Indonesian Journal of Educational Innovation (IJEI)
Volume 1, Issue 2, August 2025
Pages: 37–41

ISSN : 3109-0176
E-ISSN : 3109-0168

The Impact of Problem-Based Learning on The Biology Achievement of Grade XI Students at SMAN 1 Sikur, East Lombok

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Article Info

Article History
Received: June 3, 2025
Revised: June 8, 2025
Accepted: June 30, 2025
Published: August 31, 2025

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Abstract

The increasing demand for 21st-century education requires innovative learning models that enhance students' critical thinking and problem-solving skills. This study aims to analyse the effect of the Problem-Based Learning (PBL) model on Biology learning outcomes among Grade XI students at SMAN 1 Sikur, East Lombok. A quantitative approach was employed using a quasi-experimental design with a pretest–posttest control group. The sample consisted of two classes, XI IPA 1 (control group) and XI IPA 3 (experimental group), each comprising 30 students. Data were collected through pretests and post-tests and analysed using an independent samples t-test. The results showed a significant difference in post-test scores between the experimental group (81.2) and the control group (73.3), with a p-value of 0.0006 ($p < 0.05$). It can be concluded that the PBL model has a significant positive impact on students' biology learning outcomes. These findings imply that PBL can be a practical instructional approach to foster meaningful and skill-oriented learning in secondary education.

Keywords: Problem-Based Learning; student learning outcomes; innovative learning models; critical thinking skills; problem-solving skills.

INTRODUCTION

Students in today's era of education are expected to go beyond mastering factual knowledge by acquiring essential competencies such as critical thinking, problem-solving, communication, and collaboration to navigate global challenges (Trilling & Fadel, 2009). In this regard, student learning outcomes play a crucial role in assessing the quality and effectiveness of the educational process. Among school subjects, Biology plays a pivotal role in fostering scientific literacy, as it involves not only conceptual understanding and scientific inquiry but also the development of complex and advanced thinking skills (Wood, 2003).

One approach believed to enhance both learning outcomes and 21st-century skills is the Problem-Based Learning (PBL) model. Rooted in constructivist theory, PBL emphasizes the importance of active student participation in the learning process through collaborative problem-solving of real-world issues (Savery, 2006). This model is designed to promote exploration, discussion, and critical reflection, thereby supporting deeper conceptual understanding and mastery of subject matter (Hmelo-Silver, 2004). Consequently, there is a functional relationship between the use of the PBL model as the independent variable and student learning outcomes as the dependent variable, which serves as the central focus of learning evaluation.

Although many studies have reported the positive impact of Problem-Based Learning (PBL) on student learning outcomes, the findings remain diverse and sometimes contradictory. Several studies have shown that consistent implementation of PBL can enhance students' conceptual understanding and critical thinking skills (Dochy et al., 2003; Schmidt et al., 2009). However, other findings highlight that the success of PBL largely depends on teacher readiness, availability of resources, and the learning environment (Kirschner et al., 2006). In certain regions, particularly in underdeveloped areas, limited facilities and a reliance on conventional teaching approaches continue to hinder the optimal application of innovative learning models, such as PBL (Yew & Goh, 2016). Nevertheless, previous research has demonstrated the effectiveness of PBL across various contexts. For instance, Fitriyyah and Wulandari (2019) found that PBL improved junior high school students' critical thinking skills on the topic of global warming, while Helmi and Selaras (2024) reported that PBL enhanced high school students' problem-solving abilities in Biology. In medical education, Alrahlah (2016) showed that PBL was effective in improving both conceptual understanding and clinical skills. On the other hand, a meta-analysis by Walker and Leary (2009) concluded that the effectiveness of PBL is highly dependent on instructional design and student engagement.

However, to date, there has been limited research specifically examining the impact of Problem-Based Learning (PBL) on Biology learning outcomes in secondary schools located in peripheral areas such as East Lombok. This presents a significant research gap that needs to be addressed. Therefore, this study aims to analyze the effect of the Problem-Based Learning model on the learning outcomes of Grade XI students in Biology at SMAN 1 Sikur, East Lombok. The novelty of this research lies in the implementation of PBL within a secondary school context with limited resources, thereby contributing to the expanding body of empirical evidence on the effectiveness of PBL in improving Biology learning outcomes.

MATERIALS AND METHODS

Time and Place

The study was conducted at SMAN 1 Sikur, East Lombok Regency, West Nusa Tenggara, during the odd semester of the 2024/2025 academic year. The intervention consisted of 10 sessions, each lasting 90 minutes.

Research Design

This study employed a quantitative approach using a quasi-experimental method with a pretest-posttest control group design. This design allows the researcher to compare students' learning outcomes between the group receiving the treatment (PBL) and the group taught using a conventional method (lecture), both before and after the intervention.

Population and Sample

The population of this study consisted of all Grade XI students at SMAN 1 Sikur, totaling 200 students. The sampling technique used was purposive sampling, considering the equivalence of academic achievement across classes. The selected samples were: Class XI Science 1 (30 students), serving as the control group (taught using the lecture method), and Class XI Science 3 (30 students), serving as the experimental group (taught using the PBL model).

Research Instrument

The primary instrument used in this study was the Biology Learning Outcomes Test, which consisted of multiple-choice and essay questions. The test was administered before (pretest) and after the intervention (post-test). The content validity of the instrument was ensured through expert review and a trial test conducted outside the sample in a classroom setting. The reliability of the multiple-choice items was analysed using the KR-20 formula and was categorized as highly reliable ($r = 0.87$). Supplementary data in the form of report card scores were used to support the initial academic equivalence between groups. Additionally, an observation sheet was used to directly monitor the implementation of PBL, focusing on student engagement, group collaboration, and the presentation of solutions.

Implementation Procedures of Research

The research procedure began with the preparation stage, which involved developing learning materials, validating instruments, and obtaining formal permission from the school. A pretest was then administered to both the experimental and control groups to assess their initial academic abilities. During the intervention phase, the experimental group was taught using the Problem-Based Learning (PBL) model through a series of stages: problem identification, group discussion, information gathering, and solution presentation. Meanwhile, the control group received instruction using the conventional lecture method based on the Remps-TPS strategy (Team, Pair, Solo, Presentation). Following the intervention, a post-test was conducted to assess improvements in students' learning outcomes. Finally, the data were analyzed both descriptively and inferentially using an independent samples t-test to determine whether there were significant differences between the two groups.

Data Analysis Techniques

To evaluate the effectiveness of improving student learning outcomes, pretest and posttest data were analyzed using the N-Gain test. The N-Gain was calculated using the formula proposed by Hake (1998): N-Gain = (Posttest Score – Pretest Score) / (Maximum Score – Pretest Score). The resulting gain scores were then categorized into three levels: high (≥ 0.7), moderate ($0.3 \leq g < 0.7$), and low (< 0.3). These categories provide a clear indication of the extent to which students' learning outcomes improved following the implementation of the instructional intervention.

In addition to the N-Gain test, descriptive statistical analysis was conducted to offer a comprehensive overview of the students' score distribution. This analysis included the calculation of the mean, standard deviation, maximum, and minimum scores. Such data provides insights into overall learning trends and variations in student performance. This approach follows the quantitative data analysis framework suggested by Creswell (2014), emphasizing the importance of understanding data distribution to support a more comprehensive interpretation of research findings.

Result and Discussion

Result

Learning Improvement (pretest to post-test)

Learning outcome data were obtained from the pretest and posttest administered to two groups: the experimental group (Class XI Science 3) and the control group (Class XI Science 1). The posttest scores were analyzed to determine the effect of the Problem-Based Learning (PBL) model on improving biology learning outcomes.

Table 1. Average Learning Outcomes of Students in the Control and Experimental Groups

Group	N	Average	Min	Max
Control class	30	73,3	62	85
Eksperiment class	30	81,2	70	91

The difference in scores was further tested using an independent samples t-test. The statistical analysis revealed a t-value of 3.74 with a significance level of $p = 0.0006$ ($p < 0.05$). This suggests a significant difference in learning outcomes between students taught using the PBL model and those taught using the lecture method.

Comparison of Average Student Learning Outcomes

Based on the post-test results, students in the experimental group who received instruction using the Problem-Based Learning (PBL) model achieved an average score of 81.2, with a score range of 70–91. Meanwhile, students in the control group taught through the lecture method obtained an average score of 73.3, with a range of 62–85. This difference was analysed using an independent samples t-test, yielding a significance value of $p = 0.0006$ ($p < 0.05$).

These results indicate a statistically significant difference between the two groups, with the experimental group outperforming the control group. This finding suggests that the Problem-Based Learning (PBL) model has a significant impact on improving student learning outcomes in Biology. The higher average post-test score in the experimental group further supports the effectiveness of PBL as a learning model that can meaningfully enhance students' academic achievement.

Student Activities in PBL Learning

Observation data on the learning implementation showed that students in the experimental class demonstrated a high level of engagement in problem identification, group discussions, information gathering, and solution presentation. These activities were consistently observed throughout the ten sessions, indicating that students were able to think critically and collaborate effectively to solve the problems provided by the teacher. In contrast, students in the control class tended to be more passive, primarily taking notes from the teacher without engaging in active participation.

Discussion

The Effect of PBL on Biology Learning Outcomes

The PBL model enables students to learn through contextual experiences, confront real-world problems, and collaborate to find solutions. This approach aligns with the principles of social constructivism, which emphasize that knowledge is actively constructed through interaction and exploration (Savery, 2006; Hmelo-Silver, 2004). It also addresses the demands of 21st-century learning, in which students are expected not only to memorize information but also to develop critical, creative, and reflective thinking skills (Trilling & Fadel, 2009).

A meta-analysis by Dochy et al. (2003), involving 43 studies, showed that PBL has a positive impact on conceptual understanding and the application of knowledge. Similarly, Schmidt et al. (2009) found that PBL enhances cognitive achievement and knowledge transfer skills in science education. Therefore, the findings of this study reinforce the growing body of empirical evidence supporting the effectiveness of PBL at the secondary education level.

This research aligns with the findings of Fitriyyah and Wulandari (2019), who reported that PBL enhances the critical thinking skills of junior high school students. Likewise, Helmi and Selaras (2024) found that PBL enhanced problem-solving abilities among senior high school Biology students. Dole et al. (2017) highlighted that PBL can foster students' intrinsic motivation, while Albanese and Mitchell (1993) emphasized that the success of PBL depends on task design and facilitator support. Furthermore, a meta-analysis by Strobel and van Barneveld (2009) concluded that PBL excels in developing non-cognitive skills such as teamwork and communication. Thus, the findings of this study contribute to the expanding empirical support for the broader implementation of PBL in diverse educational contexts.

Cognitive and Social Activities in PBL Learning

During the implementation of the PBL model, students demonstrated active engagement in group discussions, problem analysis, information gathering, and solution presentations. This suggests that PBL not only supports cognitive learning outcomes but also promotes affective and social development, encompassing aspects such as communication, collaboration, and responsibility (Wood, 2003; Belland et al., 2013).

Biology education, which is rich in abstract concepts, requires a high level of cognitive activity to prevent misconceptions. PBL provides students with the opportunity to elaborate on concepts using various sources, engage in discussions, and reflect on their understanding. This process aligns with the theory of scaffolding, which emphasizes the importance of providing gradual support to promote active learning (Hmelo-Silver et al., 2007).

Comparison of the Effectiveness of PBL and the Lecture Method

The control group, which was taught using the lecture method, showed lower learning outcomes. This can be attributed to the characteristics of the lecture method, which tends to be one-way and does not actively engage students in the processes of thinking and problem-solving (Kirschner et al., 2006). In Biology lessons, which require deep understanding and interconnected concepts, such a method is often inadequate.

A study by Alrahlah (2016) in the context of medical education found that PBL resulted in higher learning achievement and motivation compared to the lecture method. Similarly, Nurhidayati and Kurniawan (2020) concluded that the PBL method provides a more meaningful and sustainable learning experience than conventional approaches.

Accordingly, the results of this study indicate that students who learned through the Problem-Based Learning (PBL) model achieved higher learning outcomes than those taught using the lecture method. The experimental group demonstrated significantly higher average posttest scores, while the control group, which received lecture-based instruction, showed lower achievement levels. This reflects the limitations of the lecture method in promoting active student engagement. In contrast, PBL encourages students to think critically, solve problems, and construct understanding through group collaboration and direct involvement with contextual issues.

The Relevance of PBL in Biology Education in the Era of the Merdeka Curriculum

The Merdeka Curriculum emphasizes project-based learning and the strengthening of the Pancasila

Student Profile, which includes critical thinking, creativity, and collaboration. The PBL model is highly relevant to this policy direction, as it focuses on contextual problem-solving and promotes student autonomy in learning (Kemendikbudristek, 2022).

Through PBL, students not only learn Biology content but also how to learn, filter information, and present logical arguments. This aligns with the concept of scientific literacy, which is defined as the ability to understand and apply scientific knowledge to solve problems and make informed decisions (OECD, 2019).

Challenges in Implementing PBL in Secondary Schools

Although PBL has been proven effective, its implementation presents several challenges, especially in resource-constrained areas such as East Lombok. The success of this model largely depends on factors such as teacher preparedness, the availability of instructional time and learning facilities, and a shift in instructional mindset (Barrows, 1996; Tan, 2003).

Nonetheless, with ongoing professional development and strong institutional support, teachers can be gradually encouraged to implement the model. It is also essential for schools to foster teacher learning communities and provide contextually relevant learning resources that are grounded in the local environment.

Theoretical and Practical Implications

Theoretically, this study supports the argument that constructivist approaches, such as PBL, are more effective in fostering conceptual understanding and higher-order thinking skills. Practically, the findings encourage teachers to innovate by developing more participatory and meaningful learning models. Teachers can apply the PBL approach not only in Biology but also in other exploratory subjects. Furthermore, schools can use the results of this study as a basis for designing teacher training programs and implementing problem-based learning policies.

CONCLUSION

This study confirms that the Problem-Based Learning (PBL) model significantly enhances students' learning outcomes in Biology. Students taught using PBL showed higher posttest achievement compared to those taught through traditional lectures, indicating improved conceptual understanding, active engagement, and academic performance. PBL proves to be a practical approach for developing both subject mastery and essential 21st-century skills.

Teachers are encouraged to apply PBL in Biology and other concept-heavy subjects, while schools should provide continuous support through training, mentoring, and relevant learning resources. Future research can expand on this study by involving more schools, exploring additional variables such as motivation and collaboration, and examining the effectiveness of PBL in digital or blended learning settings. Despite its limitations in geographic scope and focus on cognitive outcomes, this study provides strong evidence for the broader implementation of PBL in secondary education.

ACKNOWLEDGEMENT

The researcher extends sincere gratitude to the school principal, the biology teacher, and all colleagues who provided valuable support throughout this study.

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