Bioscientist: Jurnal Ilmiah Biologi
https://e-journal.undikma.ac.id/index.php/bioscientist

June 2026 Vol. 14, No. 2
e-ISSN: 2654-4571
pp. 935-944

The Effect of Implementing the Problem-Based Learning Model on Science Learning Outcomes at SMP Negeri 13 Sigi Biromaru

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Received: April 2026; Revised: May 2026; Accepted: June 2026; Published: June 2026

Abstract: This study aimed to analyze the effect of implementing the Problem-Based Learning (PBL) model on eighth-grade students' science learning outcomes. This study employed a quantitative quasi-experimental approach with a nonequivalent control group design. The sample consisted of 53 eighth-grade students who were assigned to an experimental class and a control class. The experimental class was taught using the PBL model, whereas the control class received conventional instruction. Data were collected using a multiple-choice test administered before and after the treatment as a pretest and posttest. The test was designed to measure students' cognitive learning outcomes in science. The data were analyzed using an independent samples t-test after the initial abilities of the two groups were examined. The results indicated that the two groups had relatively equivalent initial abilities before the intervention. After the treatment, the experimental class achieved a higher posttest mean score than the control class, and the difference between the groups was statistically significant. These findings suggest that PBL is more effective than conventional instruction in improving students' science learning outcomes.
Keywords: Learning outcomes; Problem-Based Learning; conventional instruction; science; quasi-experiment

How to Cite: Aulia, A., Lilies, Ashari, A., Shamdas, G. B. N., Alibasyah, L., & Zainal, S. (2026). The Effect of Implementing the Problem-Based Learning Model on Science Learning Outcomes at SMP Negeri 13 Sigi Biromaru. *Bioscientist: Jurnal Ilmiah Biologi*, *14*(2), 935–944. https://doi.org/10.33394/bioscientist.v14i2.20156

https://doi.org/10.33394/bioscientist.v14i2.20156

INTRODUCTION

Education plays a fundamental role in improving the quality of human resources through effective learning processes. One indicator of educational success is the achievement of optimal student learning outcomes. However, low learning outcomes remain a persistent problem in education, particularly in science learning. This condition indicates that classroom instruction has not fully supported the development of students' critical thinking, problem-solving skills, creativity, and active engagement, which are essential competencies for twenty-first-century learning (Sudarsono et al., 2021). Recent international assessments also emphasize that creative thinking and problem-solving are important indicators of how well education systems prepare students to respond to diverse learning and real-life contexts (OECD, 2024).

Learning is an interactive process between teachers and students aimed at promoting behavioral change and improving learning outcomes. To enhance student achievement, teachers need to select and implement instructional models that are appropriate to the characteristics of the learning material and the learners (Yulianti, 2019). The selection of an effective instructional model strongly influences student learning success because it affects not only students' motivation but also their active participation in the learning process (Putri et al., 2021). Therefore, the use of innovative and interactive instructional models, such as Problem-Based Learning (PBL), is a relevant alternative for creating more meaningful and student-centered learning (Susanti et al., 2020).

Based on observations conducted at SMP Negeri 13 Sigi Biromaru, science learning has not yet been implemented optimally. Instruction tends to be dominated by conventional teacher-centered methods, particularly lectures, resulting in low levels of student participation. This situation contributes to limited conceptual understanding and weak critical thinking skills among students. Learning outcome data show that most students had not reached the Minimum Mastery Criterion (Kriteria Ketuntasan Minimal, KKM) of 75. In class VIII A, only 29.63% of students achieved the KKM before remedial instruction, while in class VIII B, the figure was 29.17%. Even after remedial instruction, 62.96% of students in class VIII A and 50% of students in class VIII B still had not achieved the KKM. These findings indicate the need to implement a more innovative instructional model to improve both the quality of the learning process and student learning outcomes.

One instructional model that can be applied to address these problems is Problem-Based Learning (PBL). PBL is not merely a current trend in education; rather, it is a pedagogical approach that emphasizes active, collaborative, and meaningful learning. Savery (2006) explains that PBL is a learner-centered instructional approach that enables students to conduct inquiry, integrate theory and practice, and apply knowledge and skills to develop solutions to defined problems. This model uses real-world problems as the starting point for learning, thereby encouraging students to think critically, seek solutions, and connect scientific concepts with everyday life (Aini, 2021). Through the problem-solving process, PBL can increase students' active participation, motivation, and understanding of the learning material (Pratiwi, 2020).

Theoretically, PBL is grounded in constructivist learning theory, which emphasizes that knowledge is actively constructed through learning experiences and social interaction. This foundation is consistent with Jean Piaget's concepts of assimilation and accommodation, in which students integrate new problem-based stimuli into their existing cognitive schemas to construct new knowledge. It is also aligned with Lev Vygotsky's social constructivist theory, particularly the concept of the Zone of Proximal Development (ZPD), in which collaborative learning and peer interaction provide scaffolding that helps students achieve higher levels of understanding. In addition, PBL reflects John Dewey's view that learning should be connected to real-life problems and meaningful experience. In this regard, PBL provides students with opportunities to learn through facilitated problem solving, collaborative inquiry, self-directed learning, and reflection, all of which support the development of flexible knowledge and problem-solving skills (Hmelo-Silver, 2004). Furthermore, PBL is consistent with experiential learning, which provides students with direct experiences in constructing knowledge and solving authentic problems, thereby making learning more meaningful (Lestari et al., 2025).

The implementation of the PBL model in this study followed five instructional phases: (1) orienting students to the problem, (2) organizing students for learning, (3) guiding individual and group investigations, (4) developing and presenting work products, and (5) analyzing and evaluating the problem-solving process. Through these stages, students engage in active learning experiences that can enhance conceptual understanding and learning outcomes (Wulandari et al., 2024). These phases also position the teacher as a facilitator who guides inquiry, supports collaboration, and encourages students to evaluate their own problem-solving processes.

The PBL instructional model is closely related to improved student learning outcomes because it emphasizes active engagement in learning through the resolution of real-world problems. In PBL, students do not merely receive information; rather, they independently construct knowledge through discussion, investigation, and reflection, resulting in deeper conceptual understanding (Pratama, 2020). Moreover, the student-centered nature of PBL can enhance motivation, critical thinking, and problem-solving skills, which directly contribute to improved learning outcomes, particularly in science learning (Saputra, 2022). In this study, learning outcomes were focused on the cognitive domain, including the abilities to understand (C2), apply (C3), and analyze (C4), which are consistent with the characteristics of PBL in developing higher-order thinking skills. Operationally, cognitive learning outcomes were measured based on the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). First, the understanding level (C2) was measured through students' ability to explain concepts related to natural phenomena, classify science content, and interpret data on scientific phenomena. Second, the applying level (C3) was measured through students' ability to use formulas, principles, or scientific methods to solve problems in new and concrete situations. Third, the analyzing level (C4) was measured through students' ability to break down science learning material into its constituent components, determine relationships among these components, and distinguish between facts and assumptions in scientific problems presented in the test instrument.

Previous studies have shown that the implementation of PBL can significantly improve student learning outcomes. Amanda (2023) reported a high-category improvement in student learning outcomes, while Darmawati (2024) found a gradual increase in learning mastery. In addition, Suryani (2023) and Wijaya (2023) demonstrated that PBL influences students' critical thinking and problem-solving abilities. Although these studies provide valuable empirical evidence, they were conducted in different school contexts, learning materials, and student populations. Moreover, earlier literature suggests that further research is still needed to examine how PBL works with less-skilled learners and in diverse classroom contexts beyond the settings that have been most frequently studied (Hmelo-Silver, 2004). Therefore, a research gap remains regarding the extent to which PBL can produce consistent effects when implemented in a school characterized by very low initial student mastery, with KKM achievement below 30%. Another gap concerns how this model supports students' cognitive development from understanding to analysis in science learning, particularly in contexts where conventional teacher-centered instruction remains dominant.

Based on this gap, research on the effect of implementing PBL on science learning outcomes at SMP Negeri 13 Sigi Biromaru is necessary to provide empirical evidence regarding the effectiveness of this model in the specific school context. The novelty of this study lies in its focus on the implementation of PBL in a junior high school with low initial mastery levels and in its specific measurement of cognitive learning outcomes across the C2, C3, and C4 levels. Accordingly, this study addresses the following research question: Does the implementation of the PBL instructional model have a significant effect on improving students' cognitive science learning outcomes at SMP Negeri 13 Sigi Biromaru compared with conventional instruction? This study aims to analyze the effect of implementing the PBL model on students' science learning outcomes at SMP Negeri 13 Sigi Biromaru. The hypotheses proposed in this study are as follows: H_0 states that there is no significant effect of implementing the PBL model on students' science learning outcomes at SMP Negeri 13 Sigi Biromaru, whereas H_a states that there is a significant effect of implementing the PBL model on students' science learning outcomes at SMP Negeri 13 Sigi Biromaru.

METHOD

Research Design

This study employed a quantitative approach using a quasi-experimental method with a nonequivalent control group design. This design was selected because the study did not involve random assignment of participants; instead, it used existing classes as intact groups. The study involved two groups: an experimental class and a control class. Both groups were administered a pretest to determine students' initial abilities before the treatment.

The experimental class received instruction using the Problem-Based Learning (PBL) model, whereas the control class was taught using conventional learning methods. After the instructional process was completed, both groups were administered a posttest to measure students' learning outcomes. The implementation of the PBL model was conducted over four meetings and followed the main stages of PBL, namely problem orientation, student organization for learning, individual or group investigation, development and presentation of findings, and evaluation of the problem-solving process. In contrast, instruction in the control class was conducted through conventional methods, including lectures, question-and-answer activities, and assignments.

Research Location and Sample

This study was conducted from June to July 2026 at SMP Negeri 13 Sigi Biromaru. The population consisted of all Grade VIII students, totaling 53 students distributed across two existing classes. The sample was determined using an intact group technique. Class VIII A, consisting of 27 students, was assigned as the experimental class, whereas Class VIII B, consisting of 26 students, was assigned as the control class. The use of intact groups was considered appropriate because the study was conducted in a natural classroom setting without changing the existing class composition.

Research Instrument

The research instrument was a multiple-choice test consisting of 20 items. The test was designed to measure students' cognitive learning outcomes based on the revised Bloom's Taxonomy, specifically at the levels of understanding (C2), applying (C3), and analyzing (C4). Each item was developed to assess students' mastery of science concepts after the instructional treatment. Students' test scores were used as the main data for comparing learning outcomes between the experimental and control groups.

Data Collection Technique

Data were collected through pretest and posttest administration. The pretest was administered before the treatment to measure the initial abilities of students in both groups. After the instructional intervention was completed, the posttest was administered to measure students' learning achievement. The comparison between pretest and posttest results was used to identify changes in students' learning outcomes after the implementation of the instructional model.

Data Analysis

The collected data were analyzed using inferential statistics. Prior to hypothesis testing, prerequisite tests were conducted to examine whether the data met the assumptions for parametric analysis. The normality of the data was tested using the Shapiro–Wilk test, while the homogeneity of variance was examined using Levene's test. After the assumptions of normality and homogeneity were met, an independent samples t-test was performed at a significance level of 0.05 to determine whether there was a significant difference in learning outcomes between the experimental and control groups.

RESULTS AND DISCUSSION

The normality test was conducted to determine whether the students' learning outcome data were normally distributed. In this study, normality was tested using the Shapiro–Wilk test at a significance level of 0.05. The data were considered normally distributed when the significance value was greater than 0.05 (Sig. > 0.05). The results of the normality test are presented in Table 1.

Table 1. Results of the normality test

Data	Class	Statistic	df	Sig.
Students' learning outcomes	Experimental class pretest	0.978	27	0.429
Students' learning outcomes	Experimental class posttest	0.970	27	0.396
Students' learning outcomes	Control class pretest	0.972	26	0.380
Students' learning outcomes	Control class posttest	0.953	26	0.220

Based on Table 1, all significance values were greater than 0.05. Therefore, the students' learning outcome data in both the experimental and control classes were normally distributed. These results indicate that the data met the assumption required for parametric statistical analysis.

The homogeneity test was conducted using Levene's test. The result showed a significance value of 0.091, which was greater than 0.05. Therefore, the variances of the two groups were homogeneous.

Table 2. Results of the homogeneity test

Data	Basis of test	Levene Statistic	df1	df2	Sig.
Students' learning outcomes	Based on mean	2.970	1	51	0.091
Students' learning outcomes	Based on median	2.812	1	51	0.096
Students' learning outcomes	Based on median and adjusted df	2.812	1	50.912	0.096
Students' learning outcomes	Based on trimmed mean	3.012	1	51	0.088

As shown in Table 2, the variance of the students' learning outcome data in both classes was homogeneous. Since the assumptions of normality and homogeneity were met, the analysis proceeded to hypothesis testing.

The hypothesis was tested using the independent-samples t-test. The results showed a t-value of 8.35 with a significance value of $p < 0.001$. In addition, the mean difference was 16.32, indicating a difference in the average learning outcomes between the experimental and control classes.

Table 3. Results of the independent-samples t-test

Students' learning outcomes	Levene's test Sig.	t	df	Sig.	Mean Difference
Equal variances assumed	0.091	8.35	51	0.000	16.32
Equal variances not assumed	0.091	8.35	50.912	0.000	16.32

The study began with the administration of a pretest to both the experimental and control classes to determine students' initial abilities before the treatment. The analysis showed that the mean pretest score of the experimental class was 39.44, while that of the control class was 39.42. These results indicate that the initial abilities of the two classes were relatively equivalent. Therefore, differences in learning outcomes after the treatment can reasonably be associated with the learning model implemented.

After the pretest, the experimental class received instruction using the Problem-Based Learning (PBL) model, whereas the control class was taught using conventional learning methods. The analysis showed that the mean posttest score of the experimental class was 80.74, while that of the control class was 64.42. The greater increase in learning outcomes in the experimental class indicates that the implementation of the PBL model improved students' understanding of the material. Furthermore, the independent-samples t-test produced a significance value of $p < 0.001$, confirming that there was a statistically significant difference in learning outcomes between students taught using PBL and those taught using conventional learning methods.

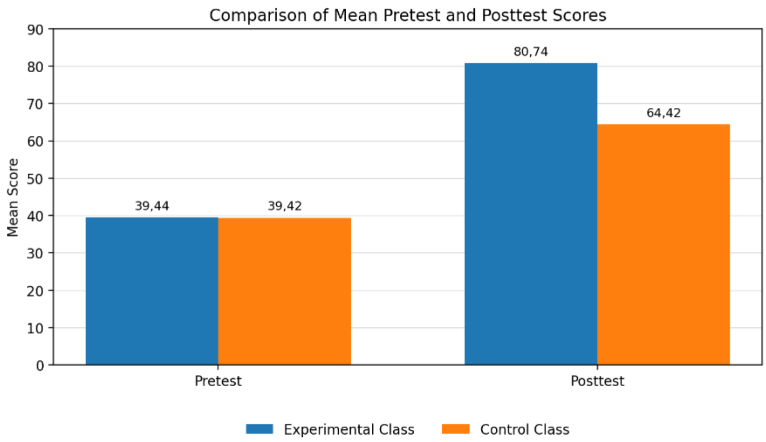

Figure 1. Comparison of mean pretest and posttest scores between the experimental and control classes

The visual comparison of the increase in learning achievement between the class taught using the PBL model and the class taught using conventional methods is presented in Figure 1. Based on the statistical results, all prerequisite assumptions were satisfied, and a significant difference was found between the two groups. Therefore, the following discussion explains how the characteristics of PBL contributed to the improvement of students' science learning outcomes.

The findings of this study indicate that the implementation of the PBL model significantly improved students' science learning outcomes. This is shown by the higher posttest mean score of the experimental class compared with the control class. The mean difference of 16.32 further indicates that students who learned through PBL achieved better learning outcomes than students who learned through conventional instruction. These findings are consistent with Amanda (2023) and Darmawati (2024), who reported that PBL significantly improved students' learning outcomes. The results are also supported by Suryani (2023) and Wijaya (2023), who found that PBL was effective in developing students' critical thinking and problem-solving skills.

The improvement in the experimental class can be explained by the characteristics of PBL as a student-centered instructional model. In PBL, students are not positioned as passive recipients of information but as active learners who engage with contextual problems, explore relevant concepts, and construct understanding through investigation and discussion. This learning process enables students to connect scientific concepts with real-life phenomena, making the material more meaningful and easier to understand. Hmelo-Silver (2004) explains that PBL supports the development of flexible knowledge, problem-solving skills, self-directed learning, collaboration, and intrinsic motivation. These characteristics are relevant to science learning because science concepts often require students to interpret evidence, reason logically, and apply concepts to new situations.

The stages of PBL implemented in this study also contributed to students' cognitive development. During the problem-orientation stage, students were introduced to contextual problems that stimulated curiosity and activated prior knowledge. In the investigation stage, students searched for information, discussed possible explanations, and tested their understanding through group interaction. During the presentation and evaluation stages, students communicated their findings and reflected on the problem-solving process. These stages are consistent with the cognitive mechanisms of PBL described by Schmidt et al. (2011), in which problem analysis, prior knowledge activation, self-directed learning, and elaboration of new information play important roles in improving conceptual understanding. Therefore, the higher posttest score in the experimental class suggests that the PBL learning sequence helped students understand, apply, and analyze science concepts more effectively.

The effectiveness of PBL in this study is also closely related to students' active involvement during learning. The PBL model encouraged students to ask questions, exchange ideas, evaluate information, and collaborate in solving problems. This condition differs from conventional learning, which tends to rely more heavily on teacher explanation and individual task completion. Freeman et al. (2014) found that active learning improves students' performance in science, engineering, and mathematics compared with traditional lecture-based instruction. In the context of this study, active participation helped students process information more deeply and reduced their dependence on teacher-centered explanations.

Furthermore, collaborative learning activities within PBL provided opportunities for students to develop communication and reasoning skills. Group discussion enabled students to compare ideas, clarify misunderstandings, and strengthen their conceptual understanding through peer interaction. This finding supports Johnson et al. (2021), who stated that collaborative learning in PBL environments has a positive impact on learning outcomes. It is also consistent with Rahman et al. (2020), who reported that contextual problem-solving activities can improve students' problem-solving skills. Through collaboration, students were able to build shared understanding, while the teacher's role as a facilitator helped guide the learning process without directly providing all answers. This facilitative role is essential in PBL because it allows students to take greater responsibility for their own learning while still receiving appropriate guidance.

Compared with conventional instruction, PBL created a more interactive and meaningful learning environment. Conventional learning may help students acquire information, but it often provides limited opportunities for students to explore concepts independently, discuss alternative explanations, or apply knowledge to contextual problems. In contrast, PBL requires students to engage in inquiry, reasoning, collaboration, and reflection. This explains why the experimental class showed a greater improvement in learning outcomes than the control class. The results support Nugroho et al. (2023), who stated that problem-based learning can increase student participation and conceptual understanding, and Anderson et al. (2021), who emphasized that deeper conceptual understanding contributes to improved academic achievement.

The findings of this study are also consistent with broader evidence on PBL. Dochy et al. (2003) reported that PBL can support learning outcomes, particularly when students are actively involved in knowledge construction and problem-solving processes. In this study, the learning activities in the experimental class required students to analyze problems, identify relevant information, discuss possible solutions, and present their findings. These activities likely contributed to the improvement of students' cognitive learning outcomes, particularly in the domains of understanding, applying, and analyzing.

Overall, the results demonstrate that PBL is an effective instructional model for improving students' science learning outcomes. The significant difference between the experimental and control classes indicates that the improvement was not merely caused by repeated testing but was associated with the instructional approach used in the classroom. However, future studies are recommended to include effect-size analysis, such as Cohen's d, or normalized gain analysis to provide a more detailed explanation of the magnitude of PBL's effect. Further research may also examine the influence of PBL on other learning variables, such as critical thinking, scientific reasoning, motivation, and students' long-term retention of science concepts.

CONCLUSION

Based on the findings of this study, it can be concluded that the implementation of the Problem-Based Learning (PBL) model had a positive effect on improving students' learning outcomes in science. This model was found to be more effective than conventional instruction in helping students develop a deeper understanding of scientific concepts. The effectiveness of PBL was reflected in the increased active engagement of students during the learning process, which supported the development of critical thinking and problem-solving skills. These findings indicate that problem-based learning can create a more meaningful learning experience. The implication of this study is that PBL can be used as an effective alternative instructional strategy to improve students' science learning outcomes. Furthermore, the findings support constructivist learning theory, which emphasizes the importance of students' active roles in constructing knowledge through learning experiences.

RECOMMENDATION

Based on the findings of this study, teachers are encouraged to optimize the implementation of the PBL model in science learning, as this model has been shown to increase student engagement through activities such as problem analysis, discussion, and independent solution development. The application of PBL can serve as an effective instructional strategy to strengthen students' conceptual understanding. In addition, teachers are expected to create a more interactive learning environment by providing students with opportunities to collaborate in groups, exchange ideas, and express their opinions. Through such learning conditions, students' critical thinking skills, problem-solving abilities, and self-confidence can develop optimally, thereby contributing positively to improved learning outcomes.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Biology Education Study Program of Tadulako University, particularly the academic supervisors and examiners, as well as to SMP Negeri 13 Sigi Biromaru, especially the principal, science teachers, and students, for their participation and support in the implementation of this study.

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