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The Effect of the Use of Problem-Based Learning E-Modules on Student Learning Outcomes in Elementary School

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Abstract
The material of rotation and earth revolution is one of the materials in science learning in elementary schools that is abstract so that it requires learning media that is able to visualize concepts concretely. One alternative that can be used is an E-Module based on Problem Based Learning which integrates interactive digital media with problem-solving-based learning. This study aims to determine the effect of the use of Problem Based Learning-based E-Modules on the learning outcomes of elementary school students. This study uses a quantitative method with a quasi-experimental design using a nonequivalent control group design. The research subjects consisted of two classes, namely the experimental class that used E-Module based on Problem Based Learning and the control class that used conventional learning. Data collection techniques include observation, documentation, and learning outcome tests in the form of pretests and posttests. Data analysis was carried out using the Normalized Gain (N-Gain) test to determine the level of improvement in student learning outcomes. The results showed that the experimental class obtained an N-Gain value of 0.82 in the high category, while the control class obtained an N-Gain value of 0.42 in the medium category. The findings show that the use of Problem Based Learning-based E-Modules is more effective in improving student learning outcomes than learning without using Problem Based Learning-based E-Modules. This study provides recommendations for elementary school teachers to utilize E-Modules based on Problem Based Learning as one of the innovations in digital teaching materials to create more interactive, contextual, and student-centered learning.

Keywords:
E-Module; Problem Based Learning; learning outcomes; Elementary School

A. INTRODUCTION

Digital transformation in the education era encourages a learning paradigm that was initially teacher-centered to be student-centered (Mhlanga, 2024). The development of information technology provides opportunities for educators to utilize various information through digital media that are able to improve the quality of the learning process (Mukul & Büyüközkan, 2023). One form of innovation can be implemented in the Electronic Module or E-Module which is able to allow students to learn material independently through the presentation of material that is interactive, systematic, and easy to access (Okta Priantini & Widiastuti, 2021).

At the elementary school level, the use of digital teaching materials is increasingly important because the characteristics of students are at a concrete operational stage that requires interesting, contextual, and able to visualize abstract concepts (Wang, 2025). However, based on the results of initial observations at SD Muhammadiyah 9 Malang City, it was found that the learning process was still dominated by the use of printed books and lecture methods. This condition causes student involvement in learning to be relatively low, which has an impact on less than optimal learning outcomes. These problems are also found in the learning of Natural and Social Sciences (IPAS),

especially the material of rotation and the earth revolution which requires visualization and learning activities that are able to connect scientific concepts with phenomena encountered in daily life.

One of the approaches that is considered to be able to overcome these problems is Problem Based Learning (PBL). This learning model places students as the center of learning through activities of identifying problems, collecting information, analyzing alternative solutions, and concluding learning outcomes (Ennis, 2011). The integration of the PBL model into the E-Module is expected to not only make it easier for students to understand the material, but also to train critical thinking, problem-solving, and learning independence skills (Nurtanto et al., 2020).

The Problem Based Learning (PBL) model is seen as relevant to be integrated into the E-Module because it provides opportunities for students to learn through problem-solving related to daily life (Oktapianti, 2021). Through problem-based learning, students are encouraged to observe, discuss, gather information, express opinions, and draw conclusions based on their own findings (Kusumasari et al., 2022). This process is expected to be able to build a deeper understanding of concepts than learning that is only oriented towards the delivery of material (Suwardika et al., 2024).

Research conducted by (Utaminingsih & Ellianawati, 2025) stated that the use of E-Modules is able to increase learning motivation, learning independence, and student learning outcomes. On the other hand, the findings of the study by (Antari et al., 2023) mentioned that the application of Problem Based Learning has also been proven to improve learning activities, critical thinking skills, and concept understanding. In addition, the statement from (Istiqomah et al., 2022), which has combined E-Modules with various learning models to produce teaching materials that are more interactive and in accordance with the needs of students. However, research on the use of Problem-Based Learning-based E-Modules in IPAS learning in elementary schools is still relatively limited, especially on rotation materials and earth revolutions that do not yet exist. Based on this description, the purpose of this study is to analyze the influence of Problem Based Learning-based E-Modules on student learning outcomes.

B. METHODS

This study uses a quantitative approach with a quasi experiment method which aims to determine the effect of the use of Problem Based Learning (PBL)-based E-Modules on the learning outcomes of elementary school students. The research design used is the Nonequivalent Control Group Design, which involves two groups consisting of an experimental class and a control class (Jelena & Jelena, 2022). Both groups were given a pretest to find out the students' initial ability, then the experimental class learned using PBL-based E-Modules, while the control class followed learning using teaching materials commonly used in schools. After the entire learning series was completed, both groups were given a posttest to measure student learning outcomes.

The research was carried out at SD Muhammadiyah 9 Malang City with the research subjects of 60 grade VI students divided into two classes, namely 30 students in the experimental class and 30 students in the control class. The sample was determined using the purposive sampling technique by considering the equality of the characteristics of the two classes based on the school's recommendation. Because class assignment was not fully randomized, factors such as the two classes being taught by different teachers, or pre-existing differences in class composition, cannot be ruled out as alternative explanations for the outcome differences observed; a baseline (pretest) equivalence test between the two groups was not conducted in this study and is recommended before the difference in outcomes is attributed solely to the E-Module treatment. This is acknowledged as a limitation of the quasi-experimental design. The research instrument is in the form of a multiple-choice learning outcome test and a description that is arranged according to the learning outcomes of rotation and earth revolution materials. Before being used in research, the instrument has gone through validity tests by experts. This expert judgment covered the content of the test items; a quantitative reliability coefficient for the learning-outcome test instrument itself (e.g., Cronbach's alpha), reported separately from the validity of the E-Module material presented in the Results, was not computed in this study and should be reported in a future revision. In addition to learning outcome tests, the research also uses observation sheets as supporting data during the learning implementation process. The results of these observation sheets are not yet reported in the Results section of this study; including this observational data is recommended for a future revision of the

manuscript.

The data obtained were analyzed descriptively and quantitatively. Descriptive analysis was used to describe the average pretest and posttest scores in each class. Furthermore, the effectiveness of the use of E-Modules was analyzed using Normalized Gain (N-Gain) to determine the level of improvement in student learning outcomes after being given treatment. The N-Gain value is calculated using the following formula (Sugiyono, 2019).

$$\langle g \rangle = \frac{Score\ postest - Score\ pretest}{Score\ maksimum - Score\ pretest}$$

To find out how much of an increase it is, you can interpret the N-Gain value obtained based on the criteria (Sugiyono, 2019):

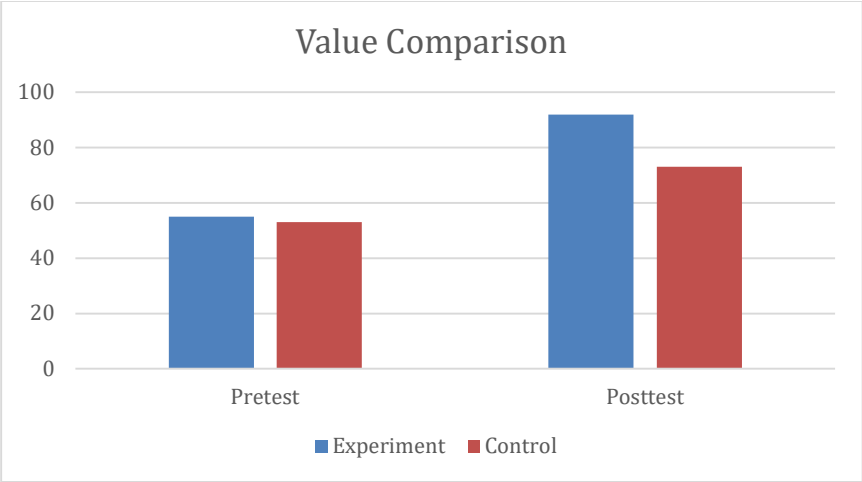
Interval N-Gain	Effectiveness Category
N -Gain > 0,70	High
0,30 ≤ N -Gain ≤ 0,70	Medium
N -Gain < 0,30	Low

C. RESULT & DISCUSSION

The E-Module used in this research process contains learning materials on rotation and earth revolution. This material is one of the materials that requires concrete visualization, so media that can help students understand the material well. In addition, the developed E-Module is also integrated with problem-based learning. In addition, the developed E-Module is also integrated with the Problem Based Learning (PBL) model, so that the learning process not only focuses on delivering the material, but also encourages students to actively build knowledge through contextual problem solving.

E-Modules based on problem-based learning before being implemented have gone through the stages of validity testing to experts, in the praise includes a material test that includes aspects of learning objectives, suitability of the material with the objectives, giving examples, the use of images and videos used, quiz questions given in the material are adjusted to the syntax of Problem Based Learning. The results of the overall validity test obtained a score of 98%, this shows that the E-Module based on Problem Based Learning is valid and feasible to be applied in the learning process, This is in accordance with the findings by (Febriyanti & Restian, 2026) that the media to be used in the learning process must be validated, especially regarding the objectives, materials, and questions used.

This research involves two classes, namely the control class and the experimental class. The control class is a class that does not get the treatment of the learning process by using the E-Module, while the experimental class is the class that gets the treatment by using the E-Module. So that the comparison of the scores obtained in the two classes is different. The results obtained are presented in diagram 1.



Based on Figure 1, the use of Problem-Based Learning-based E-Modules has a positive effect on the learning outcomes of elementary school students. This is shown by an increase in posttest scores in the experimental class which is higher than the control class. The results of the N-Gain test also showed a numerical difference between the two classes after being given treatment. However, this difference was evaluated using descriptive N-Gain scores only; no inferential statistical test (e.g., an independent-samples t-test or ANCOVA) was conducted to confirm that it is statistically significant. This limitation should be addressed before the effectiveness claim below can be considered firmly established. Based on this descriptive difference, it is tentatively suggested that the use of Problem Based Learning-based E-Modules is effective in improving student learning outcomes on rotation materials and earth revolutions. This is in line with research by (Gunawan et al., 2024) that the use of E-Modules can encourage students to actively contribute to the learning process, so that it can ultimately improve learning outcomes. The results of the calculation with the N-Gain test for the experimental class are presented as follows.

$$\langle g \rangle = \frac{92-55}{100}$$
$$= 0{,}82$$

For comparison, the results of the N-Gain calculation for the control class are presented as follows.

$$\langle g \rangle = \frac{73-}{100-}$$
$$= 0{,}42$$

The results of the summary analysis are presented in Table 1.

Table. 1 Value Comparison

Class	Pretest	Posttest	N-Gain	Criteria
Experimen	55	92	0,82	High
Control	53	73	0,42	Medium

Based on Table 1. then it can be found that the results of the N-Gain test in the experimental class using E-Module based on Problem Based Learning were 0.82 with high effectiveness criteria, while in the control class showed a value of 0.42 with moderate effectiveness criteria. The difference in the N-Gain value shows that the improvement in student learning outcomes in the experimental class was more optimal than the control class. The high increase in learning outcomes in the experimental class indicates that the use of Problem Based Learning-based E-Modules is able to help students understand the concept of rotation and the earth's revolution more deeply through the presentation of interactive, visual, and problem-solving-oriented materials. Meanwhile, the increase in the control class which was only in the medium category showed that learning without the support of E-Modules based on Problem Based Learning still provided an increase in learning outcomes, but was not able to facilitate students in building maximum conceptual understanding.

A higher improvement in the experimental classroom occurred because the E-Module not only presented material in the form of text, but also integrated images, animations, learning videos, as well as interactive exercises that made it easier for students to visualize the phenomenon of rotation and the earth's revolution. In addition, the application of Problem Based Learning syntax encourages students to identify problems, seek information, analyze the causes of a phenomenon, and conclude solutions based on the results of discussion and material exploration (Astuti et al., 2020). This activity makes students more active in building knowledge rather than just receiving information from teachers, so that the concepts learned are easier to understand and remember (Nurtanto et al., 2020).

The application of Problem Based Learning syntax in the E-Module begins with the presentation of problems related to the phenomenon of rotation and earth revolutions that are close to students' lives, such as the occurrence of day and night, the change of seasons, and the difference in time in various regions. These problems are a stimulus for students to identify problems, gather information from the materials available in the E-Module, discuss alternative solutions, and conclude

their findings. During the learning process, students also have the opportunity to observe illustrations, drawings, animations, and videos contained in the E-Module so that concepts that were previously abstract can be visualized in a more concrete way. This condition makes it easier for students to connect theory with real phenomena and increase their involvement in the learning process(Ningrum et al., 2026).

The improvement of learning outcomes obtained by students is inseparable from the characteristics of the E-Module which is interactive. In contrast to conventional teaching materials that are dominated by texts, the E-Module provides a variety of multimedia components, such as images, animations, videos, interactive practice questions, and live feedback(Agustin et al., 2025). The existence of these various features is able to increase students' attention and motivation to learn so that the learning process becomes more interesting and not monotonous. When students acquire information through a combination of text and visuals simultaneously, they have an easier time organizing information into a complete knowledge structure (Asysyura et al., 2023). Thus, students not only memorize concepts, but are also able to understand the relationships between concepts so that they have an impact on improving learning outcomes.

The findings of this study are in line with the multimedia learning theory put forward by (Mayer, 2017), which explains that the learning process will be more effective if information is presented through a combination of words and pictures that complement each other. The presentation of material in multimedia form helps reduce the cognitive burden of students because information can be processed through visual and verbal channels simultaneously. In the material of rotation and revolution of the earth, the use of animation and simulation in the E-Module allows students to build a mental representation of the direction of the earth's rotation, the process of revolution, and the consequences of these two phenomena. With this visualization, concepts that were initially difficult to understand become easier to learn, thus increasing students' conceptual understanding.

Although the E-Module developed in this study is scientific in content, the material of the earth's rotation and revolution also offers a clear opportunity for integration with Islamic educational values, which was not elaborated above despite this research being conducted at SD Muhammadiyah 9 Malang City and involving a researcher from the Department of Islamic Primary Education. The regularity and precision of the movement of the sun, the moon, and the earth are repeatedly presented in the Qur'an as a sign inviting reflection of *tafakkur* on the order of God's creation, for example in Surah Ya-Sin (36:38–40) and Surah Al-Anbiya' (21:33), which describe the sun and the moon each moving in their own orbit. Framing the problem scenarios in the PBL-based E-Module around these verses, alongside the scientific explanation of rotation and revolution, would allow students not only to understand the phenomenon empirically but also to connect it to tafakkur alam (contemplation of the natural world) as an Islamic way of knowing. A future revision of the E-Module and of this manuscript is encouraged to make this integration explicit, for instance through reflection questions or discussion prompts that relate the scientific content to relevant Qur'anic verses and to the broader objectives of Islamic education (tarbiyah).

In addition to being supported by multimedia theory, the results of this study also show the effectiveness of the application of the Problem Based Learning model in improving learning outcomes. Problem-based learning provides opportunities for students to think critically, analyze information, and find solutions to given problems. This process makes students the center of learning (student-centered learning), while the teacher plays the role of a facilitator who guides the course of discussion and investigation. Through these learning experiences, students not only gain conceptual knowledge, but also develop high-level thinking skills, cooperative skills, communication, and problem-solving that are so much needed in 21st-century learning (Panggabean et al., 2021).

The results of this study also show that the combination of digital media and the Problem Based Learning model has a more optimal impact than the use of one component alone. E-Modules provide learning resources that are easily accessible, engaging, and interactive, while the Problem Based Learning model provides a learning structure that encourages students to actively explore the material. The synergy between the two creates a more meaningful learning experience because students have the opportunity to observe, explore, discuss, and solve problems independently or in groups. These activities strengthen the knowledge construction process so that the information

learned is easier to understand and remember in the long term.

Overall, the results of the study show that the use of Problem Based Learning-based E-Modules is an effective alternative learning media to improve the learning outcomes of elementary school students, especially in abstract materials such as rotation and the earth revolution. The advantages of E-Modules are that they are able to integrate interactive multimedia with problem-based learning stages to provide a more active, contextual, and meaningful learning experience. Therefore, Problem-Based Learning-based E-Modules deserve to be considered as one of the learning innovations that can be applied by elementary school teachers to improve the quality of the learning process while optimizing the achievement of student learning outcomes.

D. CONCLUSION

The use of Problem-Based Learning-based E-Modules in the learning process can be one of the effective digital learning media alternatives to improve student learning outcomes on rotation materials and the earth revolution. This is evidenced by the increase in the average student score from 55 to 92 in the experimental class, and strengthened by the results of the N-Gain test of 0.82 which is included in the high category, while the control class only obtained an N-Gain score of 0.42 in the medium category. These findings show that E-Modules based on Problem Based Learning are able to support a more effective learning process than learning without using the E-Module. In addition to improving learning outcomes, the use of E-Modules also provides opportunities for students to learn more independently, actively, and in a directed manner through the presentation of interactive materials and problem-solving activities related to daily life. This research is expected to contribute to the development of technology-based learning innovations in elementary schools, especially in the use of digital teaching materials that are integrated with the Problem Based Learning model. This research still has limitations because it is only applied to one learning material and involves a limited number of samples. This study also did not include an inferential statistical test of the between-group difference, a baseline (pretest) equivalence check between the experimental and control classes, a separately reported reliability coefficient for the learning-outcome test instrument, reported results of the observation sheets, or an explicit elaboration of Islamic educational values relevant to the research context; these points remain to be addressed in a follow-up study or revision. Therefore, further research is expected to develop E-Modules based on Problem Based Learning on other materials, different levels of education, as well as by examining its influence on other abilities, such as critical thinking, problem solving, science literacy, and higher order thinking skills.

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