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The Effect of Problem-Based Learning on Students' Critical Thinking and Learning Motivation in Mathematics at the Fifth Grade of Elementary School

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ABSTRACT

This research is motivated by the low critical thinking skills and learning motivation of students in mathematics learning which is still dominated by conventional methods. The purpose of this study is to examine the effect of the Problem-Based Learning (PBL) model on the critical thinking skills and learning motivation of elementary school students. The research design used was a quasi-experimental with a Nonequivalent Control Group Design using a saturated sample technique, thus involving 52 fifth grade students. The research instrument consisted of a critical thinking skills test and a learning motivation questionnaire. Data were analyzed using Multivariate Analysis of Variance (MANOVA). The results showed that the implementation of PBL had a significant effect on both variables, with a significance value of 0.000 (<0.05), F = 12.37, and an effect size (partial eta squared) of 0.42 which is included in the medium-strong category. The average critical thinking score of students in the experimental group reached 144, higher than the control group (135). Similarly, the learning motivation score of students in the experimental group (158) exceeded the control group (137). Thus, PBL has been proven effective as a mathematics learning strategy in elementary schools because it is able to improve critical thinking skills as well as students' learning motivation.

Keywords: *problem-based learning, critical thinking skills, learning motivation, mathematics education, elementary school*

ABSTRAK

Penelitian ini dilatarbelakangi oleh rendahnya keterampilan berpikir kritis dan motivasi belajar siswa pada pembelajaran matematika yang masih didominasi metode konvensional. Tujuan penelitian ini adalah menguji pengaruh model Problem-Based Learning (PBL) terhadap keterampilan berpikir kritis dan motivasi belajar siswa sekolah dasar. Desain penelitian yang digunakan adalah kuasi-eksperimen dengan Nonequivalent Control Group Design menggunakan teknik sampel jenuh, sehingga melibatkan 52 siswa kelas V. Instrumen penelitian terdiri atas tes keterampilan berpikir kritis dan kuesioner motivasi belajar. Data dianalisis menggunakan Multivariate Analysis of Variance (MANOVA). Hasil penelitian menunjukkan bahwa penerapan PBL berpengaruh signifikan terhadap kedua variabel, dengan nilai signifikansi 0,000 (<0,05), F = 12,37, dan ukuran efek (partial eta squared) sebesar 0,42 yang termasuk kategori sedang-kuat. Rata-rata skor berpikir kritis siswa pada kelompok eksperimen mencapai 144, lebih tinggi dibandingkan kelompok kontrol (135). Demikian pula, skor motivasi belajar siswa pada kelompok eksperimen (158) melampaui kelompok kontrol (137). Dengan demikian, PBL terbukti efektif sebagai strategi pembelajaran matematika di sekolah dasar karena mampu meningkatkan keterampilan berpikir kritis sekaligus motivasi belajar siswa.

Kata kunci: pembelajaran berbasis masalah , kemampuan Berpikir kritis , motivasi belajar , pendidikan matematika , sekolah dasar

INTRODUCTION

The 21st century demands that students master higher-order thinking skills, particularly critical thinking, and possess strong learning motivation to face global challenges (Anggita, 2025; Arigawati & Kusnandi, 2023; Pamalah et al., 2025). In the context of elementary school mathematics learning, these two aspects are not only benchmarks for academic success but also determine the quality of learning oriented toward future needs. Therefore, critical thinking skills and learning motivation should be viewed as core competencies that must be developed from the elementary school level.

However, observations and preliminary studies at SDN 20 Indarung indicate that students' critical thinking skills and learning motivation remain below 40%. This data was obtained through a standardized questionnaire that measures four indicators of critical thinking (interpretation, analysis, evaluation, inference) and six indicators of learning motivation (desire to achieve, drive to learn, future aspirations, appreciation, engaging activities, and a conducive learning environment). This situation underscores the need for learning innovations that can foster active participation and enhance these skills. Without appropriate intervention, this low achievement is at risk of continuing and negatively impacting the overall quality of mathematics learning.

One strategy considered relevant is Problem-Based Learning (PBL). Rooted in constructivist theory, PBL positions students as active learning subjects, encouraging self-

directed learning, collaboration, and the development of intrinsic motivation and critical thinking skills (Kartikasari et al., 2021; Salsabila & Asih, 2024; Syahrizal & Jailani, 2023). Through contextual problems, students are required to analyze information, evaluate alternatives, and generate solutions, making learning more meaningful. In other words, PBL functions not only as a method but also as an approach that reorients learning toward student-centered learning.

With this framework, PBL is seen as having a direct relationship with the indicators examined in this study. The investigation and discussion processes in PBL contribute to the development of interpretation, analysis, evaluation, and inference skills. Meanwhile, teamwork, curiosity, and experience solving real-life problems have the potential to strengthen learning motivation indicators such as the desire to achieve, appreciation, and the drive to continue learning. This makes PBL a learning model capable of meeting the demands of simultaneously mastering cognitive and affective skills.

Several studies support the effectiveness of PBL. For example, (Anisa, 2024; S. Mayasari, 2025; Pratiwi & Setyaningtyas, 2020) demonstrated that PBL improves students' critical thinking skills. Meanwhile, (Merritt et al., 2017; Septyan & Kuswanto, 2025) demonstrated that PBL can increase learning motivation through active engagement and group work. Thus, PBL has the potential to be an appropriate strategy to address the challenges of mathematics learning in elementary schools. Furthermore, the combined results of these studies demonstrate consistency of findings, while also strengthening the need for further research in more specific contexts.

However, previous research has been conducted primarily at the secondary and tertiary levels and has focused on general learning outcomes, rather than on the integration of critical thinking skills and learning motivation simultaneously (Azura et al., 2024; A. Mayasari et al., 2022; Saputri, 2020). The use of PBL at the elementary school level, particularly in mathematics learning, remains relatively rare. This gap highlights the need for more context-specific research. Therefore, this study occupies an important position in the literature as it fills the gap between theory, practice, and basic learning needs.

Therefore, this study aims to analyze the effect of problem-based learning on critical thinking skills and mathematics learning motivation of fifth-grade students at SDN 20 Indarung. This study used a quasi-experimental Nonequivalent Control Group design with MANOVA analysis, which is relatively rarely applied at the elementary school level (A. Mayasari et al., 2022; Sagita & Ikashaum, 2023; Shanti et al., 2017). The research findings are expected to not only strengthen the theoretical basis of PBL but also provide practical recommendations for educators and policymakers in improving the quality of mathematics learning according to the demands of the 21st century. Thus, the results of this study have both academic and practical relevance for the development of elementary education.

METHOD

Types and Design of Research

This study used a quantitative approach with a quasi-experimental design. The chosen design was a Nonequivalent Control Group Design, which involves two groups without full randomization. This design was chosen based on the limitations of student randomization practices in formal schools, so class assignments were based on existing class divisions. With this design, researchers could still compare the effects of treatments even though field conditions did not permit pure randomization.

The experimental group received problem-based learning (PBL), while the control group received Direct Instruction (DI). The main difference between these two methods is active student involvement: PBL emphasizes identifying and solving real-world problems, while DI emphasizes direct teacher explanations. This design was chosen to test the extent to which PBL can improve students' critical thinking skills and learning motivation compared to conventional methods.

Table 1. Research Design

Class Example	Pre-exam	Treatment	Posttest (Final Exam)
Test	O_1	X	O_2
Control	O_3	–	O_4

Source: Sugiyono (2012:79)

Description: X is the treatment given to the experimental class in the form of the Problem Based Learning (PBL) learning model. O_1 is the pretest of critical thinking skills and learning motivation of students in the experimental class before using the PBL model, while O_2 is the posttest of critical thinking skills and learning motivation of students in the experimental class after using the PBL model. O_3 is the pretest of critical thinking skills and learning motivation of students in the control class before using the conventional learning model, while O_4 is the posttest of critical thinking skills and learning motivation of students in the control class after using the conventional learning model.

Data and Data Sources

This research was conducted in the odd semester of the 2024/2025 academic year at SDN 20 Indarung with a population of all fifth-grade students totaling 52 people, divided into two classes: VA (26 students) and VC (26 students). Due to the relatively small population, a saturated sampling technique was used so that all students were included in the research sample. Class VA was designated as the control (DI method), while class VC was designated

as the experiment (PBL model). The material taught was the same, namely fractions according to the fifth-grade curriculum, with the intervention lasting four meetings.

Research Instruments

The research instrument consisted of two main parts: First, a critical thinking test in the form of descriptive questions based on five indicators: providing a simple explanation, providing reasons, drawing conclusions, providing further explanations, and developing problem-solving strategies. The test consisted of 10 questions with a scoring scale of 0–4. Content validity testing was conducted by three mathematics education expert lecturers, while the reliability test (Cronbach's Alpha) of 0.87 indicated high reliability. Second, a learning motivation questionnaire in the form of a 4-point Likert scale (1 = strongly disagree to 4 = strongly agree) with 30 statements. Indicators included perseverance, tenacity in the face of difficulties, interest, independence, and the tendency to find and solve problems. The item validity test showed that most of the statements were valid, and the instrument reliability reached 0.89 (very good category).

The description of this instrument serves as the main reference, while the data collection techniques section only explains its use without repeating the full details.

Data collection technique

Data collection is carried out through several stages:

1. A pretest was given to both groups before treatment, to determine the initial ability of critical thinking skills and learning motivation.
2. The learning intervention was carried out in four meetings: the experimental group used the PBL model, while the control group used the DI method.
3. The posttest was given after the intervention in the form of a critical thinking test and a learning motivation questionnaire.
4. Observations were conducted throughout the intervention to monitor the implementation of lesson plans, student activity, questioning, and group collaboration. The observation instrument used a sheet validated by educational experts.

Documentation is used as supporting data in the form of student attendance lists, lesson plans, activity photos, and learning notes. Documentation serves to supplement primary data and is analyzed descriptively to provide a contextual overview.

Data analysis

Data were analyzed using Multivariate Analysis of Variance (MANOVA) to examine the simultaneous influence of the PBL model on students' critical thinking skills and learning motivation. The analysis was conducted using the latest version of SPSS. Prerequisite tests were conducted before MANOVA, including normality (Kolmogorov-Smirnov), homogeneity (Levene's Test), and multicollinearity (Tolerance & VIF).

Research Limitations

Despite the careful design of the study, several limitations exist. First, the relatively small sample size (52 students) makes the results difficult to generalize to the broader population. Second, the intervention lasted only four sessions, which limits the measurement of long-term effects. Third, learning motivation was measured using a self-report questionnaire, which is susceptible to social bias. Fourth, although the same teacher taught both groups (a good internal control), the study does not fully address the potential effects of teacher expectations on student outcomes.

RESULTS AND DISCUSSION

This study aims to determine the impact of implementing the Problem-Based Learning (PBL) model on students' critical thinking skills and learning motivation compared to direct learning. Both groups of students, class VC (experimental) and VA (control), studied fractions but with different approaches. Posttest results showed significant differences in the average scores of critical thinking skills and learning motivation, as shown in the following table:

Table 1: Posttest Results of the Experimental and Control Groups on Learning Motivation and Critical Thinking Skills.

Value	Critical Thinking Skills		Motivation to learn	
	Control	Exsperiment	Control	Exsperiment
Highest	173	139	169	167
Lowest	114	99	146	115
Average	144	135	158	137

With an average posttest score of 144 for the experimental class and 135 for the control class, Table 1 shows that the experimental class performed better than the control class in terms of critical thinking skills. Furthermore, the average learning motivation score of the experimental class was 158, which was higher than the average score of 137 for the control group.

The highest score indicates that the critical thinking ability of the experimental class peaked at 173, while the control group was only 139. The experimental class scored 169 on the learning motivation scale, compared to 167 in the control group. For the lowest score, the critical thinking ability of the experimental class was at the lower limit, namely 114, while the control class was lower, namely 99. The experimental class had the lowest learning motivation score (146), while the control group had a lower score (115).

Furthermore, the MANOVA test yielded a significance value of 0.000 (<0.05) with an F value of 12.37 and a partial eta square of 0.42, indicating a moderate-strong effect of PBL implementation on both variables. These findings confirm that PBL provides a substantial

contribution to improving students' critical thinking skills and learning motivation. In addition, the highest scores achieved by students in the experimental class were consistently higher than the highest scores of the control group, indicating that the benefits of PBL are not only limited to the average but also to the distribution of individual achievements.

The integration of these results can be seen in the following figure which shows the trend of differences in achievement between the experimental group and the control group.

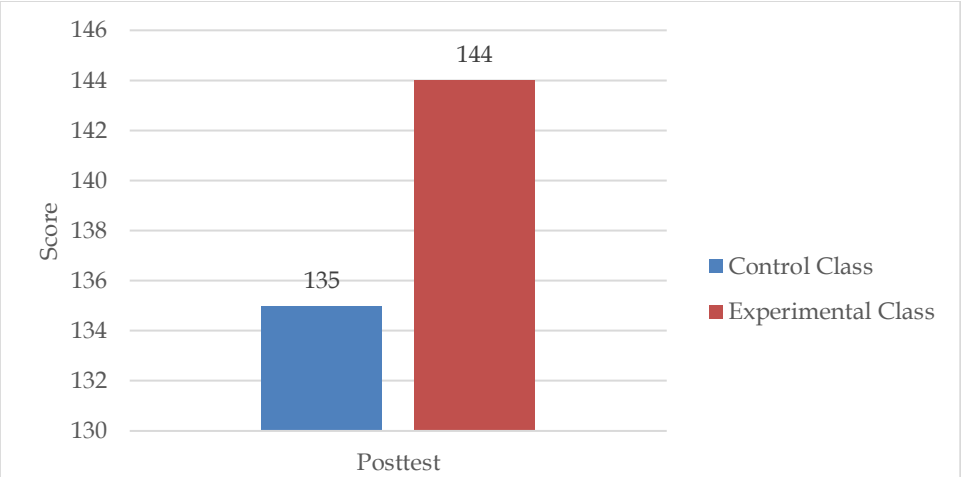

Figure 1: Posttest Graph of Critical Thinking Skills of Control Class and Experimental

Figure 1 shows a clear difference between the experimental and control classes in critical thinking skills, with the experimental class achieving a higher average score. This finding supports the view (Kusumawati et al., 2022; Sani & Ambarwati, 2024; Wijnia et al., 2024) that PBL encourages students' active engagement in solving challenging real-world situations, thereby enhancing higher-order thinking skills. Furthermore, PBL enables students to develop logical, analytical, and reflective thinking skills while participating in problem-solving (Abdurrahman et al., 2021; Elsa, 2023; Safitri et al., 2023). Thus, it can be concluded that the implementation of PBL significantly contributes to strengthening students' critical thinking skills. The following are the findings from the learning motivation posttest for both classes:

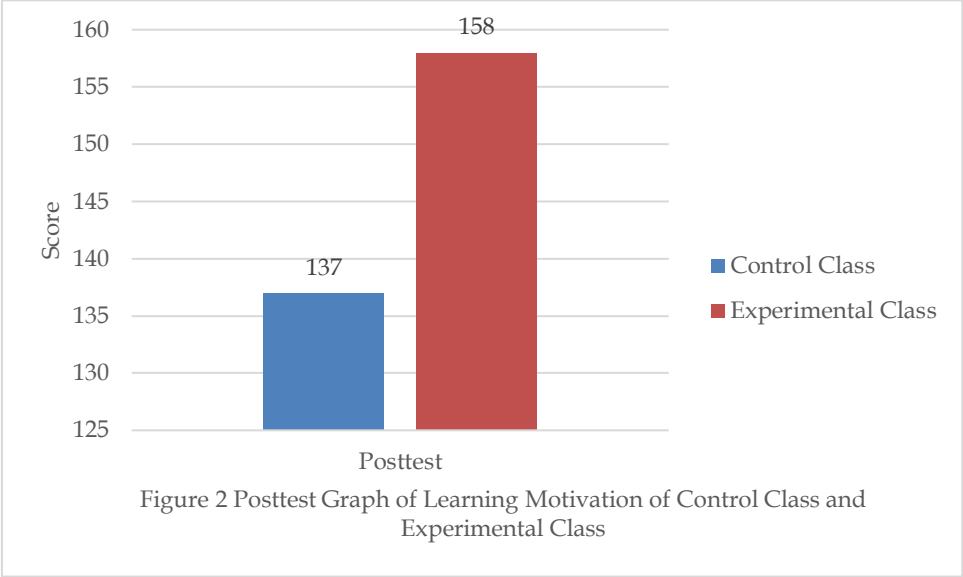

Figure 2 Posttest Graph of Learning Motivation of Control Class and Experimental Class

As seen in Figure 2, the average posttest score for student learning motivation in the experimental class (158) was higher than that of the control group (137). These results indicate that the implementation of PBL was able to significantly increase student learning motivation, characterized by their involvement, enthusiasm, and active participation in learning, in contrast to the control group which tended to be passive.

Theoretically, these findings are consistent with the constructivist approach, which views students as active subjects in constructing knowledge through meaningful experiences (Azura et al., 2024; Lin et al., 2023; Salsabila & Asih, 2024). This is also in line with research by (Astriani et al., 2017; Siregar, 2023; Zakaria et al., 2023) in elementary school science learning, which showed that PBL fosters student curiosity and engagement. However, in contrast to the results of (Nafiah, 2025; Neevitha et al., 2025; Subarjo, 2025) in secondary language learning, the increase in motivation in the elementary school mathematics context was stronger, as students responded positively to concrete problems relevant to their lives. This difference confirms the contribution of this study in strengthening the evidence of the effectiveness of PBL in the realm of elementary mathematics, which is still rarely explored.

While supporting the effectiveness of PBL, this study has limitations. First, it was conducted in only one school with a limited sample size, requiring caution when generalizing. Second, the intervention was short (four meetings), so it does not reflect long-term impact. Third, the measurement of motivation using a self-report questionnaire is potentially influenced by social bias.

Practically, these results recommend that elementary school mathematics teachers begin integrating PBL gradually, tailored to the local context and resource support. Teacher training is also crucial for effective implementation. For further research, longitudinal studies covering

a wider range of schools and the use of digital technology in PBL could be potential future directions.

CONCLUSION

The results of this study indicate that the implementation of the Problem-Based Learning (PBL) model significantly improves the critical thinking skills and learning motivation of elementary school students. The data show that the experimental class obtained an average critical thinking score of 144, higher than the control class (135), as well as learning motivation with an average of 158 compared to 137 in the control group. MANOVA analysis confirmed these findings with a significance value of 0.000 (<0.05), F = 12.37, and an effect size (partial eta squared) of 0.42, reflecting a moderate-strong effect. Thus, the recommendation for the implementation of PBL is supported by empirical evidence, not merely normative assumptions.

Theoretically, this study contributes to the strengthening of constructivist theory by confirming that PBL provides space for students to construct knowledge through contextual problem-solving. These findings also support self-determination theory, as active engagement in learning has been shown to increase students' intrinsic motivation. This contribution broadens understanding of the effectiveness of PBL in elementary school contexts, particularly in mathematics learning, which remains relatively underexplored.

Practically, the results of this study can serve as a reference for teachers and policymakers in elementary education. Teachers are advised to integrate PBL gradually, tailored to classroom conditions and school resources, for example, through the use of contextual problems on fractions. Teacher training and institutional support are crucial factors in ensuring effective PBL implementation.

However, this study has limitations. First, the sample size was limited to two classes from one elementary school, so generalization of the findings should be done with caution. Second, the intervention was short, lasting only four sessions, so it may not reflect long-term effects. Third, the motivation measurement was based on a self-report questionnaire, which is susceptible to social bias. Future research is recommended to use a longitudinal design with a wider school coverage and incorporate various measurement instruments, including observation and digital technology, to provide a more comprehensive picture of the effectiveness of PBL.

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