and meaningfully. The focus is not only on mathematical solutions but also on understanding the physical meaning behind them.

The ability of students to solve physics problems is considered essential, in line with the statement from the Ministry of Education and Culture (2012) that science learning should be oriented towards application, the development of thinking skills, curiosity, as well as fostering a caring and responsible attitude towards the natural and social environment. Application-oriented learning means students are given opportunities to apply their knowledge to solve problems encountered in daily life.

The use of multimodal representations in the problem-solving stages also greatly aids students in understanding and practicing problem-solving skills. A successful problem-solving process relies on skills in representing problems, such as constructing representations in words, graphs, tables, and equations, solving, and manipulating symbols [12]. Multimodal representations involve sequentially translating the given physics problem from one symbolic language to another, starting with writing a verbal description of the problem, then moving it into an adapted visual form and diagram representation, and ending (usually) with mathematical formulas that can be used to determine answers using numerical values [13].

3. CONCLUSION

The implementation of the physics textbook developed using multimodal representations has a significant impact on improving students' cognitive abilities and problem-solving skills. The use of various representations, such as words, images, diagrams, graphs, and mathematical equations, in the textbook helps students better understand complex concepts in physics. By presenting contextual and relatable problems, the textbook makes learning more meaningful and easily accessible to students.

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