PUBLISHER
YAYASAN PENDIDIKAN DAN PENGEMBANGAN HARAPAN ANANDA

JURNAL
WAWASAN DAN AKSARA

Juwara | p-issn: 2797-2097 | e-issn: 2797-2119 | **Vol. 6 No. 1 (2026)**
https://doi.org/10.58740/juwara.v6i1.821

The Effect of Ethnomathematics E-Modules in Problem-Based Learning on Elementary Students Mathematics Learning Outcomes

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Abstract
This study aims to examine the effect of the Problem Based Learning (PBL) model assisted by ethnomathematics-based e-modules on elementary students' mathematics learning outcomes on geometry topics. A quantitative approach with a quasi-experimental nonequivalent control group design was applied. The experimental group received PBL instruction supported by ethnomathematics-based e-modules, while the control group received conventional instruction. Data were collected using a 20-item multiple-choice test with validated reliability (Cronbach's alpha). Data analysis included normality and homogeneity tests, an independent sample t-test, and N-gain analysis. The results showed a independent t-test indicated a significant effect ($t = 5.12$, $p < 0.001$). The experimental group achieved a higher N-gain score (0.62, medium to high category) compared to the control group (0.36, medium category). These results indicate that PBL assisted by ethnomathematics-based e-modules significantly improves students' mathematics learning outcomes. The findings highlight the effectiveness of integrating contextual learning models and digital ethnomathematics media in improving learning achievement in elementary mathematics education.

Keywords
e-module; elementary school; ethnomathematics; mathematics learning outcomes; problem-based learning

INTRODUCTION

Mathematics has an important role in the development of logical, systematic, and analytical thinking skills in elementary school students (Suparman et al., 2021). However, in classroom learning practice, mathematics is often perceived as an abstract and difficult subject to understand due to its lack of relevance to the student's real-life context. This condition shows that mathematics learning still tends to be oriented to algorithmic procedures without providing enough space for students to construct the meaning of concepts contextually (Pratiwi et al., 2024). The learning process becomes less meaningful and not optimal in developing students' high-level thinking skills.

These problems are reflected in the low mathematics learning outcomes of elementary school students in various regions, including basic materials such as calculation operations, measurements, and simple problem solving (Musna et al., 2021; Yasin et al., 2020). Many students have difficulty understanding story problems and relating the information provided to relevant mathematical concepts. This indicates that the mastery of mathematical concepts has not been at the expected level (Suparman & Tamur, 2021). In addition, the results of the learning evaluation show that most students are still below the minimum completeness criteria, which indicates the need for innovation in the learning process.

One of the approaches that is considered relevant to overcome these problems is Problem Based Learning (PBL) (Amalia et al., 2017). This learning model places students as active learning centers in solving contextual problems through critical thinking, collaboration, and mathematical reasoning (Ahmad et al., 2023; Suparman et al., 2021; Susanti et al., 2020). PBL provides students with the opportunity to build knowledge through hands-on experience in solving problems that are close to students' lives (Maulidia et al., 2020). Thus, PBL does not only focus on the final result, but also on the thinking process that students go through in finding solutions.

However, the implementation of PBL requires the support of learning media that is able to facilitate students in understanding problems independently and systematically. One of the relevant media is ethnomathematics-based e-modules (Khery et al., 2025). This e-module is designed by integrating mathematical concepts into the context of local culture that is close to students' lives, so that the material becomes more concrete and easy to understand (Widayanti et al., 2022). The ethnomathematical approach allows students to relate abstract concepts to cultural experiences such as traditional market activities, batik motifs, traditional games, and the surrounding environment.

The integration between PBL and ethnomathematics-based e-modules provides a stronger potential in improving the quality of mathematics learning (Alghiffari et al., 2024). E-modules serve as systematic self-study guides, while PBL provides a framework of learning activities that require students to be active in problem-solving (Sumaji et al., 2025). The combination of the two creates a learning environment that encourages the exploration, analysis, and application of mathematical concepts in real-world contexts. This integration also supports more flexible, interactive, and student-oriented learning (Gesty & Leonard, 2025).

There is a gap in previous research that shows that the application of PBL and ethnomathematics-based e-modules is still often carried out separately. Many studies have focused only on the effectiveness of PBL without the integration of local culture-based media, or only developed e-modules without directly linking them to problem-based learning models (Aisyah & Gumala, 2025; Susanti et al., 2020; Wijnia et al., 2024). In addition, research that specifically examines the integration of the two in the context of elementary school is still limited, especially in relation to improving mathematics learning outcomes. A state-of-the-art study shows that PBL-based learning is effective in improving higher-level thinking skills, while ethnomathematics has been proven to be able to improve conceptual understanding through cultural contexts familiar to students (Aisyah & Gumala, 2025; Awami et al., 2022; Siradjuddin et al., 2026). However, there is still little research that combines the two approaches in a single digital-based learning system such as e-modules. The novelty of this research lies in the integration of PBL with ethnomathematics-based e-modules that are systematically designed to improve the mathematics learning outcomes of elementary school students through contextual and digital approaches.

Based on these problems, this study aims to analyze the influence of the Problem Based Learning model assisted by ethnomathematics-based e-modules on the mathematics learning outcomes of elementary school students. In particular, this study aims to find out the difference in the learning outcomes of students who use this model compared to conventional learning. The results of this study are expected to make an empirical contribution to the development of innovative learning models that are relevant to the needs of mathematics learning in elementary schools.

METHOD

Research Design

This study uses a quantitative approach with a quasi-experimental method. The design used is *a nonequivalent control group design*, which involves two groups, namely the experimental class and the control class. The experimental class was given treatment using the Problem Based Learning model assisted by ethnomathematics-based e-modules, while the control class used conventional learning. Both groups were given a pretest before treatment and a posttest after treatment to measure students' math learning outcomes.

Table 1. Experiment research design

Groups	Pretest	Treatment	Posttest
Experimental class	O1	Problem Based Learning assisted by Ethnomathematics-based e-modules	O2
Control class	O3	Conventional learning	O4

Treatment was carried out during four meetings with flat building materials, including the introduction of flat buildings, properties of flat, circumference, and spaciousness. After the treatment was completed, both classes were given a posttest with the same instrument.

Participants and Research Locations

This research was carried out at SD Negeri Gunungan. The subject of the study was a grade IV student. The sample consisted of two classes with a total of 60 students. The experimental class consisted of 30 students, while the control class consisted of 30 students. Class selection is carried out based on the classes that already exist at the school, so that individual students are not randomized. The experimental learning class uses the Problem Based Learning model assisted by ethnomathematics-based e-modules. The control class learns with conventional learning on the same material, namely flat building, with the same learning duration.

Learning Treatment

Problem Based Learning in the experimental class is carried out through five stages. First, students are given contextual problems related to building flat in the context of local culture. Second, students are formed in small groups to understand the problem and identify relevant information. Third, students conduct investigations using e-modules as the main guide. Fourth, students presented the results of problem solving and discussed with other groups. Fifth, students and teachers evaluate the problem-solving process and strengthen concepts. In the control class, learning is carried out conventionally. The teacher explained the material, gave examples, students did the exercises, and discussed together. The control class did not use the Problem Based Learning model or ethnomathematics-based e-modules.

Research Instruments

The main instrument in this study is the mathematics learning outcome test. The test consists of 20 multiple-choice questions arranged based on flat wake learning indicators for grade IV students. Each question has one correct answer. Correct answers are scored 1 and incorrect answers are scored 0. The total score is then converted to a scale of 0–100. The indicators measured included students' ability to identify flat buildings, determine the properties of flat buildings, calculate the circumference, calculate the area, and solve contextual story problems. The test is given twice, namely as a pretest and posttest.

Instrument Validity and Reliability

The research instrument is tested for validity and reliability before use. The validity test was carried out to determine the accuracy of each question item in measuring the indicators of learning outcomes. The validity test was carried out using product moment correlation. Question items with a correlation value greater than the r-value of the table are declared valid, while items that do not meet the criteria are corrected or deleted. The reliability of the instrument was tested using Cronbach's Alpha to determine the internal consistency of the question items. The instrument is declared reliable if the Cronbach's Alpha value is in the category that meets the eligibility standards. The higher the reliability score, the more consistent the instrument is in measuring student learning outcomes.

Data Analysis Techniques

Data were analyzed using descriptive and inferential statistics. Descriptive statistics are used to determine the minimum, maximum, average, and standard deviation values of pretest and posttest results in both classes. Before the hypothesis test was carried out, a prerequisite test was carried out in the form of a normality test to determine the distribution of data and a homogeneity test to determine the similarity of variance between groups. If the data is distributed normally and homogeneously, then a hypothesis test is carried out using the t-test (independent sample t-test).

The t-test was used to find out whether there was a significant difference between the learning outcomes of students who used the Problem Based Learning model assisted by ethnomathematics-based e-modules and students who used conventional learning. The significance level used is 0.05. If the significance value is less than 0.05, then an alternative hypothesis is accepted.

The hypothesis in this study is formulated as follows:

H_0: There was no significant difference between the mathematics learning outcomes of students who used the Problem Based Learning model assisted by ethnomathematics-based e-modules and students who used conventional learning.

H_1: There is a significant difference between the mathematics learning outcomes of students who use the Problem Based Learning model assisted by ethnomathematics-based e-modules and students who use conventional learning.

RESULT

Pretest and Posttest Results

The data of the pretest and posttest results were used to see the initial and final abilities of students in the experimental and control classes. Measurements were carried out in two groups of 30 students each. The results of the descriptive statistical calculation are presented in Table 12.

Table 2. Descriptive Statistics of Pretest and Posttest Results

Groups	Your	N	Mean	SD	Min	Max
Eksperimen	Pretest	30	61.20	7.85	45	75
Eksperimen	Posttest	30	85.40	6.92	70	98
Control	Pretest	30	60.10	8.10	42	76
Control	Posttest	30	74.30	7.55	60	90

Based on Table 2, the pretest data showed that the experimental class obtained an average score of 61.20 with a standard deviation of 7.85, a minimum score of 45, and a maximum score of 75. In the control class, the average pretest score was recorded at 60.10

with a standard deviation of 8.10, a minimum score of 42, and a maximum score of 76. The average difference between the two groups in the pretest stage was relatively small, which was 1.10 points, which shows that the initial ability of students in both classes was at a relatively comparable level before being given treatment.

In the posttest results, the experimental class obtained an average score of 85.40 with a standard deviation of 6.92, a minimum score of 70, and a maximum score of 98. Meanwhile, the control class obtained an average score of 74.30 with a standard deviation of 7.55, a minimum score of 60, and a maximum score of 90. This data shows an increase in average scores in both groups after the learning process is carried out. The average difference of the posttest between the experimental class and the control class was 11.10 points.

In addition, the distribution of data shown through standard deviation showed that the variation in the value in the experimental class was smaller than in the control class at the posttest stage. This can be seen from the standard deviation of the experimental class of 6.92, while the control class of 7.55. The range of values in the experimental class also showed a consistently higher score distribution than the initial condition before treatment.

Normality Test

Normality tests are carried out to find out whether the data from the research results are distributed normally or not. This test uses the Shapiro-Wilk method because it is suitable for a relatively small sample count, i.e. less than 50 subjects per group. The test was carried out on pretest and posttest data from the experimental class and the control class. The results of the normality test are presented in Table 3.

Table 3. Normality Test Results

Groups	**Say. (Pretest)**	**Remarks**	**Say. (Posttest)**	**Remarks**
Eksperimen	0.112	Normal	0.089	Normal
Control	0.104	Normal	0.076	Normal

Based on Table 3, the significance value of Shapiro-Wilk in the experimental class for pretest data was 0.112, while in the posttest data was 0.089. Both values are greater than 0.05 so that the data in the experimental class is declared to be normally distributed. In the control class, the significance value for the pretest was 0.104 and for the posttest was 0.076. Both values were also above the significance limit of 0.05, so the data on the control class was declared to be normally distributed. The results of the normality test showed that all research data, both in the experimental class and the control class, met the normal distribution assumption. This is indicated by the overall significance value greater than 0.05 on each measurement. Thus, the data obtained is worthy of further analysis using parametric statistical tests.

Homogeneity Test

The homogeneity test was performed to determine the similarity of variance between the experimental class and the control class. This test uses the Levene's Test as one of the prerequisite tests in parametric statistical analysis. The homogeneity test was carried out on pretest and posttest data from both research groups. The results of the homogeneity test are presented in Table 4.

Table 4. Homogeneity Test Results

Data	Sig.	Remarks
Pretest	0.438	Homogeneous
Posttest	0.391	Homogeneous

Based on Table 3, the significance value of Levene's Test in the pretest data is 0.438. The value is greater than 0.05 so that the variance of pretest data between the experimental class and the control class is declared homogeneous. In the posttest data, the significance value obtained was 0.391. This value is also greater than 0.05 so that the variance of posttest data between the two groups is declared homogeneous. The results of the homogeneity test showed that the variance of data in the experimental class and the control class had similarities. All significance values obtained are above the limit of 0.05, so that the homogeneity of variance assumption is met. Thus, the research data is eligible to be continued on the analysis of parametric statistical tests.

Hypothesis test (Independent t-test)

Hypothesis tests were carried out to determine the difference in mathematics learning outcomes between the experimental class and the control class after being given treatment. The test used an independent sample t-test on the posttest data of both groups. The results of the hypothesis test are presented in Table 5.

Table 5. Test Results t

Groups	N	Mean	t count	df	Sig. (2-tailed)
Eksperimen	30	85.40	5.12	58	0.000

Based on Table 5, the average posttest result in the experimental class was 85.40, while the control class was 74.30. The average difference between the two groups showed a clear difference in values after the treatment was given. The calculated t value obtained was 5.12 with a degree of freedom (df) 58. The test results showed a significance value (2-tailed) of 0.000. The value is smaller than 0.05 so that the test results are in the area of null hypothesis rejection. Thus, it can be stated that there is a significant difference between the students' mathematics learning outcomes in the experimental class and the control class after the application of the treatment.

N-Gain Test

The N-gain calculation is used to measure the improvement of student learning outcomes from pretest to posttest. This analysis provides an overview of the effectiveness of learning in each group. The results of the N-gain calculation are presented in Table 6.

Table 6. N-Gain Results

Groups	N	Mean Pretest	Mean Posttest	N-Gain	Category
Eksperimen	30	61.20	85.40	0.62	Height
Control	30	60.10	74.30	0.36	Medium

Based on Table 6, the experimental class obtained an average pretest score of 61.20 and a posttest score of 85.40 with an N-gain value of 0.62. The value is in the medium to high category. Meanwhile, the control class obtained an average pretest score of 60.10 and a posttest of 74.30 with an N-gain value of 0.36 which was in the medium category. These results show a difference in the level of improvement in learning outcomes between the two groups based on the calculation of N-gain. The value of the increase in the experimental class was recorded higher than in the control class.

DISCUSSION

The Problem Based Learning model assisted by ethnomathematics-based e-modules produced significant differences in the experimental class compared to the control class. Experimental classes using the Problem Based Learning model assisted by ethnomathematics-based e-modules obtained higher results than control classes using conventional learning. These findings were reinforced by a larger average posttest score in the experimental class as well as an N-gain value indicating an increase in the higher category than in the control class. This condition indicates that learning designs that integrate problem-based approaches, digital media, and local cultural contexts have a more optimal impact on improving the mathematics learning outcomes of elementary school students on flat building materials (Masruroh & Amir, 2024).

The improvement of learning outcomes in experimental classes can be explained through the main characteristics of Problem Based Learning which places students as active subjects in the learning process. In this process, students not only receive information from the teacher, but are also required to identify problems, gather relevant information, discuss alternative solutions, and draw conclusions based on the results of their own analysis. The process creates learning situations that demand a high level of cognitive engagement, particularly in terms of the analysis and synthesis of mathematical concepts (Awami et al., 2022). In flat building material, this activity allows students to not only memorize formulas, but understand the meaning of concepts through direct application in contextually given problem solving (Purnomo et al., 2019).

In addition, the use of e-modules in learning makes an important contribution to the structure and independence of student learning. The e-modules used in this study are designed systematically by containing materials, sample questions, learning activities, and exercises that are arranged gradually according to the level of cognitive development of elementary school students (Sari et al., 2024; Sutarto et al., 2022). The main advantage of e-modules lies in their flexibility which allows students to learn independently and in a guided manner (Anriana et al., 2024). Students can repeat the material as needed, deepen their understanding of the parts they have not mastered, and evaluate their learning results directly. This condition supports the process of repeatedly strengthening mathematical concepts so that learning outcomes become more stable and measurable (Putri & Junaedi, 2022).

The integration of ethnomathematics in the e-module provides a contextual dimension that strengthens the connection between mathematical concepts and the reality of students' lives (Anriana et al., 2024; Sumaji et al., 2025). In this study, the concept of flat building is associated with various phenomena that exist in the local cultural environment, such as traditional building shapes, cultural motifs, and objects around students' daily lives (Putri & Junaedi, 2022). This approach transforms the characteristics of mathematics from abstract concepts to more concrete and meaningful. When students are able to relate the subject matter to experiences they know in real life, the process of internalizing concepts becomes more effective (Gesty & Leonard, 2025). It also has an impact on increased motivation to learn because students feel that mathematics is not just an academic material, but a part of their lives.

The synergy between Problem Based Learning, e-modules, and ethnomathematics creates a learning ecosystem that strengthens each other. Problem Based Learning acts as a framework of activities that encourage students to think actively and systematically in solving problems (Tan, 2021). E-modules function as learning media that provide structured, visual, and easily accessible learning guides (Delimanugari, 2024). Meanwhile, ethnomathematics provides a real context that bridges abstract concepts with students' cultural experiences (Sutarto et al., 2022). The combination of these three components results in learning that is not only oriented to the end result, but also to the thought process that takes place in a meaningful way. This condition can be seen from the increase in learning outcomes in the experimental class which is consistently higher than the control class.

Overall, the findings of this study confirm that the integration of Problem Based Learning assisted by ethnomathematics-based e-modules is an effective learning approach in improving mathematics learning outcomes of elementary school students. This approach not only improves students' cognitive achievement, but also strengthens active engagement, learning independence, and understanding of more meaningful concepts. Thus, this learning model has the potential to be used as an alternative to mathematics learning strategies that are relevant to the needs of 21st century education, especially in the context of learning based on local culture and digital technology at the elementary school level.

CONCLUSION

This study shows that the application of the Problem Based Learning model assisted by ethnomathematics-based e-modules has a positive influence on improving the mathematics learning outcomes of elementary school students on flat building materials.

Learning that integrates problem-solving, digital media, and local cultural contexts creates a more active, meaningful, and structured learning process that can improve students' understanding of mathematical concepts more optimally than conventional learning. These findings confirm that a learning approach that connects students' real experiences with mathematical concepts through the support of learning technology can be an effective strategy in improving the quality of mathematics learning in elementary schools. Based on these results, teachers are advised to develop and implement a problem-based learning model combined with contextual e-module media so that the learning process becomes more interactive and in accordance with the characteristics of students. Schools are also expected to support the development of ethnomathematics-based teaching materials as an effort to preserve local culture as well as improve the quality of learning. In addition, further research can expand the scope of the material, increase the number of samples, and test the effectiveness of this model on the variables of high-level thinking ability or mathematical literacy so that the research results become more comprehensive and can be generalized more widely.

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