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The Effect of Problem-Based Learning on Biology Achievement Grade XII-1 Students at Pakusari Senior High School

Pengaruh Pembelajaran *Problem-Based Learning* (PBL) terhadap Prestasi Biologi Murid Kelas XII 1 di Sekolah Menengah Atas Negeri Pakusari

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Abstract

This research has the purpose to assess the effect of the Problem-Based Learning (PBL) approach on biology achievement among XII 1 grade students at Pakusari State Senior High School, focusing on biotechnology material. It adopted a quantitative experimental method featuring a one-group pretest-posttest design. The sample consisted of 36 students. Learning outcome data were collected via a consistent pretest and posttest. Statistical analysis encompassed descriptive statistics, normality testing, and the Wilcoxon signed-rank test. Results showed pretest averages increasing from 42.5 to 65.83 in the posttest. Normality assessment confirmed non-normal distribution (Sig. < 0.05), prompting use of the Wilcoxon test, which produced a p-value level of 0.000 (< 0.05). As a result, the null hypothesis (H_0) was rejected in favor of the alternative (H_1), validating a statistically meaningful enhancement in students' learning outcomes pre- and post-PBL implementation. Hence, the PBL model demonstrably boosts learning outcomes effectively.

Penelitian ini memiliki tujuan untuk mengkaji pengaruh pendekatan Pembelajaran Berbasis Masalah (PBL) terhadap prestasi biologi siswa kelas XII 1 di SMA Negeri Pakusari, dengan fokus pada materi bioteknologi. Penelitian ini menggunakan metode eksperimental kuantitatif dengan desain pretest-posttest satu kelompok. Penelitian ini melibatkan 36 peserta. Data hasil belajar dikumpulkan melalui tes pra dan pasca intervensi. Analisis statistik meliputi statistik deskriptif, uji normalitas, dan uji Wilcoxon. Hasil menyatakan bahwa nilai rata-rata pretest meningkat dari 42,5 menjadi 65,83 pada posttest. Uji normalitas mengonfirmasi distribusi yang tidak normal (Sig. < 0,05), sehingga digunakan uji Wilcoxon, yang menghasilkan tingkat signifikansi 0,000 (< 0,05). Akibatnya, hipotesis nol (H_0) ditolak demi hipotesis alternatif (H_1), yang mengonfirmasi adanya peningkatan yang signifikan secara statistik dalam kinerja biologi siswa sebelum dan sesudah penerapan PBL. Oleh karena itu, model PBL terbukti berpengaruh dalam meningkatkan hasil belajar.

Article Information

Keywords: biology learning outcomes; Pakusari State Senior High School; pretest-posttest; problem-based learning.

Kata kunci: pembelajaran biologi; pretest-posttest; problem-based learning; SMA Negeri Pakusari.

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A. INTRODUCTION

Education is fundamentally essential for developing human resources to achieve a better future (Sa'diah et al., 2025). The level of progress of a nation is greatly influenced by the quality of its education, because a good education system produces high-quality human resources. Through the educational process, individuals can be shaped into people who are capable of realizing their full potential while contributing to the nation's progress (Pramana et al., 2020). Education has been a hot topic lately, requiring teachers to manage the learning process more effectively so that students are actively engaged rather than simply relying on the teacher. Active student engagement in independently discovering and processing information is expected to improve learning outcomes and help the information stay in their memory longer than if they were merely listening to the teacher's explanations (Lara & Syamsurizal, 2024). In the learning process, teachers need to continuously develop their teaching skills so that students' potential can be fully realized, even though in reality, many teachers in Indonesia still rely on conventional teaching models (Djonomiarjo, 2019). An instructional model is a design or framework used to develop a curriculum (long-term instructional planning), organize instructional resources, and act as a guide for implementing the learning process in the classroom or other settings (Mirdad, 2020). In this context, there are two primary approaches: the teacher-centered approach, which focuses on direct instruction, and the student-centered approach, which enables students to explore, discover, and investigate independently (Mawikere, 2022). Djonomiarjo (2019) argues that the teacher-centered approach is increasingly regarded as a traditional method in need of reform, as its emphasis on content delivery often limits student engagement, making it less relevant to the demands of the modern knowledge-based era.

The study of biology is one of the branches of the natural sciences. Essentially, biology is not an inconvenient subject to learn, because studying it means understanding oneself and one's surroundings. Biology also involves a systematic approach to exploring and understanding nature. Thus, biology is not merely about mastering and accumulating factual knowledge, concepts, and principles, but is also a process of finding (Harefa et al., 2022). Biology is not limited to the study of living organisms alone, but also encompasses their interactions with their environment. Biology can be studied through both textual and contextual approaches. Contextual biology instruction motivates students more engaged and enlivens the learning process more meaningful, as this approach focuses on student activities (Jayawardana & Gita, 2020). According to (Sudarisman, 2015), science (biology) education essentially encompasses six main elements, namely: 1) Active learning (students actively engaged in activities); 2) Discovery/inquiry approach (discovery-oriented learning); 3) Scientific literacy (learning based on scientific literacy); 4) Constructivism (learning that enables students to construct knowledge independently); 5) Science, technology, and society (science learning to solve everyday problems in society); and 6) The understanding that scientific truth is tentative, not absolute.

The Problem-Based Learning (PBL) model is an instructional approach that starts with presenting real-life, contextual problems. Students are then guided to analyze and solve these problems, enabling them to deepen their understanding of the subject matter (Nofziarni et al., 2019). The Problem-Based Learning (PBL) approach draws from cognitive psychology, especially the constructivist ideas developed by Piaget and Vygotsky. According to constructivism, learners do not simply absorb knowledge passively; instead, they build it actively through personal experiences and hands-on experiments. Within this framework, students take an active part in developing their own comprehension, centering on problem-solving as the core driver of the learning process (Mardani et al., 2021). The application of the Problem-Based Learning (PBL) model is an effective way to actively involve all students in the learning process while developing their thinking skills, as learning activities are linked to relevant real-life problems (Eismawati et al., 2019). Therefore, the application of the Problem-Based Learning (PBL) model is necessary as an alternative that can inspire students to take a more active role, express their opinions, think critically, participate in problem-solving, and improve learning outcomes.

Research demonstrates that applying the Problem-Based Learning (PBL) model enhances students' learning results by positioning them at the heart of the process. It does this through real-life problems that prompt active thinking, group discussions, and solution-finding. This finding aligns with a study by Fardi et al. (2024), which found that PBL significantly boosted performance in environmental pollution lessons. The data showed a marked quantitative gain from Cycle I to Cycle II: in Cycle I, only 35% of students (9 out of 26) met the achievement criteria, but after refinements in Cycle II, this jumped to 92% (24 out of 26). These gains were reinforced by shifts in engagement levels, with student participation rising from 50% in Cycle I to 83% in Cycle II, and teacher involvement improving from 58% to 83%. The findings reveal that the PBL model boosts not just cognitive achievements but also student involvement and instructor performance during learning. Consequently, PBL stands out as a powerful strategy for elevating science education quality, especially on environmental pollution topics (Fardi et al., 2024). Problem-Based Learning (PBL) is carried out via a series of stages: (1) presenting the problem for students to examine; (2) arranging students into learning groups; (3) facilitating individual and collaborative investigations; (4) creating and sharing study or case outcomes; and (5) reviewing and assessing the problem solutions (Anas, 2018).

In the Problem-Based Learning (PBL) approach, educators act as motivators, guides, and mentors throughout the process. Key benefits include: (1) promoting advanced thinking skills and active involvement in tackling problems; (2) basing learning on students' existing knowledge or mental frameworks for greater relevance; (3) allowing students to see direct real-world applications in the issues they address, which heightens their enthusiasm and drive; (4) building greater independence and maturity, enabling students to voice ideas, value diverse views, and cultivate constructive social behaviors; and (5) cultivating a teamwork-oriented setting via group tasks and peer exchanges. Moreover, PBL sparks creativity at both individual and collective levels, leading to peak learning results (Mardani et al., 2021).

This research aims to examine the effects of implementing the Problem-Based Learning (PBL) model on students’ biology learning results. It is designed to evaluate how effective the PBL approach is in enhancing students’ academic achievement. It is anticipated that the findings of this study will offer significant insights into how well the problem-based learning paradigm works in the biology education process.

B. METHOD

This study employs an experimental research method, specifically a pre-experimental design. This type is selected because it permits external factors to potentially affect the independent variable (Nuryanti, 2019). Studies adopting a pre-experimental method feature various design options, selected according to the study's objectives and the specific questions under investigation. With these factors in mind, this research utilized a one-group pretest-posttest design. This design does not include a control or comparison group; instead, it involves only a single group that serves as the experimental group (Kastrena et al., 2020). Thus, the focus of this study is to examine the changes that occurred within the group before and after the intervention was implemented. In this study, the students first took a pre-test to assess their initial abilities before the learning process began. Next, the students were introduced to the Problem-Based Learning (PBL) approach as part of their learning process. Afterward, all students completed a final test to assess the impact of the Problem-Based Learning (PBL) model on their learning results (Pangga et al., 2020).

This study was conducted at Pakusari State High School, involving 12th-grade students during the 2025/2026 academic year. The research activities took place from January to February 2026. The research subjects were the students of XII 1 Grade, designated as the experimental class for the second semester, consisting of 36 students, 10 males and 26 females. In the initial phase of the study, students were administered a pre-test aimed at measuring their baseline proficiency in the learning material before the implementation of the Problem-Based Learning (PBL) model. The pre-test results were used to establish an average baseline of student learning outcomes before the intervention was administered. Subsequently, the learning process was conducted by applying the Problem-Based Learning (PBL) model in accordance with the established syntax. After the entire learning sequence was completed, students were given a post-test to measure their abilities following the intervention. The post-test results were then analyzed to determine the average learning outcomes of the students after the implementation of the Problem-Based Learning (PBL) model and to compare them with the results before the intervention.

The data in this study include field notes and student learning results. The instruments used in this study consist of instructional instruments and assessment instruments. The instructional instruments used include learning modules based on the Problem-Based Learning (PBL) model, teaching materials, and worksheets. Meanwhile, the assessment instruments consist of a written test comprising 10 multiple-choice questions administered using the Quizizz app.

Data analysis techniques include descriptive analysis to describe learning outcomes and inferential analysis to test hypotheses. A normality test is conducted as an initial step. If the data are normally distributed, a Paired Samples T-Test is applied; if not, a Wilcoxon Signed-Rank Test is used, ensuring that the analysis aligns with the data characteristics and yields more accurate results (Rahmani et al., 2025). The N-Gain Score, also known as normalized gain, serves as a tool to evaluate how effectively a specific method or intervention performs in research (Andiniati et al., 2023). The data analysis for this study was carried out using SPSS (Statistical Package for the Social Sciences) and Microsoft Excel to achieve more accurate, systematic, and organized results.

Table 1. N-Gain Score Criteria

N-gain	Criteria
0,7 ≤ N-Gain ≤ 1	High
0,3 ≤ N-Gain ≤ 0,7	Medium
N-Gain < 0,3	Low

(Ramadhani & Amudi, 2020)

C. RESULTS AND DISCUSSION

The Problem-Based Learning (PBL) model represents an innovative, learner-focused strategy. It supports the growth of key cognitive abilities, including creative thinking, problem resolution, and effective communication. Throughout the process, students become more engaged by confronting genuine, real-life challenges that demand resolution via exploratory tasks. Solutions are derived through structured problem-solving steps and then reviewed, drawing from the learners' own encounters (Hamid et al., 2021). Within the Problem-Based Learning (PBL) framework, learners actively employ their cognitive capacities and scientific reasoning. The model's success also hinges on students' participation levels, which tie directly to their enthusiasm for the subject. A robust link here boosts their motivation. Such interest is vital for sharpening focus and concentration, curbing disinterest, and deepening comprehension of content. Highly motivated students approach the material diligently, which helps overcome learning obstacles (Asriningsih et al., 2021).

This research employs a quantitative approach to examine and evaluate the impacts of adopting the problem-based learning model on the academic achievement of XII 1 grade students at Pakusari State High School. This research design used is a one-group pretest-posttest design, which allows the researcher to assess the effectiveness of the model using a single group of students as the sample. In this design, students first took a pretest to measure their initial abilities, followed by Problem-Based Learning (PBL) based instruction, and concluded with a posttest to detect improvements in learning outcomes after the intervention. Therefore, the disparity between the pretest and posttest scores was used as the primary indicator to conclude the impact of the problem-based learning approach on student academic results.

Table 2. Results of the Descriptive Analysis of Learning Outcomes (Pretest and Posttest)

Statistics	Pretest	Posttest
Mean	42.5	65.83
Variance	329.86	385.42
Standard Deviation	18.17	19.63
Number of Students (n)	36	36
Average increase	23.33	

According to the data presented in Table 2, the descriptive analysis indicates that students' biology learning outcomes improved subsequent to the execution of the problem-based learning approach. This is evident from the pretest average score of 42.5, which subsequently increased to 65.83 on the posttest. This increase in scores indicates that students' initial ability before instruction was still relatively low; however, after being taught using the Problem-Based Learning (PBL) model, their learning outcomes showed a significant improvement. The 23.33 point increase indicates a positive change in students' understanding of biology material. This improvement suggests that students' active engagement in problem-based learning helps them grasp concepts more deeply. This is not only evident from the comparison of pretest and posttest results but is also supported by statistical test results. A normality test was conducted as an initial step. A Paired T-test was used if the data had a normal distribution; otherwise, the Wilcoxon Signed Rank Test was utilized, ensuring the analysis aligns with the data characteristics and yields more accurate results (Rahmani et al., 2025).

Table 3. Results of the Normality Test for Learning Outcomes (Pretest and Posttest)

Tests of Normality			
	Statistic	df	Sig.
Pretest Biotechnology	.196	36	.001
Posttest Biotechnology	.176	36	.007

According to Table 3, the p-value (Sig.) for the pretest data is 0.001, and for the posttest data, it is 0.007. In a normality test, data are regarded as following a normal distribution if the p-value level exceeds 0.05 (Sig. > 0.05); otherwise, if it is less than or equal to 0.05 (Sig. ≤ 0.05), the data do not follow a normal distribution (Simatupang, 2021). Therefore, since the p-values for the pretest (0.001) and posttest (0.007) are both less than 0.05 (0.001 < 0.05 and 0.007 < 0.05), we can conclude that the students' learning outcome data from both measurements are not normally distributed. This indicates that the data do not satisfy the normality assumption; therefore, subsequent analysis should employ a nonparametric statistical method. The nonparametric test used is the Wilcoxon Signed Rank Test.

Table 4. Results of the Wilcoxon Nonparametric Statistical Test

Test Statistics[a]	
	Posttest Biotechnology - Pretest Biotechnology
Z	-4.189[b]
Sig. (2-tailed)	.000

In hypothesis testing, the decision criterion is based on the significance level (Sig.); specifically, if Sig. < 0.05, the null hypothesis (H_0) is rejected, supporting the alternative hypothesis (H_1), whereas if Sig. > 0.05, H_0 is accepted (Suwele et al., 2024). The Wilcoxon Signed-Rank Test results shown in the table yield a Sig. value of 0.000, which is below 0.05 (0.000 < 0.05). Thus, H_0 is rejected, and H_1 is accepted. Rejecting H_0 confirms a statistically significant difference in students' learning results between the pretest (before intervention) and posttest (after intervention).

Table 5. Results of the N-Gain Statistical Test

	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain score	36	-1.00	1.00	.3652	.41670
N-Gain percent	36	-100.00	100.00	36.5212	41.67013
Valid N (listwise)	36				

The N-Gain statistical analysis table shows that the study involved 36 students, yielding an average N-Gain score of 0.3652 (or 36.52% in percentage terms). This points to enhanced learning results after applying the Problem-Based Learning (PBL) model, though individual gains varied, as indicated by the range of minimum and maximum scores. Per standard N-Gain benchmarks, the 0.3652 average falls in the moderate range. Overall, these results confirm that PBL delivers a reasonably effective boost to student performance, yet it does not qualify as highly effective.

More specifically, these results show that applying the Problem-Based Learning (PBL) model significantly enhanced the learning results of students in Class XII 1 at Pakusari State High School. This improvement did not occur by chance but was the result of a learning process that encouraged students to be active, think critically, and solve contextual problems. These results offer solid proof that dynamic approaches like Problem-Based Learning (PBL) enhance students' comprehension more potently, even if their impact stays at a moderate level.

Using the Problem-Based Learning (PBL) model boosts student achievement by involving phases that promote hands-on problem resolution. These encompass exchanging thoughts or views, teamwork, data collection, posing queries or suggestions, and showcasing outcomes. Problem-Based Learning (PBL) also immerses learners in grasping core concepts and principles, starting with problem presentation. Such challenges cultivate problem-solving routines, fostering advanced cognitive abilities like innovative ideation via idea probing and sharing, plus pinpointing viable fixes for given issues (Utami et al., 2023).

As an innovative teaching strategy, the Problem-Based Learning (PBL) model brings numerous benefits that elevate both the learning experience and results. That said, similar to other methods, it comes with certain drawbacks that require careful management during application to maximize its benefits (Alan & Afriansyah, 2017). The Problem-Based Learning (PBL) model delivers many benefits during instruction. It effectively deepens students' grasp of content, tests their capabilities, and instills satisfaction from uncovering fresh insights. Additionally, Problem-Based Learning (PBL) heightens learner participation and highlights that every topic involves active mental engagement rather than just absorbing facts from instructors or books. Problem-based learning (PBL) sessions are typically more captivating and fun while nurturing critical thinking. It equips students to use their knowledge in practical scenarios and sparks enduring curiosity beyond school. On the downside, Problem-Based Learning (PBL) poses challenges: disinterested or insecure students often struggle and avoid problem-solving. It also demands extended upfront planning for smooth execution. Moreover, if learners fail to see the point of the tasks, the experience loses value since they don't fully comprehend the intended lessons.

This study's results align with those from Sa'diah et al. (2025), who demonstrated that applying the Problem-Based Learning (PBL) model positively and significantly impacts student performance on ecosystem topics. Their work used an experimental approach featuring a one-group pretest-posttest design. In quantitative terms, a notable increase in learning achievement was observed. The average score of the students before the implementation of Problem-Based Learning (PBL) (pretest) was 60.42, which then increased to 82.61 after the implementation of Problem-Based Learning (PBL) (posttest), with an increase of 22.18 points. The statistical test results revealed a p-value (Sig.) level of $0.000 < 0.05$, verifying a notable disparity in learning results prior to and following the intervention. Furthermore, the average N-Gain of 56.36% falls into the moderate category, indicating that Problem-Based Learning (PBL) is quite effective in enhancing student learning outcomes (Sa'diah et al., 2025). Thus, this study demonstrates that the PBL model is capable of significantly improving learning outcomes, enhancing conceptual understanding, and fostering active student engagement in biology learning.

The findings of this study also demonstrate an enhancement in learning outcomes, specifically from an average score of 42.5 on the pretest to 65.83 on the posttest. The findings from the Wilcoxon Signed Ranks Test produced a p-value of 0.000 (< 0.05), so H_0 was rejected. The N-Gain test results also showed an average value of 0.3652 or 36.52%, which falls into the moderate category, indicating that the improvement in learning outcomes is considered fairly effective. In summary, the applied learning strategy substantially enhanced XII 1 grade students' results at Pakusari State High School, achieving moderate effectiveness and supporting prior studies on the Problem-Based Learning (PBL) model's solid potential in education. Deploying PBL has shown it can advance both cognitive and psychomotor gains, as it motivates learners to proactively research and resolve issues by gathering diverse data. Problem-based learning (PBL) often lacks a single right answer, allowing students to exercise critical and creative thought. This makes education more relevant by linking content to everyday experiences, beyond mere theory. Hands-on participation also aids long-term retention. In PBL, student involvement is essential: greater activity in debating, questioning, sourcing data, and sharing insights leads to stronger comprehension (Darmayanti et al., 2022).

In general, the study reveals that using the Problem-Based Learning (PBL) model can boost student performance, though the gains fall short of ideal levels. This is evident from the N-Gain scores in the low range, signaling that effectiveness hasn't met expectations. Factors like tight timelines for Problem-Based Learning (PBL) phases, varying starting abilities and participation among students, unfamiliarity with the full structured process, and scarce resources all contributed. Thus, future applications should refine planning, time allocation, and student preparation to achieve superior outcomes.

D. CONCLUSION

The comprehensive research outcomes confirm that applying the Problem-Based Learning (PBL) model markedly enhances biology achievement for XII 1 grade students at Pakusari State High School in biotechnology. Evidence includes the mean score rising from 42.5 (pretest) to 65.83 (posttest), plus the Wilcoxon Signed Ranks Test showing a p-value of 0.000 (< 0.05), leading to rejection of the null hypothesis (H_0). Furthermore, the N-Gain score of 0.3652 (36.52%) places it in the moderate effectiveness bracket, suggesting that Problem-Based Learning (PBL) provides adequate improvement in student results. These advances stem from Problem-Based Learning (PBL) emphasis on active student roles via problem-solving, collaboration, research, and result-sharing, which not only elevate scores but also build critical/creative thinking and profound conceptual insight—though further refinement is required for peak impact.

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