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THE EFFECT OF PROBLEM-BASED LEARNING MODEL ASSISTED BY PUZZLE MEDIA ON ELEMENTARY STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY

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ABSTRACT

The purpose of this study is to examine how students' ability to solve mathematical problems is influenced by problem-based learning (PBL) using puzzles as a teaching tool. This study adopted a quasi-experimental method using a quantitative approach with a non-equivalent control group design. A total of 48 participants were selected as the sample through purposive sampling because the selected classes had similar academic characteristics and met the criteria required for the quasi-experimental design. The assessment consisted of a written report and five essay-type questions. The experimental group obtained a mean score of 69.58, while the control group obtained a mean score of 54.04. The independent sample t-test showed a significant difference between the two groups, p-value < 0.001, with a large effect size (Cohen's d = 2.370), indicating that the Problem-Based Learning (PBL) model assisted by puzzle media had a strong positive impact on students' mathematical problem-solving abilities. Regression analysis revealed a coefficient of determination of 52.5% and a correlation coefficient of 0.700. The findings from the regression analysis confirm that the puzzle-based learning method has a significant impact, contributing more than fifty percent to the improvement of students' ability to solve mathematical problems. Thus, the main conclusion indicates that students' ability to handle numerical problems is significantly influenced and positively driven by the puzzle-assisted problem-based learning model.

Keywords: Problem-Based Learning, Puzzle, Mathematical Problem-Solving Ability

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PRELIMINARY

Mathematics plays a vital role in developing students' basic thinking skills. It is a mandatory subject taught to all students from elementary through higher education. The goal is to provide students with logical, analytical, systematic, and critical thinking skills (Wijayanti & Yanto, 2023). Mathematics instruction teaches computational skills and helps students understand and solve problems they face daily (Pitria & Kurnia, 2022). Therefore, mathematics must be taught optimally to enhance students' thinking and problem-solving abilities. The current curriculum is designed to equip students with various mathematical competencies to achieve learning objectives. Siswanto & Meiliasari (2024) support this.

They state that five criteria for mathematical ability must be met in the mathematics learning process: reasoning and proof, problem-solving, connection, representation, and communication. Among these aspects, problem-solving ability is very important because it reflects students' capacity to apply mathematical concepts and strategies in solving various problems encountered both in academic contexts an real life.

Mathematical problem-solving skills are key competencies to develop in mathematics learning. Solving mathematical problems refers to the process of applying logical thinking to find a solution to a problem (Widyastuti & Airlanda, 2021). These skills are crucial as they help students participate actively, answer questions, and tackle challenges while solving problems. They also help students solve issues in mathematics and everyday life. In addition, these skills contribute to logical thinking, better learning outcomes, and foster independent attitudes. They also prepare students to study at the next level (Astuti & Ulia, 2025; Rasmitadila et al., 2021; Susanto & Wulandari, 2024). Thus, problem-solving skills are fundamental. They should be developed from the early stages of education, supporting student success in math and daily challenges.

However, students' ability to solve math challenges remains generally low. The 2022 PISA (Program for International Student Assessment) results show that although Indonesia's ranking in mathematics and numeracy skills has improved, the mathematics score actually declined to 366 and remains far below the global average. Approximately 82% of students are below Level 2, indicating low numeracy and mathematical problem-solving skills (OECD, 2023). In line with this, research conducted by Putri & Fauzi (2025) involving 55 fourth-grade students at SD Negeri 44 Cakranegara showed that students' ability to solve mathematical problems is still considered minimal. This is evidenced by results showing that 42 out of a total of 55 students had difficulty identifying problems and understanding the concepts involved in determining the steps to solve mathematical problems.

Furthermore, research conducted by Hidayah & Andrijati (2025) on mathematics instruction regarding fractions in elementary schools still reveals quite serious problems. The findings revealed that students have difficulty solving fraction problems. This is supported by daily assessment data showing that only 40.9% of fourth-grade students achieved scores above the Learning Objective Achievement Criteria (KKTP), while the remaining 59.09% were still below the KKTP. This percentage indicates that the majority of students have not yet mastered mathematical problem-solving skills regarding fractions. This is supported by the findings of Maqbulah & Baalwi (2025), who state that students still struggle to understand fraction concepts, particularly in story-based problem-solving questions. In line with this, students also experience difficulties in the stages of implementing a plan and reviewing the problem-solving process, particularly in performing systematic calculations and drawing conclusions from the solutions(Fitriana et al., 2026). This situation indicates that the pupil's mathematical problem-solving competence regarding fractions remains in the low category.

Students' low mathematical problem-solving skills are influenced by several factors, one of which is their lack of practice in solving problems that require higher-order thinking skills; as the problems given in classroom instruction are still dominated by questions that measure only basic thinking skills (Sulistifa et al., 2025), low motivation to learn, the emergence of anxiety in mathematics learning, and a lack of support from the learning environment (Tanjung, 2025). The mathematical problem-solving proficiency of the learners can be shaped by elements such as self-efficacy and adversity quotient. Students who are confident and able to persevere in the face of challenges tend to be more successful in solving mathematical problems (Ahmad & Dewi, 2024). Furthermore, classroom learning tends to be passive and is not sufficiently supported by the implementation of appropriate instructional models, particularly in mathematics education (Fitriyani et al., 2026). Therefore, to address these challenges, an instructional model is needed that can encourage active student participation and foster resilience in overcoming difficulties when solving mathematical problems.

An alternative approach to addressing these challenges is to implement a learning model that encourages active student engagement and provides gradual challenges to develop confidence and resilience in learning mathematics. Adopting the Problem-Based Learning (PBL) framework can be a highly successful method for advising students' skills in tackling mathematical problem-solving. Problem-Based Learning (PBL) is a teaching approach that positions students as active participants throughout the learning process. This model motivates students to think critically and systematically, and improves their ability to identify, analyze, and solve the problems they face (Meilasari & Yelianti, 2020). The PBL model encourages students to collaborate with one another in addressing the problems presented. Through such collaboration, students' critical thinking skills can develop more effectively (Tiara, 2024). This result is backed by empirical evidence presented by Supriono et al (2023), which revealed that the mean post-test performance of the treatment class using the PBL reached 83.82, exceeding that of the control class that implemented expository learning, which obtained an average of 78.97. Consequently, these findings demonstrate that the PBL model has a more significant impact on improving students' mathematical problem-solving skills.

In addition to instructional models, there are several other factors that can influence mathematical problem-solving skills, one of which is the use of engaging teaching materials. This is supported by Setyawardani & Edy (2024) who states that learning media need to be provided to support the implementation of this learning model in order to achieve a conducive learning atmosphere and optimal learning outcomes. This study uses puzzles as a tool in the implementation of the PBL model in mathematics instruction. Puzzles are a type of game involving assembling pieces or matching images that require thinking skills, knowledge, and problem-solving abilities (Nurfitriani, 2024). The use of puzzle teaching aids in mathematics learning can transform abstract concepts into more concrete ones. Through puzzles, students have the opportunity to observe, handle, and manipulate objects, making the thinking process more tangible and aiding in understanding the material (Lewi, 2025). Thus, the use of puzzles in mathematics learning can be utilized as an effective tool for training and enhancing mathematical problem-solving skills.

Based on the background described above, there is a need for a learning model that not only emphasizes the delivery of content but also engages students in mathematical thinking and problem-solving processes. This study has great potential to strengthen students' ability to tackle mathematical challenges, given that the PBL approach facilitates students' understanding of problems, the development of strategic solutions, and the evaluation of results. The distinctive contribution offered by this research is centered on merging the Problem-Based Learning (PBL) model alongside puzzle media in mathematics learning, which is expected to support the improvement of students' ability to solve mathematical problems. Previous studies generally used puzzle media only to aid in the understanding of mathematical concepts. Therefore, although the PBL model and puzzle media are frequently used in mathematics education. Although both have been widely studied separately, research investigating their integration in mathematics learning is still relatively limited. Therefore, this study was conducted to examine the effectiveness of implementing the PBL model supported by puzzle media in improving elementary school students' mathematical problem-solving abilities.

METHODS

This study employs an experimental research design. An experimental study is a research approach aimed at observing and measuring the effects of a treatment or intervention on related variables (Arib et al, 2024). The research design adopted in this study employs a quasi-experimental methodology that includes a non-equivalent control group. In this design, the research subjects are divided into two distinct groups to facilitate comparison of the results. The first group is given a specific treatment that is the focus of the study (experimental group), while the second group does not receive this treatment and serves as the control group (Saputri & Mardiati, 2025). In this study, the experimental class is the class that receives the treatment in the form of learning using the Problem-Based Learning (PBL) model combined with puzzle media. Meanwhile, the control class employed the Think-Pair-Share (TPS) model. The TPS model was chosen as a comparison because it is one of the cooperative learning models frequently used in mathematics instruction. The non-equivalent control group design is illustrated in Figure 1.

$$\frac{O_1 \quad X \quad O_2}{O_3 \qquad\quad O_4}$$

Figure 1. Non-equivalent Control Group Design

Description:

O1, O2 = Pre-tests for the experimental and control groups

X1 = Use of the PBL model aided by puzzle media

O3, O4 = Post-tests after the treatment

The researchers carried out this investigation at a primary institution located in the Purwakarta region, specifically at SDN 1 Ciseureuh, with fourth-grade students from classes 4 A and 4 B as the research subjects. Each class had 24 students. In this study, class 4 B was selected to receive the treatment group, whereas class 4 A functioned as the comparative group using a purposive sampling technique. Data collection was conducted through two methods: test and documentation to support the research. Tests were administered to students utilizing a pre-test and post-test design, each consisting of 5 open-ended questions based on indicators of mathematical problem-solving ability proposed by Polya, which include understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Documentation was also utilized as supporting data throughout the research process. Before use, the test instruments were first pilot-tested to assess their suitability, particularly regarding validity and reliability. The results are presented in Table 1.

Table 1. Instrument Validity Results

No question	Correlation	Interpretation
1	0.914	Very High
2	0.905	Very High
3	0.928	Very High
4	0.899	Very High
5	0.918	Very High

Table 1 shows that the correlation coefficients for each item range from 0.899 to 0.928. By considering the interpretation criteria, all the test items show a very high level of validity. Therefore, this tool is considered suitable and valid for assessing students' ability to solve mathematical problems. The next step was to analyze the reliability of the instrument.

Table 2. Reliability Test Results of Test Items

Results of Instrumen Reliability Test	Correlation	Description
0.95	Very High	Excellent

The results of the reliability evaluation show that the test tool for mathematical problem-solving ability has a coefficient of 0.95, which falls into the Very High category. Thus, the tool has a good level of consistency and is suitable for use as a means of data collection in research. After all data were collected, preliminary analysis was conducted using prerequisite tests, including normality and reliability tests. Subsequently, the analysis continued with an independent samples t-test in order to evaluate differences in mathematical problem-solving skills across the two classes. Although an independent sample t-test is commonly used to compare two groups, this study also employed simple linear regression analysis to determine the effect of the learning model on students' mathematical problem-solving ability. The learning model was represented in a coded form to enable regression analysis. This approach was used to provide additional information regarding the magnitude and direction of the effect, complementing the results of the difference test. The computational data analysis was facilitated through the use of IBM SPSS Statistics version 27.

RESULT AND DISCUSSION

Students' ability to solve mathematical problems in this study was analyzed using Polya's problem-solving indicators, which consist of understanding the problem, devising a solution, implementing the plan, and checking the final result. Based on these indicators, information from pre- and post-tests across the treatment and comparison groups was analyzed in order to provide an overview of the learners' mathematical problem-solving skills. To provide an enhanced, clearer picture regarding the data, a descriptive analysis was conducted, which encompassed metrics such as the average, highest, and lowest scores, along with the standard deviation. The descriptive statistics are presented in Table 3, which outlines the outcomes associated with this descriptive analysis.

Table 3. Descriptive Statistics Results

Class	**Type**	**Skor**		***Mean***	***sd***
		Min	**Max**		
Experiment	*Pre-test*	25	45	34.08	6.338
	Post-test	59	80	69.58	6.121
Control	*Pre-test*	23	42	32.25	5.503
	Post-test	43	68	54.04	6.969

Table 3 shows a significant and prominent shift regarding how the experiment group individuals performed in solving mathematical problems before and after the intervention. Pre-intervention scores ranged from 25 to 45, reporting a mean value of 34.08 alongside a standard deviation equivalent to 6.338. Following the execution of the intervention, the dataset shifted from 59 to 80, yielding a mean of 69.58 paired with a standard deviation of 6.121. These results indicate that the participants' problem-solving skills improved significantly. On the other hand, the control cohort group recorded a mean baseline value of 32.25 on the pre-test and increased to 54.04 on the post-test. The comparative analysis of the two groups' performance showed that the average scores increased in both learning environments. However, the increase was more significant within the treatment cohort than within the comparison group.

Furthermore, before conducting the hypothesis test, statistical analyses were carried out to evaluate the statistical hypotheses, and the Shapiro-Wilk method was utilized to execute a normality check, primarily to assess the distribution of the data for this research. Table 4 details the outcomes of this distribution analysis.

Table 4. Pre-test and Post-test Normality Results

Class	***Shapiro-Wilk***		
Experiment		*Pre-test*	*Post-test*
	Statistic	0,946	0,951
	Df	24	24
	p-value	0,222	0,289
Control	*Statistic*	0,962	0,975
	Df	24	24
	p-value	0,485	0,789

As shown in Table 4, the significance values obtained from the results of the pre-test and post-test for the experimental group and the control group were higher than 0,05. These results show that the data from both groups followed a normal distribution. Accordingly, the normality assumption for all research data was considered fulfilled. This requirement also allowed the analysis to proceed to the subsequent stage, namely the homogeneity test. The table below shows the results of the homogeneity test.

Table 5. Variance Homogeneity Testing Across Experimental and Control Groups

Data	Sig.	Interpretation
Pre-test Analysis of Experimental and Control Classes	0.384	Homogen
Post-test Analysis of Experimental and Control Classes	0.480	Homogen

Referring to Table 5, the homogeneity test results indicate that the significance level of the pre-test data from both groups had a significance value of 0.384. The value being above 0.05 suggests that the pre-test data met the homogeneity assumption. This is also supported by the post-test data, which obtained a significance value of 0.480.The findings indicate that the final assessment data in both groups had homogeneous variances. In addition, the initial and final assessment data of the treatment and comparison groups fulfilled the assumption of homogeneity. Consequently, the requirements for parametric statistical analysis were satisfied.

Once the assumptions were met, the analysis was conducted using an Independent t-Test to measure differences in mathematical problem-solving ability following the intervention. The following is a presentation of the test results.

Table 6. Data Derived from the Independent Sample t-Test Analysis

Data	*Sig. (2-tailed)*	α	Description
Pre-test Results for the Experimental Class and the Control Class	0.290	0,05	There is no difference

Table 6 presents a significance value of 0.290, which exceeded 0.05. This statistical finding confirms the acceptance of H0 while simultaneously rejecting H1. This means that the average pre-test scores between the experimental and control groups do not have a significant difference. Thus, it can be concluded that the initial proficiency in mathematical problem-solving processes of the students in both classes is at a balanced level. Furthermore, the analysis could proceed by comparing the final assessment data of the treatment and comparison groups to identify differences after the treatment was applied. To further evaluate the students' mathematical problem-solving proficiency, the post-intervention outcomes from both classes were analyzed using an independent sample t-test.

Table 7. Post-test Outcomes Analyzed Using the Independent t-Test

Data	*Sig. (2-tailed)*	α	Description
Post-test Results for the Experimental and the Control Class	< 0.001	0.05	There is a difference

The p-value for the follow-up data in the entirety across both the treatment and comparison cohorts was less than 0.001, meaning it fell below the statistical significance level of α = 0.05. These metrics point to a variance separating the post-intervention mean scores of both groups. In addition, the effect size was classified as large (Cohen's d = 2.370), indicating that the intervention had substantial practical significance. Therefore, students who applied the problem-based learning (PBL) model supported by puzzles achieved better results in solving math problems compared to the control group.

The analysis was further conducted using a simple linear regression test to examine how the PBL (Problem-Based Learning) approach shapes the mathematical problem-solving proficiency of the learners. The findings of the regression analysis are detailed in Table 8.

Table 8. Outcomes of the Linear Regression Analysis

Model	*Unstandardized Coefficients*	
	β	***Std. Error***
Constant	45.719	4.914
Problem-Based Learning (PBL) Model	0.700	0.142

Based on a simple linear regression model, the corresponding statistical equation is outlined as follows:

$$\hat{Y} = \alpha + \beta X$$
$$\hat{Y} = 45{,}719 + 0{,}700X$$

Table 8 shows that the constant is 45.719 and β (the regression coefficient) is 0.700. A positive coefficient indicates a linear relationship between the Problem-Based Learning (PBL) model using puzzle media and the dependent variable. This indicates that executing the puzzle-enhanced Problem-Based Learning (PBL) framework is positively related to students' mathematical problem-solving ability, as indicated by the regression coefficient of 0.700.

Furthermore, to identify the magnitude of the contribution provided by the Puzzle-Assisted Problem-Based Learning approach, the study applied the R^2. This statistical value reflects the degree to which the PBL method shapes mathematical problem-solving capabilities. The outcomes generated from this determinative evaluation are detailed in Table 9.

Table 9. Coefficient of Determination Results

R	R Square	Std. Error of the Estimate
0.725^a	0.525	4.311

Data from the coefficient of determination evaluation reveals an R-squared score of 0,525, as outlined in Table 4. The procedural calculation for this metric relies on the subsequent formula.

$D = R^2 \times 100\%$

$D = 0{,}525 \times 100\%$

$D = 52.5\%$

The analysis produced an R^2 value of 0.525, which corresponds to a coefficient of determination of 52.5%. Consequently, the data reveals that deploying the PBL approach alongside puzzle tools is responsible for a 52.5% contribution of sudents mathematical problem-solving ability. The remaining 47.5% is attributable to external variables not examined within the parameters of this research. Accordingly, the PBL model assisted by puzzle media yields a profound outcome on students' mathematical problem-solving aptitude. Nevertheless, optimizing this skill also relies on external determinants excluded from this specific scholarly inquiry.

The gathered data clearly demonstrates that utilizing a puzzle-mediated Problem-Based Learning (PBL) framework successfully guides and elevates the learners' problem-solving skills. Regression analysis produced a beta coefficient equating to 0.700 and established a determination index of 52.5%, and the results of the independence test showed a p-value of < 0.001. These findings indicate that a problem-based learning (PBL) approach utilizing puzzle-based instructional materials influences 52.5% of students' skills in solving mathematical problems. The current outcome corresponds with the investigation carried out by Guntur et al (2025), establishing that implementing a problem-based learning (PBL) design exerts a favorable impact on students' ability to solve mathematical problems. This finding is supported by the research of Safirah & Abdillah (2024), indicating that the implementation of a Problem-Based Learning (PBL) model successfully empowers learners to resolve mathematical problems with heightened efficacy.

The adoption of a Problem-Based Learning framework serves to motivate learners toward comprehending problems and seeking solutions. During this process, students learn to identify problems, develop a plan of action, implement the plan, and evaluate the results. This learning activity encourages students to actively participate in every step of the problem-solving process, thereby helping them build understanding and develop appropriate solution strategies. This learning process aligns with the results of this research, which shows that students who engage in PBL with the aid of puzzle media have better mathematical problem-solving skills compared to those who use the think-pair-share cooperative model. Thus, these steps assist the students in improving and strengthening their mathematical problem-solving competence. The findings of Irkham & Sutriyani (2025) support the premise that a Problem-Based Learning (PBL) approach supports students in finding solutions, while also helping to create a more focused learning process, helping students understand the steps to solve problems, particularly in word problems. Furthermore, Putriana & Fajriyah (2023) argue that integrating a Problem-Based Learning (PBL) strategy gives students opportunities to gain hands-on learning experiences, such as collaborating in groups, gathering relevant information, seeking solutions to given problems, and presenting the results of problem-solving. Students' active involvement in learning makes the learning process more meaningful and helps them find solutions to problems in a more focused manner. Therefore, the implementation of the PBL model assisted by puzzle media can develop the learners' mathematical problem-solving proficiency.

Integrating educational puzzles throughout instructional activities is capable of influencing students' competence in solving mathematical problems. By utilizing puzzle media, students can recognize and categorize information related to equivalent fraction problems, thereby helping them understand the context of the issues. This is in line with the opinion of Suryani et al. (2023), who state that puzzle media can increase students' learning motivation, making them more enthusiastic and capable of solving problems in a more creative way. Through the use of puzzles, students can observe, try various possibilities, and discover relationships between fractions. Fausta et al. (2026) state that puzzle media can provide students with the opportunity to explore and reflect on their understanding, making learning more active and not one-sided. Puzzle media can also help students formulate plans by arranging puzzle pieces that fit the context of the problem. The current outcome highly corresponds to what was reported by Indah et al (2025), who state how incorporating puzzle-based media can foster the learners' creativity, critical thinking, and cognitive abilities. Therefore, the implementation of a problem-based learning model with the help of puzzle media can have a positive impact on mathematical problem-solving skills.

CONCLUSION

Research findings reveal that the problem-based learning (PBL) approach influences students' ability to solve mathematical problems. This is evident from the independent samples t-test findings, a p-value below 0.001, indicating that students in the experimental and control groups have different levels of mathematical problem-solving skills. Furthermore, regression analysis revealed that the PBL approach explained 52.5% of the variance in students' mathematical problem-solving skills. Thus, the implementation of the PBL approach produces more favorable outcomes in improving students' ability to solve mathematical problems.

Analysis of the evaluation reveals that incorporating the Problem-Based Learning (PBL) approach through puzzles elevates students' mathematical problem-solving skills by 52.5%, while other factors influence the remaining 47.5%. Future research should investigate these other factors to gain clearer insights into what supports students' abilities in solving mathematical problems.

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