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The Effectiveness of Problem-Based Learning on Problem-Solving Skills in Elementary Schools: A Multidimensional Study

Lailatul Karimah, Baihaqi Siddik Lubis*
Department of Elementary School Teacher Education, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia

*Correspondence to: *baihaqisiddik@umsu.ac.id*

Abstract: This study examines the effect of the problem-based learning approach on primary school students' problem-solving abilities. This research investigates the extent to which the problem-based learning model affects primary school students' problem-solving abilities, with a special focus on its factors. This quantitative study uses a sample of 42 students and employs an exhaustive sampling approach and an experimental research design. We analyzed students' problem-solving ability using a validated and reliable assessment. The researcher used the Mann-Whitney U test to compare the inquiry learning model in the control group with the problem-based learning model in the experimental group. The findings indicate that students in the experimental group have enhanced problem-solving abilities compared with those in the control group. The problem-based learning model did not markedly improve students' problem-solving skills in analysis, assessment, and invention compared with the inquiry learning model. Consequently, to achieve better results, it is important to use innovative learning implementation strategies and additional methods.

Keywords: *Problem-based learning; problem-solving skills; inquiry-based learning; elementary school*

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INTRODUCTION

Problem-solving skills are crucial for learning in the twenty-first century. This skill is essential for cultivating a systematic and analytical mindset. Students' survival and future success depend heavily on their proficiency in effective problem-solving (Mahanal et al., 2022; Nguyen et al., 2024; Riyadi et al., 2021; Yeh & Fu, 2025). Students with problem-solving skills are better able to address the challenges that commonly arise in their social lives. Students can utilize these skills to identify their requirements and devise innovative solutions to meet them (Erol, 2024;Kwangmuang et al., 2021). Several studies suggest that this cultivates students' creativity, changes their environment and behavior, and improves their ability to address and solve problems in their surroundings (Mangaroska et al., 2022; Ramadhani et al., 2023). Consequently, to ensure that students not only grasp concepts but also apply them effectively across many contexts, the cultivation of problem-solving skills must be included in learning through a method that encourages engagement and exploration (Sari, 2026).

Problem-solving skills involve the capacity to recognize problems, devise solutions, assess alternatives, and execute the optimal decision. The study emphasizes the cognitive, emotional, and behavioral dimensions of these talents, which are crucial for academic and professional achievement. They empower individuals to manage uncertainty and tackle obstacles efficiently and adaptively (Alexander & Winne, 2012; Jonassen, 2010). This capability addresses problems systematically and incrementally, yielding efficient solutions (Calma, 2025; Fauziana & Fazilla, 2022). Polya (1973) elucidated that problem-solving aptitude comprises multiple dimensions, including (1) problem identification, which entails the capacity to comprehend and ascertain the true nature of the problem. At this juncture, the emphasis is on monitoring the circumstances, collecting data, and articulating the problem clearly; (2) devising strategies, which entails the capacity to plan or ascertain the approaches that will be employed to resolve the problem. Strategies must be rational, suitable for the circumstances, and attainable for students; (3) executing the strategy entails the capability to perform tangible actions based on the established plan. This phase encompasses field activities and coordination; (4) validating the solution, which entails the capacity to reassess whether the implemented actions effectively resolve the problem. These four stages show that problem-solving is a methodical cognitive process that requires diligence, strategic planning, implementation, and ongoing assessment. This framework applies in several contexts, from individual decision-making to addressing complex organizational challenges (Darvishi et al., 2023; Riyadi et al., 2021).

The academic community continues to focus on students' problem-solving abilities in contemporary education (Erol & Çırak, 2021). This talent indicates academic achievement. To determine the optimal solution, students must research problem scenarios and synthesize and organize diverse knowledge (Daryanes et al., 2023; C. Zhang et al., 2025). Direct training and enrichment materials enhance individuals' problem-solving

skills (Amalina & Vidákovich, 2023; Lu & Xie, 2024). Students with problem-solving skills show stronger comprehension of core concepts, better pattern recognition, and more effective problem-solving strategies (Fouze et al., 2021; Sinaga et al., 2023). This competence is often required creatively to address open or complex circumstances (Mangaroska et al., 2022; Oliveira et al., 2021). Students' ability to resolve problems is correlated with their creativity and confidence. It involves using critical thinking, reasoning, and knowledge to surmount challenges. Proficiency in techniques and an adaptable, imaginative approach to novel problems are essential for effective problem-solving (Sitepu et al., 2026; Szabo et al., 2020). Students confident in their problem-solving capabilities are more inclined to engage in creative thinking, explore diverse methodologies, refine solutions, and think innovatively (Fülöp, 2021).

Given that problem-solving ability is a critical skill influencing students' academic success, research indicates that students' problem-solving competencies have not attained proficiency in factual knowledge, procedural skills, conceptual understanding, and the selection of appropriate problem-solving strategies (Ling & Mahmud, 2023). Moreover, the literature is inconsistent: some studies suggest that students' creativity improves more than their problem-solving abilities after intervention, while other research indicates that problem-solving skills exert a substantial direct influence on creative and critical thinking abilities (Orakci, 2023; Y. Zhang & Zhu, 2024). In summary, students may show creativity as they master problem-solving skills. Moreover, gender differences do not significantly affect students' problem-solving capabilities (Yılmaz & Griffiths, 2023). Regrettably, elementary school students continue to face problem-solving challenges because of insufficient comprehension of problem objectives, limited proficiency in problem-solving strategies, inadequate knowledge, a lack of precision and attentiveness in addressing problems, and minimal practice (Riyadi et al., 2021). Consequently, further study is needed to understand better initiatives to cultivate problem-solving abilities in primary school students.

To address this gap, this study uses the cognitive constructivist framework established by Piaget (1976), which asserts that knowledge is actively generated through an individual's engagement with the environment rather than passively transmitted from teacher to student. Piaget (1976) posits that learning occurs through assimilation and accommodation, in which an individual incorporates new knowledge into established cognitive frameworks or alters these frameworks when new information is incompatible with earlier cognitive structures. Learning is an adaptable process that continually evolves with an individual's experiences (Ginsburg & Opper, 2016). Piaget (1976) posits that elementary school students' cognitive development occurs at the concrete operational stage, during which they begin to engage in rational reasoning concerning tangible objects. From a constructivist perspective, Piaget (1976) views students not as passive recipients of information but as active contributors to knowledge construction. Exploration, object manipulation, and reflection on educational experiences cultivate knowledge (Huitt & Hummel, 2003). According to Piaget (1976), experiential learning that enables students to uncover concepts independently is beneficial. Piaget's concepts (1976) provided the basis for inquiry-based learning, problem-solving, and activity-based learning, enabling students to construct understanding in alignment with their cognitive development stage. Therefore, this study uses a problem-based learning model to improve elementary school students' problem-solving abilities.

Recent studies indicate that problem-based learning models have been employed to enhance students' problem-solving skills (Cong & Ironsi, 2025; Fa'iqoh et al., 2025; Husin et al., 2025). This study's results are corroborated by review findings that strongly endorse the PBL model as an effective technique for significantly enhancing students' problem-solving skills (Sihotang et al., 2025; Yuhana & Fajari, 2025). Compared with critical thinking and autonomous learning skills, problem-solving capacity shows much larger differences with PBL than with traditional learning methods (Manuaba et al., 2022). These consistent findings indicate that problem-based learning supports cognitive growth and provides a structured learning environment that engages students in analyzing, exploring, and resolving problems more effectively. Through Project-Based Learning (PBL), students actively participate in the solution-finding process by engaging in conversation, cooperation, observation, and reflection on assigned problems, rather than passively receiving knowledge from the teacher. This approach fosters systematic thinking and trains students to connect their knowledge to real-life problems.

Furthermore, incorporating contextual problems in Problem-Based Learning (PBL) enhances the significance of education, as students recognize that information extends beyond memorization and is applied to address real-world challenges. The problem-based learning methodology fosters a more dynamic, challenging, and student-centric educational experience, thereby developing problem-solving skills more effectively than traditional learning, which typically prioritizes unidirectional material delivery (Yılmaz & Griffiths, 2023). While these studies have improved understanding, they still treat problem-solving as a single entity and fail to capture students' strengths and weaknesses across its many aspects. Furthermore, analyses of the effects of different learning models on this capability have yet to provide a definitive understanding of which elements of problem-solving progress most effectively and which require further intervention. This situation signifies that the intricacy of problem-solving aptitude as a multifaceted talent has not been adequately addressed in prior studies.

This study offers empirical evidence about the impact of a well-established educational paradigm, namely Problem-Based Learning, on the problem-solving skills of primary school students. Unlike prior studies that assessed the overall efficacy of learning models, this research specifically examines how Problem-Based Learning enhances students' problem-solving capabilities across multiple dimensions and cognitive levels, providing a more thorough understanding of problem-solving development in elementary school students. This research examines students' problem-solving skills by exploring each dimension using an experimental approach. This methodology enables researchers to focus on both the ultimate outcomes of problem-solving capabilities and the developmental dynamics in each dimension associated with the administered therapy. This research investigates cognitive development via higher-order thinking skills (HOTS) in relation to the characteristics of problem-solving abilities throughout the learning process.

METHODS

This study used a quantitative approach known as the Pretest-Posttest Equivalent Groups design (Borg et al., 2014). This design was selected because it enables researchers to assess improvements in students' problem-solving skills objectively. In this research, the experimental group was taught using the problem-based learning (PBL) model, whereas the control group was instructed using the inquiry-based learning model, which is often used by the teacher in the classroom. The study's findings showed that students in the experimental group had much better problem-solving abilities than those in the control group. This implies that the PBL approach is better at encouraging critical thinking and applying knowledge in practical situations.

Table 1. Research design

Group	Pre-test	Intervention	Post-test
Experiment	O1	Problem-based learning	O2
Control	O3	Inquiry-based model	O4

Explanation:
O_1 and O_3 = Initial tests (pre-tests) to measure problem-solving abilities before the treatment.
O_2 and O_4 = Final tests (post-tests) to measure problem-solving abilities after the treatment.

Table 1 presents the research method used for enhancing students' problem-solving skills. At the initial stage, both groups took a pre-test to assess students' baseline problem-solving capabilities and confirm that their abilities were similar before the intervention. The experimental group learned using the Problem-Based Learning (PBL) approach, which began with presenting contextual problems to stimulate learning. Subsequently, students, organized in groups, identified problems, gathered and analyzed pertinent information, devised and evaluated possible solutions, presented the outcomes of their problem-solving efforts, and engaged in reflective practice on the process, with the instructor acting as a facilitator. The control group learned using the Inquiry model, which included orientation, problem framing, hypothesis generation, data collection, hypothesis testing, and conclusion drawing to uncover ideas or learning principles independently. Both groups received identical materials, learning goals, time allocation, and learning circumstances; therefore, the only difference in treatment was the learning model used. After the learning process, both groups took a post-test to assess students' final competencies. The pre-test and post-test data were analyzed to determine improvements in students' skills in each group and to evaluate the differential effectiveness of the Problem-Based Learning model versus the Inquiry model in meeting the specified learning goals.

The study's population consisted of 42 fourth-graders at SD Negeri 4064965 Medan. A complete sampling approach was employed, meaning the entire population served as the research sample. The fourth-grade students in class IV-A, totaling 24 students consisting of 13 males and 11 females (at the age range of 9 to 10 years old (, were designated as the experimental group and received instruction using the problem-based learning model. In contrast, the fourth-grade students in class IV-B, totaling 18 students consisting of 10 males and 8 females (at the age range of 9 to 10 years old (, were assigned to the control group and utilized the inquiry learning model, following the existing class divisions. Consequently, every study subject participated fully in accordance with the group divisions established in the research design. Essay tests are used as these tests are thought to be able to measure students' problem-solving skills more thoroughly, not just in the final response but also in the thinking process, which includes problem identification, strategy selection, and verification of the final solution. Essay questions allow students to provide more thorough, organized arguments, explain how to solve problems, and elaborate on their reasoning. This allows researchers to get a more complete picture of students' problem-solving skills, ensuring the assessment is not merely superficial but also more objective and reflects the real thinking process. Table 2 summarizes this information.

Table 2. Grid of problem-solving ability test

Indicator	Learning goals	Cognitive Level
Analyzing the causes of environmental damage around the school	Students can analyze the factors causing environmental damage based on data and facts	Analysis (C4)
Assessing the role of individuals in maintaining environmental sustainability	Students assess various behaviors and determine the actions that should be taken.	Evaluation (C5)
Designing solutions to overcome environmental pollution	Students make activity plans to reduce pollution	Creation (C6)

Testing the validity and reliability of an instrument is an important stage conducted before the instrument is used in research. This testing aims to ensure that the instrument used is truly capable of measuring what is supposed to be measured and has a good level of consistency. The instrument in this research consists of questions compiled from indicators of problem-solving abilities in the higher cognitive domain, namely C4 (analyzing), C5 (evaluating), and C6 (creating). Validity testing was conducted by comparing rcalculated with rtable at a certain significance level; based on the results, the rtable value obtained was 0.3126. The decision-making criterion is that if rcalculated is greater than rtable, the question item is declared valid. Consequently, the research indicates that all tested items have an r-value exceeding the r-table value. The r value for the C4 category questions was 0.490 and was deemed legitimate because it met the predetermined requirements.

Additionally, the r value for the C5 category questions was 0.860, signifying a high degree of validity. Likewise, the r-value for the C6 category questions was 0.912, significantly exceeding the r-table value. This indicates that each test item in this study effectively assessed the indicators of problem-solving skills as expected, making it suitable as a research instrument. The study also conducted a reliability test to determine the instrument's consistency. This study used Cronbach's Alpha for the reliability assessment. The computed Cronbach's Alpha value was 0.654. Since this value exceeds 0.60, the instrument is deemed reliable (Hair et al., 2021). Consequently, it may be inferred that the research instrument possesses a satisfactory level of consistency and may produce results that are comparable under similar conditions. The instrument employed in this study meets the criteria for validity and reliability. Consequently, the instrument is suitable for utilization in this study as a data collection tool to evaluate students' problem-solving abilities.

This study employs the Mann-Whitney U test, a nonparametric statistical approach for comparing differences between two independent groups. This test is appropriate for situations involving small samples or ordinal data because it is based on the data's features and does not require a normal distribution. The analysis used SPSS version 27 for Windows, which enables systematic, organized, and effective data processing from data entry to generating statistical test results. This process provides researchers with the significance values needed to assess whether the two groups under comparison differ significantly. The analysis findings then serve as the basis for objectively deriving study conclusions, resulting in findings that are both descriptive and statistically sound.

RESULT AND DISCUSSION

The researchers analyzed the problem-solving capabilities of the students in the study sample according to the research design. The results indicate that students' problem-solving abilities across each dimension and cognitive level (C4, C5, and C6) vary as high, medium, or low between the experimental and control classes. The high category predominates across nearly all parameters, particularly at the C4 cognitive level. This suggests that most students have a strong aptitude for analyzing the presented difficulties. At higher cognitive levels, specifically C5 and C6, the distribution shifts toward the medium group, while the high category continues to prevail, particularly in the experimental class. This indicates that the capacity to assess and generate still needs improvement; therefore, not all students fall within the high category. Disparities in students' capabilities are more pronounced in dimensions 3 and 4, as the population of students in the middle category rises relative to the preceding dimensions. Furthermore, in dimension 3, one student in the control class is categorized as low at the C6 cognitive level. This suggests that, at higher levels of cognitive complexity, some students continue to struggle with problem-solving. Nonetheless, the low group is negligible and does not prevail in any assessed characteristic. In comparing the two classrooms, the experimental class had more students in the high category than the control class across all dimensions and cognitive levels. The information is presented in Figure 1.

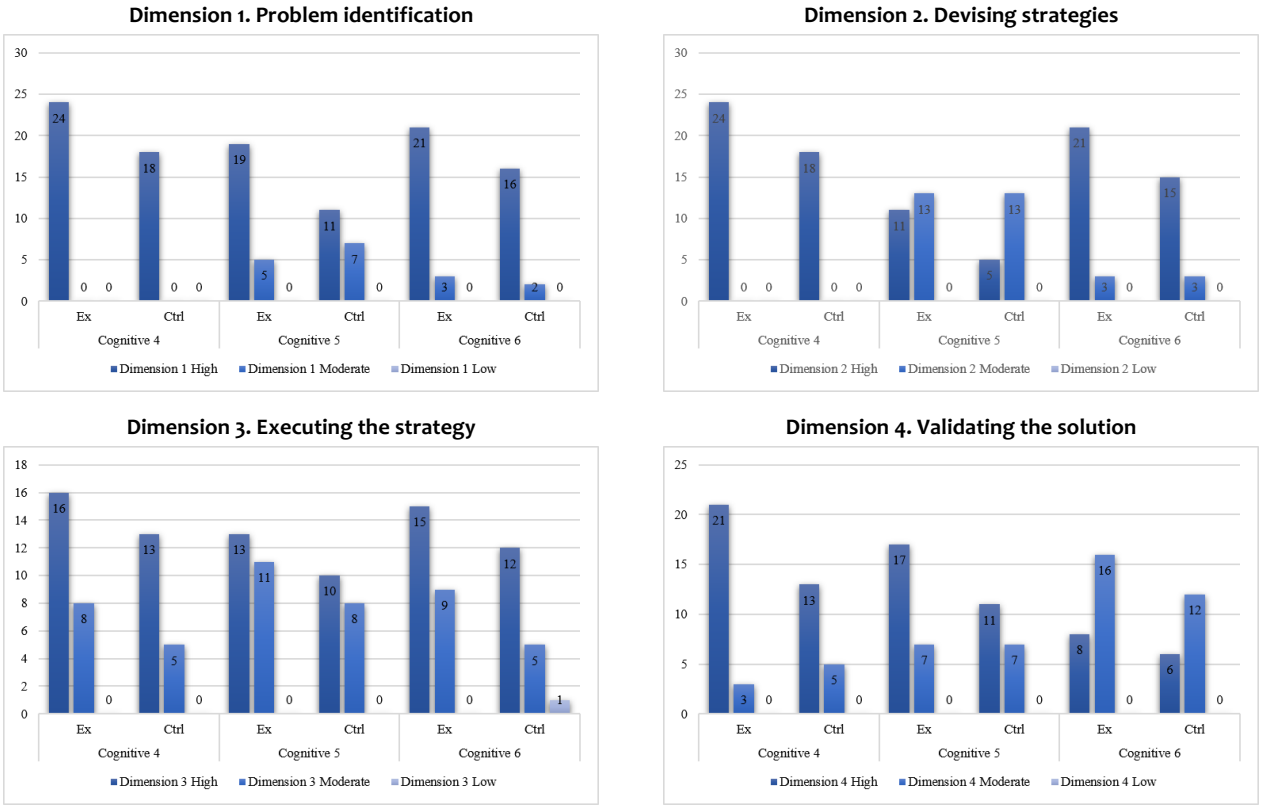


Figure 1. Comparison of problem-solving ability of the experimental class (ex) and the control class (ctrl)

The findings indicate that students in both the experimental and control groups have equivalent capacity to identify problems (dimension 1) at the analytical level. Nonetheless, disparities persist in appraisal and creativity. In the evaluation domain, students in the experimental class exhibited superior performance, with 19 students (79%) categorized as high and 5 students (21%) as medium, in contrast to the control class, where 11 students (61%) were classified as good and 7 students (39%) as medium. In the creativity domain, 21 students (87.5%) fell into the high group, while 3 students (12.5%) were classified in the medium category. In contrast, the control class had 16 students (89%) in the high category and 2 students (11%) in the medium category. Moreover, throughout the strategy development phase (dimension 2) inside the student analysis area, the experimental and control groups remained unchanged. Nonetheless, disparities persisted in appraisal and creativity. In the assessment domain, 11 students (46%) were classified in the high group, while 13 students (54%) were categorized in the medium category. In the control class, 13 students (72%) fell into the medium group, while just 5 students (28%) were classified in the high category. In the creativity domain, 21 students (87.5%) fell into the high group, while 3 students (12.5%) were classified in the medium category. In contrast, the control class had 15 students (83%) in the high category and 3 students (17%) in the medium category.

In addition, the execution of the approach (dimension 3) indicates that 16 students (67%) possess proficiency in the analytical domain, whereas 8 students (33%) fall within the medium group. In the assessment domain, 13 students (54%) were classified in the high group, while 11 students (46%) fell into the medium category. In contrast, the control class had 10 students (56%) in the high category and 8 students (44%) in the medium category. In the domain of creativity, 15 students (62.5%) were classified in the high category, while 9 students (32.5%) were in the medium category. In contrast, the control class had 12 students (67%) in the high category and 6 students (33%) in the medium category. In dimension 4, the validation of the solution revealed that, within the analytical domain, 21 students (87.5%) were classified in the high group, while 3 students (12.5%) were in the medium category. In contrast, the control class had 13 students (72%) in the high category and 5 students (28%) in the medium category. In the assessment domain, 17 students (71%) fell into the high group, while 7 students (29%) were in the medium category. In contrast, the control class had 11 students (61%) in the high category and 7 students (39%) in the medium category. In the experimental and control courses, 67% of students fell into the medium group, while only 33% were classified in the high category.

Although the experimental class had more students in the high category than the control class across all dimensions and cognitive levels, this does not mean the students have fully mastered problem-solving skills. The elevated group more accurately represents increasingly advanced cognitive development. Piaget (1976) posits that cognitive capacities evolve progressively via environmental interaction; hence, the enhancement in problem-solving capabilities in the experimental group may be seen as a sign of increased cognitive maturity,

rather than the final attainment of such abilities. Learning through significant, relevant, and demanding experiences enables students to actively participate in knowledge creation. Through this engagement, students acquire conceptual comprehension and are prompted to cultivate higher-order thinking abilities, including information analysis, evaluation of potential solutions, and logical decision-making in problem-solving. Repeated exposure to diverse problem-solving scenarios enables students to practice and enhance their cognitive methods (Bruner, 1974). Consequently, the more learning situations and the more diverse the obstacles encountered, the more effectively and sustainably students' problem-solving skills may grow. Findings from this study indicate that problem-based learning models enhance students' problem-solving skills (Cong & Ironsi, 2025; Kök & Duman, 2023; Patunah et al., 2024). PBL may strengthen students' problem-solving abilities, essential for addressing real-world problems and complexity, while also improving academic performance (Argaw et al., 2016; Tursynkulova et al., 2023). Research shows that PBL is successful in online education (Aslan, 2021). The hypothesis was tested to determine whether a significant difference exists between the problem-solving ability of students taught using the Problem-Based Learning model and those educated through the inquiry learning approach.

Table 3. Hypothesis test results of high cognitive levels

Level		Dimension 1	Dimension 2	Dimension 3	Dimension 4
Analysis (C4)	Mann-Whitney U	216.000	216.000	204.000	184.000
	Wilcoxon W	387.000	387.000	504.000	355.000
	Z	.000	.000	-.381	-1.190
	Asymp. Sig. (2-tailed)	1.000	1.000	.703	.234
Evaluation (C5)	Mann-Whitney U	171.500	143.500	181.000	181.000
	Wilcoxon W	342.500	314.500	352.000	352.000
	Z	-1.427	-1.936	-.977	-1.064
	Asymp. Sig. (2-tailed)	.154	.053	.329	.287
Create (C6)	Mann-Whitney U	212.000	199.500	203.500	214.000
	Wilcoxon W	512.000	499.500	503.500	514.000
	Z	-.181	-.689	-.371	-.053
	Asymp. Sig. (2-tailed)	.856	.491	.711	.958

Table 3 evaluates student performance, displaying the Asymp. Sig. (2-tailed) values for each dimension: dimension 1 at 1.000, dimension 2 at 1.000, dimension 3 at 0.703, and dimension 4 at 0.234. All of these substantial values exceed the significance level of 0.05 (Sig. > 0.05). This indicates no significant differences between the experimental and control groups for each assessed measure. The Problem-Based Learning (PBL) paradigm did not have a statistically significant effect on students' problem-solving abilities in any aspect. The Z values for each dimension, recorded as 0.000, 0.000, -0.381, and -1.190, indicate that the differences between the two groups are negligible and therefore insufficient to produce a significant distinction. Nevertheless, these findings indicate a tendency for improvement in students' abilities, albeit this improvement is not yet consistently distributed across the board.

The findings indicate strong analytical-level problem-solving proficiency; however, the lack of impact on students' problem-solving capabilities suggests that students' cognitive skills are evolving incrementally. Consequently, competencies such as deconstructing problems into components, recognizing interrelations among concepts, and executing systematic reasoning remain under development. PBL effectively promotes active student participation via contextual problem-solving, so it is logical that the majority of students demonstrate overall skill enhancement. Nonetheless, the analytical demands that require more abstract information processing often do not align fully with the cognitive attributes of students in the concrete operational stage (Piaget, 1976). Moreover, the gains observed in most students do not consistently reach statistical significance because of individual differences in ability and the relatively uniform constraints of cognitive development at this point. Elementary school-aged students often demonstrate advancement in comprehending and implementing concrete solutions; yet, they lack consistency in conducting thorough analyses of problem structures. This supports the notion that problem-based learning requires robust scaffolding to help students exceed their cognitive development constraints (D'Mello et al., 2024; van Nooijen et al., 2024). Consequently, its impact on analytical capabilities has been minimal owing to the constraints of students' cognitive developmental stages, the intricacy of analytical skills, and the necessity for an extended and more systematic educational experience (Cerovac & Keane, 2024).

The examination of student ratings indicates the Asymp. Sig. (2-tailed) values for each dimension: dimension 1 at 0.154, dimension 2 at 0.053, dimension 3 at 0.329, and dimension 4 at 0.287. All notable values surpass the barrier of 0.05 (Sig. > 0.05); however, the significance value for dimension 2 nears the 0.05 limit. The findings reveal no substantial difference between the experimental group and the control group on all assessed variables. Thus, the implementation of the Problem Based Learning (PBL) paradigm has not shown a

statistically significant effect on students' problem-solving abilities in all aspects. The Z values for each dimension, namely -1.427, -1.936, -0.977, and -1.064, indicate the existence of group differences; however, these differences are quite slight and inadequate to be considered significant. Nevertheless, the substantial value in dimension 2, approaching 0.05, indicates a tendency for a more marked difference compared to the other dimensions, although it has not yet reached the established significance level. This signifies an improvement in students' abilities; yet, it remains erratic and inadequate to produce a statistically meaningful difference.

Research findings reveal that students possess relatively strong evaluative abilities in problem-solving; nevertheless, this enhancement has not yet substantially influenced their total problem-solving proficiency. Jean Piaget (1976) posits that this situation arises because primary school students remain in the concrete operational stage, resulting in their cognitive capacities being confined to tangible and familiar events. Students may use basic logic to solve problems; however, they cannot make deeper critical evaluations, such as comparing different answers or offering complex, organized reasoning. Consequently, students' evaluative skills develop gradually and require ongoing practice, meaningful learning experiences, and teacher guidance through discussion, reflection, and contextual problem-solving activities to effectively strengthen their critical thinking abilities (Liu et al., 2025; Lonergan et al., 2022; Susanti et al., 2023).

The students' creative levels indicate the Asymp. Sig. (2-tailed) values for each dimension: dimension 1 at 0.856, dimension 2 at 0.491, dimension 3 at 0.711, and dimension 4 at 0.958. All notable results exceeded the 0.05 threshold (Sig. > 0.05). The results indicate no significant disparity between the experimental and control groups across all assessed dimensions. As a result, implementing the Problem-Based Learning (PBL) framework did not produce a statistically significant effect on students' problem-solving abilities in these areas. The Z values for each dimension, namely -0.181, -0.689, -0.371, and -0.053, indicate that the difference between the two groups is negligible. This suggests that students in both the experimental and control groups have nearly identical competencies. Meanwhile, students' creativity levels show the Asymp. Sig. (2-tailed) values for each dimension, namely dimension 1 at 0.856, dimension 2 at 0.491, dimension 3 at 0.711, and dimension 4 at 0.958. All of these significance values are above the threshold of 0.05 (Sig. > 0.05). The results show no significant difference between the experimental and control groups across all examined dimensions. Consequently, the Problem-Based Learning (PBL) paradigm did not significantly affect students' problem-solving skills across these domains. The Z values for each dimension, which are -0.181, -0.689, -0.371, and -0.053, suggest that the disparity between the two groups is minimal. This indicates that students in both the experimental and control groups have nearly equivalent competencies.

Research findings indicate that students possess increased problem-solving capabilities at the creation level; nevertheless, this has not yet substantially influenced their overall problem-solving skills. Piaget (1976) posits that this can be understood as elementary school students remaining in the concrete operational stage, during which they can formulate basic ideas and solutions derived from tangible experiences but lack the capacity for abstract, reflective, and critical thinking. Consequently, students' creative capacities remain relatively rudimentary and are not yet accompanied by the proficiency to assess or implement ideas in increasingly intricate scenarios critically. Consequently, despite students' existing capacity for creative problem-solving, enhancing these skills requires a gradual process, tangible learning experiences, consistent practice, and instructional support to support optimal development (Liu et al., 2025; Lonergan et al., 2022; Susanti et al., 2023).

CONCLUSION

This research achieved its goals by showing that most students developed advanced problem-solving skills through the learning process. The problem-based learning (PBL) paradigm enhances students' skills in analysis, evaluation, and invention, while also supporting problem identification, solution design, strategy execution, and assessment of problem-solving results. These accomplishments indicate advancements in students' cognitive growth throughout the learning process, but they do not yet exhibit complete mastery of problem-solving abilities. Nonetheless, the study's findings show that PBL does not significantly outperform the inquiry model, indicating that both approaches are comparably successful in fostering problem-solving skills through investigative tasks, critical analysis, and active student participation. This finding deepens understanding of constructivist learning models in primary education and underscores that cultivating problem-solving abilities is an incremental process that requires ongoing learning experiences. However, this research is limited by a very small sample size, an exclusive emphasis on problem-solving abilities, and an experimental strategy that has not thoroughly examined students' learning experiences. Consequently, future studies should use a more representative sample, adopt a mixed-methods approach, and account for other factors that may affect students' problem-solving capabilities.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Lailatul Karimah: Conceptualization, Methodology, Writing and Editing. Baihaqi Siddik Lubis: Data curation, Validation, Supervision, Writing - Review.

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