

The problem-based learning effect on student learning outcomes about environmental change in vocational high schools

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Abstract: Understanding environmental change is crucial for students; however, the continued use of conventional teaching methods has led to low student learning outcomes in this area. This study aimed to analyze the impact of the Problem-Based Learning (PBL) model on improving the learning outcomes of Grade X students at SMK Negeri 1 Paguyaman concerning the subject of environmental change. A pre-experimental research design specifically the One-Group Pretest-Posttest Design was employed. The study population consisted of Grade X students at SMK Negeri 1 Paguyaman, with a purposively selected sample of 40 students. Learning outcome data were collected through written tests (pretest and posttest) that had undergone validity and reliability testing. The data were analyzed using a paired-sample t-test. The results indicate that the PBL model was effective in improving student learning outcomes regarding environmental change ($p < 0.05$), and the N-Gain test yielded an average score of 0.71, placing it in the high category. PBL enhances student learning outcomes by fostering active engagement in inquiry, discussion, and the resolution of real-world environmental problems related to environmental change.

Keywords: Environmental change, environmental learning, biology learning

Abstrak: Memahami perubahan lingkungan merupakan hal yang krusial bagi siswa; namun, penggunaan metode pengajaran konvensional yang terus-menerus telah menyebabkan rendahnya hasil belajar siswa dalam bidang ini. Penelitian ini bertujuan untuk menganalisis dampak model *Problem-Based Learning* (PBL) terhadap peningkatan hasil belajar siswa Kelas X di SMK Negeri 1 Paguyaman pada materi perubahan lingkungan. Desain penelitian pra-eksperimen khususnya *One-Group Pretest-Posttest Design* digunakan dalam studi ini. Populasi penelitian mencakup siswa Kelas X SMK Negeri 1 Paguyaman, dengan sampel sebanyak 40 siswa yang dipilih secara purposif. Data hasil belajar dikumpulkan melalui tes tertulis *pretest* dan *posttest* yang telah melalui uji validitas dan reliabilitas. Data dianalisis menggunakan uji-t sampel berpasangan *paired-sample t-test*. Hasil penelitian menunjukkan bahwa model PBL efektif dalam meningkatkan hasil belajar siswa terkait perubahan lingkungan ($p < 0,05$), dan uji N-Gain menghasilkan skor rata-rata 0,71, yang termasuk dalam kategori tinggi. PBL meningkatkan hasil belajar siswa dengan mendorong keterlibatan aktif dalam inkuiri, diskusi, dan pemecahan masalah lingkungan dunia nyata yang berkaitan dengan perubahan lingkungan.

Kata kunci: Perubahan lingkungan, pembelajaran lingkungan, pembelajaran biologi

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INTRODUCTION

Learning becomes more effective when teaching strategies shift from being teacher-centered to student-centered, encouraging students to actively seek answers or solutions to problems and apply them in their daily lives (Damopolii et al., 2025; Rosa et al., 2024). Selecting the right teaching strategy is key to effective learning; it facilitates the delivery of concepts, enabling students to grasp material more quickly and retain it in the long term (Aprillia et al., 2025; Aristaningsih et al., 2025). Consequently, teachers must master a range of teaching techniques and approaches to boost student enthusiasm for learning. Active student engagement enlivens classroom interaction, thereby enhancing overall student

interest, curiosity, and learning outcomes (Tanjung et al., 2019). Each student's level of success in mastering subject matter is expressed through scores (Nasir et al., 2024). Learning outcome assessment serves as a strategic instrument for measuring student achievement and provides a basis for teacher evaluation. Data on learning outcomes allow for immediate improvements, such as providing targeted assistance to struggling students or adjusting teaching strategies, to ensure optimal achievement of curriculum targets (Yusuf et al., 2024)

For vocational high school (SMK) students specifically, these evaluation results serve as a primary indicator of whether learning objectives have been met; these objectives focus not only on academic grades but also on the mastery of concepts and practical skills essential for the workforce (Afrita et al., 2018). Meanwhile, the viability of vocational schools relies heavily on collaboration with the industrial sector to achieve a favorable status and outcomes (Sa'idah & Hermina, 2025). Learning outcomes assess how effectively students meet learning targets, enabling them to independently identify their strengths and weaknesses. Through constructive feedback, students can prioritize areas for development and deepen their understanding (Shodiq et al., 2025). Consequently, successfully improving student learning outcomes is key to aligning academic achievements with professional demands in the workforce.

One of the topics where learning outcomes have significantly declined is environmental change. No more than 50% of students achieve mastery in this topic (Hikmah & Winarsih, 2023). Low student motivation to learn biology is evidenced by a lack of attention to the teacher's explanations, signs of drowsiness, a lack of enthusiasm during the learning process, and issues stemming from the use of inappropriate teaching methods (Hamidah et al., 2023). While understanding environmental change is crucial for students, the continued use of conventional teaching methods has led to poor learning outcomes in this topic (Nurlaifa et al., 2025). These low outcomes are attributed to teaching methods dominated by lectures and a lack of real-world environmental facts presented during biology lessons (Shinta et al., 2024). These findings indicate that instruction on environmental change faces challenges, including low student achievement and motivation, primarily driven by conventional, unvaried teaching methods that fail to link the material to real-world environmental facts and issues.

In the actual classroom setting for Grade X in Paguyaman, student achievement levels have gone down. In the "IPAS Project" (Natural and Social Sciences Project) subject, achievement levels relative to the topic "environmental change" are low, evidenced by the fact that 75% of the students had a score below the standard benchmark; this is compounded by problems in attitude and skills such as lack of initiative (no asking of the teacher), poor concentration and basic deficiencies in answering the teacher's questions. One of the factors that contribute to this is the fact that the teacher still employs traditional methods in teaching emphasizing mere giving of information. This is problematic because the topic of environmental change is vital to the Vocational High School (SMK) curriculum; student mastery of this material demonstrates their competence in identifying, analyzing, and proposing solutions for the environmental impacts caused by industrial activities within their specific fields of expertise.

Efforts to improve the learning process can be made by employing more varied instructional methods, such as using learning models and media relevant to the subject

matter (Apriansyah et al., 2026; Suherni et al., 2026). Learning models assist students in gaining learning experiences that foster the higher-order thinking skills needed to solve problems, ultimately enhancing student learning outcomes (Jayul & Irwanto, 2020). One such model is Problem-Based Learning (PBL). Implementing the PBL model represents a crucial solution; this instructional approach is grounded in real-world problems relevant to daily life and linked to the concepts being studied (Dwi et al., 2023). PBL uses problems as a focal point to develop problem-solving skills, subject-matter understanding, and self-regulation (Damopolii et al., 2024).

Several studies demonstrate the effectiveness of PBL in teaching environmental topics. Research by Puri et al. (2016) found that PBL regarding environmental change improved students' conceptual knowledge. Maufiroh et al. (2023) also found that student mastery increased to 86% when participating in PBL classes. PBL has been shown to enhance student learning outcomes on environmental change through active engagement in discussions, problem-solving, and a more meaningful knowledge-construction process compared to teacher-centered instruction (Adha et al., 2024). PBL improves learning outcomes by fostering active engagement in information-seeking, the analysis of real-world problems, and the meaningful construction of understanding of environmental change concepts (Zahra & Handayani, 2025).

In the context of the topic of environmental change, the effectiveness of Problem-Based Learning (PBL) has also been demonstrated by various studies on biology instructional development. These findings indicate that the nature of the environmental change topic is well-suited for instruction through contextual problems, as students can directly engage with issues relevant to their own lives. Consequently, the researcher aims to determine the impact of implementing PBL on student learning outcomes regarding the topic of environmental change in Grade X at SMK Negeri 1 Paguyaman.

METHOD

This study employed a pre-experimental design, specifically the One-Group Pretest-Posttest Design. It was conducted with a Grade X class at SMK Negeri 1 Paguyaman. The sample consisted of 40 students (21 male and 19 female), selected using purposive sampling. This selection was based on teacher recommendations, identifying the class as suitable for the study due to the students' relatively uniform academic abilities. The collected data were analyzed descriptively to draw conclusions. Briefly, the PBL process begins with problem orientation using case studies based on local issues in the surrounding environment, followed by investigating and analyzing the causes of the problem and formulating solutions (both short- and long-term), and concludes with evaluation and presentation.

Learning outcome data were gathered using a written test administered twice: a pretest (prior to the PBL intervention) and a posttest (following the PBL intervention). The written test consisted of 20 multiple-choice questions (options A, B, C, D, and E) designed according to the Minimum Competency Assessment (AKM) framework. The suitability of the test instrument was assessed by two validators. Table 1 presents the results of the question validation.

Table 1. Validity test of the test items

Item	Pearson Correlation	Sig.	Reliability
1	0.773	0.000	0.732
2	0.767	0.000	
3	0.953	0.000	
4	0.873	0.000	
5	0.580	0.000	
6	0.772	0.000	
7	0.766	0.000	
8	0.576	0.000	
9	0.553	0.000	
10	0.786	0.000	
11	0.651	0.000	
12	0.783	0.000	
13	0.978	0.000	
14	0.966	0.000	
15	0.560	0.000	
16	0.770	0.000	
17	0.675	0.000	
18	0.781	0.000	
19	0.686	0.000	
20	0.760	0.000	

Based on the calculation results, the test items were determined to be valid. This is evidenced by a significance value (sig.) of less than 0.05, indicating the items were suitable for administration to the research sample. The results of the reliability test are 0.732 which is high reliability and proves that the items are appropriate for the research sample. The data analysis process was conducted using the Paired Sample t-test and N-Gain post-test using SPSS version 26. The N-Gain data categorization was done using the formula by Hake (1998). The data underwent a normality test using the Shapiro-Wilk method before the t-test.

RESULTS AND DISCUSSION

A normality test was done to confirm that the regression model's residual values are normally distributed. The statistical test's primary purpose is to establish if the residual data's distribution meets the standards of a normal distribution before additional tests. The results are tabulated below in Table 2.

Table 2. Test of normality in class

	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest	0.951	40	0.082
Posttest	0.949	40	0.072

The normality testing criteria state that data are considered normally distributed if the significance value (Sig.) is greater than 0.05. Based on the calculations in Tables 1 and 2, the Shapiro-Wilk test results show a significance value of 0.082 for the pretest and 0.072 for the posttest. Both the pre-treatment and post-treatment data meet the normality

requirement, as their significance values exceed 0.05 ($p > 0.05$). Consequently, the requirements for conducting data analysis using parametric statistical tests have been met.

Table 3. Paired samples t-test results

	Mean	SD	T	Df	Sig.
Pretest-posttest	- 23.875	8.184	-18.450	39	0.000

Based on the Paired Samples t-test results for the research class (Table 3), the significance value (Sig. 2-tailed) was found to be 0.000, which is less than 0.05 ($p < 0.05$). This indicates a significant effect of the administered intervention on the improvement of student learning outcomes in Grade X.

Table 4. Results of n-gain calculation

Average Pretest	Average Posttest	Gain	N-Gain
55	86	31	0.7055

Based on Table 4, the average N-Gain score was 0.7055 or in the high category. This result means that the implementation of PBL was effective in improving student learning outcomes.

The results of the study revealed that the implementation of PBL had a significant effect on improving students' learning outcomes about the environment change in class X at SMK Negeri 1 Paguyaman. This statement was proven by the results of the hypothesis test which showed the value of 0.000 ($p < 0.05$). It means that the result of the students' learning outcomes using PBL was significantly different from the result of the students' learning outcomes without using PBL. This significant result implies that teachers' practice with PBL had a significant contribution to the students' learning outcomes about the environment change after the treatment. Therefore, the learning outcome after the treatment had improved significantly.

Enhanced learning outcomes using PBL could be explained by the characteristic of PBL. The characteristic of PBL put the problem in the center of the learning process. Students are given a problem to solve by finding the causes of events, determining solutions, analyzing, and evaluating them (Damopolii et al., 2018; Nisak & Susantini, 2023). They are not just given information from the teacher and then assessed through a test. In other words, students construct their own knowledge through active learning. Regarding the theory of learning, this characteristic relates to constructivism. According to the theory, knowledge is not given directly by the teacher but constructed by the students through experience, interaction, and activities in the learning process.

These PBL characteristics are highly relevant to biology instruction, particularly regarding the topic of environmental change. The subject matter of environmental change involves not only concepts that must be memorized but also encompasses various real-world phenomena, such as water and air pollution, ecosystem degradation, land-use changes, waste management, and the impact of human activities on the environment. Therefore, understanding this material requires the ability to connect biological concepts with phenomena encountered in daily life. Through PBL, environmental issues can serve as a learning context, providing students with the opportunity to identify facts, explain cause-

and-effect relationships, use biological concepts to analyze problems, and formulate solutions based on available information (Sogen et al., 2018; Zannah et al., 2022).

The implementation of PBL significantly improves learning outcomes because the model allows students to integrate prior knowledge with new information. These research findings align with the meta-analysis by Erdem (2024), which indicates that PBL has a substantial impact on student academic achievement. During the problem-solving process, students must identify known information, determine what additional information is required, locate relevant sources, and apply that information to explain the given problem (Aristaningsih et al., 2025). This process allows students to learn something in the way it is applied in a particular situation. This is very important in biology education, because the topics are related to complex relationships between organisms, the environment, ecological processes, and human activities. Students get a better understanding of the relations between topics using authentic problems, compared to instruction that focuses on providing information verbally.

In addition, the results align with the second-order meta-analysis performed by Koçoğlu and Kanadlı (2025), who collected 22 meta-analyses related to problem-based learning. They concluded that problem-based learning has a positive effect on cognitive outcomes. With this information in mind, we can say that the results obtained from the participants of grade 10 at SMK Negeri 1 Paguyaman can be related to the general tendency that problem-based learning has better results than traditional instruction that does not give students the opportunity to construct their own knowledge about the topics. We believe that the students who participated in this study achieved a higher level of thinking about the concepts they learned because they did not simply memorize the information. They interpreted and explained the phenomena related to environmental changes and made decisions about the problems they were asked to solve. This kind of cognitive effort contributes to achieving a deep understanding of the topics.

Furthermore, we think that the students' learning outcomes improved because they were more engaged in the learning process. When teachers are the primary source of information, students do not participate in constructing their knowledge. However, when a problem-based approach is used, students must collaborate with their peers, hypothesize about the causes of the problems, gather information, analyze it, and propose solutions based on the information they found (Damopolii et al., 2026; Nunaki et al., 2023). The process of finding and presenting information about a particular phenomenon makes students reflect on the content at a deeper level. Therefore, we can say that their understanding of the concepts improved, which is reflected in the high scores they achieved in the post-test.

As we have explained, students' learning outcomes improved because they were encouraged to participate in the learning process and construct their own knowledge using a problem-based approach. Using problem-based learning allows students to build their understanding of the topics based on their prior knowledge and apply it to a practical case that can be related to real-life contexts. Thus, this study demonstrated that problem-based learning is an efficient approach to support the improvement of students' learning outcomes related to environmental changes. However, we must consider other factors that may have influenced the results of this study, such as the design of the study, the population of the sample, the measurement instruments, the timeframe, and the implementation of the stages

of problem-based learning. All of these elements can have an effect on how much the students' learning outcomes improved.

CONCLUSION

Based on the research findings, it can be concluded that the implementation of Problem-Based Learning (PBL) is significantly effective in improving student learning outcomes regarding the topic of Environmental Change in Grade X at SMK Negeri 1 Paguyaman. Student learning outcomes under the PBL approach fell into the high category. PBL enhances learning outcomes through active engagement in inquiry, discussion, and the resolution of real-world environmental problems, while also deepening the understanding of biological concepts, specifically those related to environmental change.

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