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Implementation of Problem-Based Learning to Improve Biology Learning Outcomes of Grade XI-D Students at MAN 1 Pamekasan

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Abstract
This classroom action research aimed to improve the cognitive learning outcomes of Grade XI-D students at MAN 1 Pamekasan through the implementation of the Problem-Based Learning (PBL) model in Biology instruction. The study employed the Kemmis and McTaggart action research model in two cycles involving 26 students. The action focused on Biology topics with comparable cognitive demands, namely the immune system and the endocrine system. Data were collected through learning outcome tests, observation sheets, field notes, and documentation. The test consisted of items representing cognitive levels C1-C4 and was assessed using a scoring rubric. Quantitative data were analyzed using descriptive statistics, mastery percentages, a paired-sample t-test, and Cohen's d. The mean score increased from 67.8 in Cycle I to 80.4 in Cycle II, while mastery increased from 53.8% (14 students) to 88.5% (23 students). The paired-sample t-test showed a significant improvement, $t(25) = 4.97$, $p < 0.001$, with a large effect size ($d = 0.974$). Classroom observations indicated improved participation after clearer instructions, role distribution, teacher scaffolding, and better time management in Cycle II. These findings indicate that PBL can improve Biology learning outcomes and support active, collaborative learning.

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Introduction

Biology provides students with an understanding of life concepts and the natural processes underlying them. Conceptual mastery of Biology is important not only for academic achievement but also as a foundation for developing critical thinking, analytical thinking, and problem-solving skills (Sitanggang et al., 2024). However, Biology learning at the senior high school or Islamic senior high school level often faces challenges because some topics are abstract, complex, and require an understanding of cause-and-effect relationships. Biology instruction that does not use an appropriate approach may result in low students' cognitive learning outcomes (Rosaningdyah & Rudyatmi, 2024).

Initial observations of Grade XI-D students at Madrasah Aliyah Negeri (MAN) 1 Pamekasan showed that 30.8% of the students, or 8 out of 26 students, had not reached the Minimum Mastery Criterion (MMC) of 70. Although 69.2% of the students had achieved mastery, this result had not yet met the classical mastery target set by the school and the researchers, namely at least 85% of students achieving the MMC. In addition, observation notes indicated that several students were still passive during discussions, were less confident in presenting scientific reasoning, and had difficulty connecting Biology concepts with real-life cases, especially in physiology topics that require an understanding of processes and mechanisms.

One learning model that is relevant for addressing these problems is Problem-Based Learning (PBL). PBL is a student-centered learning approach that uses authentic problems as learning triggers. Through PBL, students are trained to identify problems, explore information, discuss ideas, propose solutions, and reflect on the learning process collaboratively (Hidayati et al., 2024). Previous studies have also shown that PBL can improve conceptual understanding and Biology learning outcomes (Nafizatunni'am et al., 2024; Savitri et al., 2022).

Based on this background, this classroom action research aimed to improve the cognitive learning outcomes of Grade XI-D students at MAN 1 Pamekasan through the implementation of the PBL model. The study was considered successful if learning outcome means increased from cycle to cycle, at least 85% of students achieved the MMC of 70 or higher, and the quality of the learning process improved, particularly in discussion participation, group collaboration, and students' confidence in expressing ideas.

Research Method

This study was classroom action research using the Kemmis and McTaggart model, which consists of four stages in each cycle: planning, action, observation, and reflection (Tanjung et al., 2024). The research was conducted in two cycles, with each cycle consisting of one meeting lasting 2 x 45 minutes. The research subjects were 26 Grade XI-D students of MAN 1 Pamekasan in the even semester of the 2024/2025 academic year. The research was conducted from April to May 2025 in the Biology subject. Cycle I focused on the immune system topic, while Cycle II focused on the endocrine system topic. These two topics were selected because they both have conceptual and abstract characteristics, require understanding of cause-and-effect relationships, and allow the presentation of contextual problems. The equivalence of difficulty levels was maintained through the same instrument blueprint, coverage of cognitive domains C1-C4, and comparable assessment formats and weighting.

At the planning stage, the researchers prepared PBL-based teaching modules, student worksheets, problem scenarios, test instruments, observation sheets, and field notes. In Cycle I, the contextual problem used was related to the body's response to infection and the mechanism of the immune system. In Cycle II, the contextual problem was related to hormone regulation, blood glucose balance, and endocrine system disorders. Students were divided into small groups of four to five members. Each group received a problem, discussed the information needed, searched for conceptual explanations, formulated solutions, and presented the results of the discussion.

The PBL action steps included: (1) orienting students to the problem; (2) organizing students into groups; (3) guiding individual and group investigations; (4) developing and presenting problem-solving results; and (5) analyzing and reflecting on the problem-solving process. Reflection in Cycle I revealed several obstacles, including inefficient time use, insufficiently detailed instructions, and low participation among some students. Therefore, improvements were made in Cycle II by providing more structured instructions, explicitly assigning group roles, strengthening guiding questions, monitoring group work more intensively, and setting clearer discussion time limits.

The main data were collected using learning outcome tests at the end of each cycle. The test consisted of 10 items covering cognitive domains C1 to C4, with 2 items for C1, 3 items for C2, 3 items for C3, and 2 items for C4. The questions were in the form of a combination of open-ended response items and short-answer questions. Each item was scored from 0 to 10 based on a rubric that considered conceptual accuracy, completeness of reasoning, use of Biology terminology, and the ability to connect concepts with the problem context. The final score was converted to a scale of 0-100. The content validity of the instrument was examined through reviews by a Biology teacher and a Biology education lecturer to ensure alignment among indicators, content, and cognitive domains. Supporting data were obtained through observation sheets on PBL implementation, field notes, and documentation of learning activities.

Data were analyzed descriptively and inferentially. Descriptive analysis included the mean, median, standard deviation, standard error, number of students achieving mastery, and mastery percentage. The individual mastery criterion was a score of 70 or higher, while classical mastery was set at a minimum of 85%. Since the data from Cycle I and Cycle II came from the same students, the improvement in learning outcomes was analyzed using a paired-sample t-test at a 5% significance level. Before conducting the t-test, the score differences between cycles were examined to ensure that there was no serious violation of the normality assumption. The magnitude of the action effect was calculated using Cohen's d and interpreted based on the absolute value of the effect size.

Research Findings and Discussion

The implementation of the Problem-Based Learning (PBL) model had a positive impact on improving the cognitive learning outcomes of Grade XI-D students at MAN 1 Pamekasan. The final test results in Cycle I showed a mean score of 67.8 with a standard deviation of 16.16. A total of 14 out of 26 students, or 53.8%, achieved the MMC of 70 or higher. In Cycle II, after improvements were made to the learning strategy, the mean score increased to 80.4 with a standard deviation of 9.61. The number of students achieving mastery increased to 23 out of 26 students, or 88.5%. Thus, the classical mastery target of at least 85% was achieved in Cycle II.

Table 1. Description of Student Learning Outcomes in Cycle I and Cycle II

Cycle	N	Mean	Median	SD	SE
Cycle I	26	67.8	73.0	16.16	3.17
Cycle II	26	80.4	84.5	9.61	1.88

Table 2. Student Learning Outcome Mastery

Cycle	Number of Students Achieving Mastery	Number of Students Not Achieving Mastery	Classical Mastery
Cycle I	14 students	12 students	53.8%
Cycle II	23 students	3 students	88.5%

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The improvement in learning outcomes was also evident from the differences in the mean and median scores between cycles. The median score increased from 73.0 to 84.5, while the standard deviation decreased from 16.16 to 9.61. The decrease in standard deviation indicates that the variation in students' scores in Cycle II was smaller than in Cycle I. This suggests that the improved action not only increased the average score but also helped some students who previously had low achievement obtain better results.

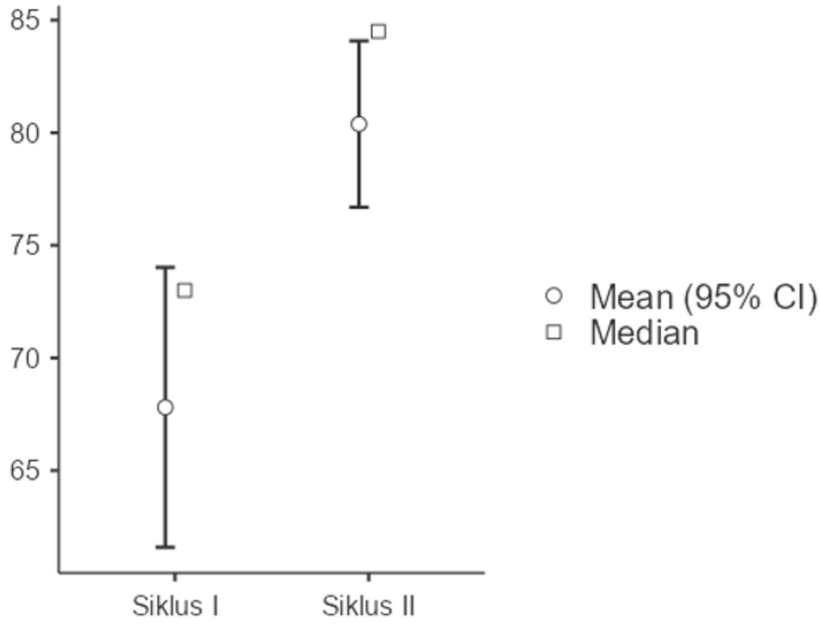

Figure 1. Graph of Student Learning Outcome Means in Cycles I and II.

The graph in Figure 1 clarifies the trend of improvement in learning outcomes between the two cycles. The refinement of the learning strategy in Cycle II, such as the use of more structured instructions and the facilitation of group discussions, had an impact on increasing student participation, including among those who had previously been passive. In addition to improving scores, learning through PBL also showed improvement in the quality of the learning process. Observations showed that students became more active in discussing, expressing ideas, and asking questions. The PBL model encourages students to construct meaning collaboratively and reflectively, which is an essential goal of 21st-century science learning (Abdurahman et al., 2024). PBL learning not only affects students' quantitative results but also develops higher-order thinking skills and meaningful learning as a whole.

Table 3. Paired-Sample t-Test Results

Paired Samples T-Test

			statistic	df	p		Effect Size
Siklus I	**Siklus II**	**Student's t**	-4.97	25.0	<.001	Cohen's d	-0.974

Note. H_a μMeasure 1 - Measure 2 < 0

The paired-sample t-test results in Table 3 show a significant improvement between Cycle I and Cycle II, $t(25) = 4.97$, $p < 0.001$. The effect size value of $d = 0.974$ falls into the large category, indicating that the improvement in learning outcomes was not only statistically significant but also practically meaningful in the learning context. The effect size was reported in absolute form because the focus of interpretation was the magnitude of the action effect, rather than the direction of the score difference.

This improvement can be associated with the characteristics of PBL, which facilitates contextual, collaborative, and active learning (Muhartini et al., 2023). Contextual problems help students activate prior knowledge and connect Biology concepts with real phenomena. When students were asked to explain immune response mechanisms or hormone regulation through cases, they did not merely memorize terms but also practiced interpreting relationships among concepts. This condition is consistent with the view that authentic problems in PBL can increase students' motivation and quality of understanding (Rozaq et al., 2024).

Classroom observation evidence showed that the quality of the learning process improved. In Cycle I, group discussions were not evenly distributed, and some students remained passive. In Cycle II, role distribution and teacher scaffolding encouraged students to be more active in expressing opinions, asking questions, and presenting discussion results. These findings support previous research showing that PBL is effective in improving Biology learning outcomes at the senior high school or Islamic senior high school level (Hartati & Billa, 2023; Thurrodliyah et al., 2024).

Nevertheless, the interpretation of the research findings should be made proportionally. The research instrument focused on cognitive learning outcomes up to the C4 level; therefore, the main claim that can be made is the improvement of cognitive learning outcomes and an indication of strengthened analytical ability. PBL has the potential to support higher-order thinking skills through problem identification, information analysis, and solution presentation activities (Busdayu et al., 2023). However, further research is still needed to measure HOTS more specifically using rubrics or instruments designed for that domain. In addition, this study was limited to one class, two cycles, and no comparison group; therefore, the generalization of the findings should be made cautiously.

Conclusion

The implementation of the Problem-Based Learning (PBL) model was proven to improve the cognitive learning outcomes of Grade XI-D students at MAN 1 Pamekasan in Biology. This was reflected in the increase in mean scores from 67.8 in Cycle I to 80.4 in Cycle II. The mastery percentage also increased from 53.8%, or 14 students, to 88.5%, or 23 students, so the classical mastery target of at least 85% was achieved in Cycle II. The paired sample t-test showed a significant improvement, $t\ (25) = 4.97$, $p < 0.001$, with a large effect size ($d = 0.974$). In addition to improving scores, classroom observations showed that PBL helped increase student participation, group collaboration, and confidence in expressing ideas after the teacher improved instructions, role distribution, scaffolding, and time management. Therefore, PBL can serve as an alternative Biology learning strategy for topics that are conceptual, abstract, and require problem solving.

Recommendations

Biology teachers are advised to implement PBL by preparing contextual problems that are close to students' daily lives, clear worksheets, group role distribution, and structured time allocation. Further research may examine the effect of PBL on non-cognitive variables, such as learning motivation, science process skills, scientific attitudes, and higher-order thinking skills, using more specific instruments. Future studies may also involve more classes, longer action cycles, or comparative designs so that the effectiveness of PBL can be analyzed more comprehensively.

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