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Enhancing High School Students' Understanding of the Excretory System through Problem-Based Learning

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ABSTRACT

Low cognitive learning outcomes in biology on the excretory system are often due to conventional learning methods that make students passive and focus on memorization. This study aims to improve students' cognitive learning outcomes by applying the Problem-Based Learning (PBL) model. The study used the Classroom Action Research (CAR) method, conducted in two cycles with 24 students from SMA Negeri 1 Kota Jambi. Data were collected through pretests and posttests in each cycle and analyzed using descriptive statistics, including average scores and learning completeness percentages. The results showed an increase in the average score from 46.25 in the pre-cycle to 80.83 in cycle I and 87.08 in cycle II, with the mastery percentage increasing from 4.17% to 100%. These findings indicate that the PBL model is effective in improving cognitive learning outcomes and fostering students' conceptual understanding and critical thinking skills. This study contributes by showing that the application of PBL through classroom action research can be an effective learning strategy for improving the quality of biology learning in secondary schools.

INTRODUCTION

Biology learning in the 21st century requires students not only to understand the material but also to develop high-level thinking and contextual problem-solving skills; however, classroom learning still tends to focus on memorization with limited opportunities for exploration, making it difficult for students to connect concepts to everyday life. Based on interviews with Biology teachers at SMA Negeri 1 Jambi City, students' cognitive learning outcomes remain low because learning is still teacher-centered, resulting in passive participation and limited involvement in analysis and problem-solving, indicating that the learning

model used has not effectively stimulated higher-order thinking skills as expected in the *Merdeka* Curriculum.

Learning innovations are needed that encourage active participation and meaningful knowledge construction, one of which is the application of the Problem-Based Learning (PBL) model (Astriawati & Djukri, 2019), which has been proven effective in improving cognitive learning outcomes across various educational contexts (Juliyanti & Nopriyeni, 2023). Learning outcomes are changes in student behavior due to learning activities. Improving student learning outcomes is an important aspect of education because it reflects the effectiveness of the learning process. Education plays a role in shaping character, expanding horizons, and changing students' behavior.

A study of learning outcomes is needed to ensure the achievement of educational goals. In addition, the learning model teachers apply also determines student success, as it serves as a guideline for the teaching process and directly affects learning outcomes. In addition, improvements in student learning outcomes are strongly influenced by the quality of instructional tools used by teachers.

Siburian et al. (2022) stated that learning tools play an important role in guiding the implementation and teaching and learning processes to achieve learning goals effectively. Furthermore, Utami et al. (2023) emphasized that the development of learning tools that are well-planned and aligned with students' needs can increase the effectiveness of implementing the learning model.

Effective learning strategies, such as PBL, are needed to train students to think critically, solve problems, and develop intellectual abilities (Rahmi et al., 2023). Therefore, evaluating learning outcomes becomes essential to determine how well the applied learning models support these skills. In this context, tracing learning outcomes is also important to assess the effectiveness of learning models implemented in schools.

The PBL model is a learning model that puts students in real-world problem situations that require them to think critically and work together to find solutions. PBL has proven effective in improving understanding of biological concepts because students are directly involved in the process of scientific inquiry (Tanjung et al., 2023). In addition, developing PBL models that incorporate environmental contexts can strengthen the connection between biological concepts and everyday phenomena, thereby improving student learning outcomes (Nurmiati et al., 2023).

The PBL model provides stimulation to provoke students' curiosity before learning a subject and prepares students to

try to solve problems by discussing them in groups, so that students are not only able to get a concept by building their own knowledge but also interact with teachers and other students through group work (Situmorang et al., 2015). Group learning can maximize students' cognitive learning outcomes by allowing them to develop their own concepts and understanding (Hilali et al., 2025).

Biology learning is experiential, so students need support to understand it. Biological material includes facts, concepts, and principles (Asyhari & Rahmawati, 2021). Biology learning is carried out through a combination of theoretical and practical learning to improve student understanding (Cahyaningrum & Supriatno, 2023). Excretory system material is one of the topics in biology that demands a high conceptual understanding because it relates to the structure of organs and the complex physiological processes of the human body.

In practice, many students struggle to understand the relationship between organ function and the process of removing metabolic waste. This is because the material is often presented theoretically and lacks contextual relevance. The application of the PBL model in this material has been shown to improve cognitive learning outcomes because students are involved in real problem-solving activities related to the human excretory system (Arni, 2023).

Various studies prove the effectiveness of PBL in improving students' cognitive learning outcomes. Hapsari et al. (2023) showed that the implementation of PBL at SMAN 2 Mataram increased the average score of learning outcomes from 68.4 to 87.6, while also reporting a significant increase in the evolution of materials through two cycles (Panuluh et al., 2023). PBL implementation. Dolmans et al. (2016) stated that PBL is effective in developing self-directed learning and students' analytical thinking skills.

However, most previous studies only used quasi-experimental methods. Therefore, Classroom Action Research (CAR) or *Penelitian Tindakan Kelas* (PTK). CAR is the right approach to examine the effectiveness of PBL in depth, because through two cycles of action, teachers can improve their learning strategies and systematically evaluate improvements in learning outcomes.

The PBL model was applied in Biology learning for grade XI through two cycles of CAR. The study focused on improving students' cognitive learning outcomes. This study measures improvements in learning outcomes and describes the systematic learning process in each action cycle (Juliyanti & Nopriyeni, 2023).

The low cognitive learning outcomes of students in the excretory system material

indicate the need to implement a learning model that can increase student involvement and encourage critical thinking and problem-solving skills. One alternative is the PBL model, which places students at the center of the learning process through contextual problem-solving activities. Through this approach, students are expected to actively construct their understanding and engage more deeply with the learning material.

The application of the PBL model is expected to help students understand excretory system concepts more thoroughly and improve their cognitive learning outcomes. Therefore, the purpose of this study is to improve the cognitive learning outcomes of grade XI students in Biology, specifically on excretory system material, through the implementation of the PBL model. This study is conducted using two cycles of Classroom Action Research.

RESEARCH METHODS

Study Design

This study uses the Classroom Action Research or CAR (*Penelitian Tindakan Kelas,* PTK) approach. This research focuses on improving student learning outcomes through a systematic and continuous learning improvement process. From these various views, it can be concluded that CAR is research conducted by teachers through a process of self-reflection in their classrooms with the main goal of improving student learning outcomes. It aligns with Sadikin & Sembiring (2023), who view CAR as an effective method for improving learning quality through cyclical improvement actions.

Location and Selection of Participants

The research was conducted starting on September 17, 2025, beginning with observation and followed by the implementation of actions in the classroom. It took place at SMA Negeri 1 Kota Jambi, Jambi Province, involving 24 students as the research subjects. Overall, the research activities were carried out over a period from September to October 2025.

Procedure

This research uses a model research design from Kemmis et al. (2014), carried out through four main stages: planning, action, observation, and reflection. In this classroom action research, improvements in learning outcomes were measured using a multiple-choice written test. The test consisted of 20 questions adopted from Muarifah (2024).

This test is given to determine the development of student learning outcomes from pre-action (*pretest*) to post-action (posttest) in cycle I, and from pre-action to post-action in cycle II. The assessment is conducted using rubrics prepared to ensure consistency and objectivity in measuring

learning outcomes. The teaching materials are in the form of point texts and Student Worksheets (*Lembar Kerja Peserta Didik*, LKPD), which serve as supporting media for learning activities.

Data Collection

The data collection technique in this study was carried out through written tests in the form of a pretest and posttest. These tests were used to measure improvements in student learning outcomes at each action cycle. In addition, data on cognitive learning outcomes were analyzed quantitatively using a formula (Anfa et al., 2023).

$$P = \frac{N}{A} x\ 100\%$$

Information:

P: Percentage increase in cognitive learning outcomes
N: Number of students who obtained a score of ≥ 70
A: Total number of students

Data Analyze

Data were analyzed using descriptive quantitative analysis. The study is considered successful if a student's cognitive learning outcome score is ≥70, and if students who obtained a score of ≥70 reached 100% of the total number of students in the class. Furthermore, to objectively interpret student learning outcomes, it is necessary to classify grades based on achievement levels. The levels of student learning outcomes are presented in **Table 1.**

Table 1. Learning outcomes categories

No.	Value Interval	Categories
1	86-100	Excellent
2	71-85	Good
3	56-70	Sufficient
4	41-55	Low
5	≤ 40	Very low

Sources: Basam et al. (2022)

RESULTS AND DISCUSSION

The results of the classroom action research conducted over two cycles showed a clear improvement in students' cognitive learning outcomes after the implementation of PBL in excretory system material. This improvement reflects a positive change in the learning process, with students becoming more actively involved and demonstrating a better understanding of the concepts. Based on the test results administered to 24 students, the average score increased from 46.25 in the pre-cycle to 80.83 in the first cycle, and further improved to 87.08 in the second cycle **(Table 2)**, indicating continuous improvement in student learning outcomes across each cycle.

Table 2. Cognitive learning outcomes in each cycle

Description	**Pre-cycle**	**Cycle I**	**Cycle II**
Number of students	24	24	24
Minimum score	30	60	70
Maximum score	70	100	100
Average score	46.25	80.83	87.08
Number of students who scored ≥70	1	23	24
Completion percentage	4.17%	95.83%	100%

Based on **Table 2**, there was a significant increase in students' cognitive learning outcomes from the pre-cycle stage to cycle II. In the pre-cycle stage, of the 24 students, only 1 (4.17%) achieved a score of ≥70, with an average class score of 46.25. This condition indicates that most students have not met the minimum completeness criteria (*Kriteria Ketuntasan Minimum*, KKM). The low learning outcomes indicate that students' understanding of the learning materials remains low and that student involvement in the learning process is suboptimal. In addition, this condition can illustrate that the previously used learning methods have not enabled students to understand concepts thoroughly.

After implementing learning actions in Cycle I, there was a clear increase in learning outcomes. The average class score rose to 80.83, and the number of students who obtained a score of ≥70 increased to 23 students (95.83%). This improvement indicates a positive change in the learning process, as greater student involvement through discussion, exploration, and problem-solving helps them understand the material more easily. In addition, increased interaction among students and with the teacher supports better conceptual understanding and the development of critical thinking skills.

In Cycle II, student learning outcomes showed more optimal improvement, with all students (100%) achieving a score of ≥70 and the average class score increasing to 87.08. These results indicate that the learning actions carried out were able to achieve the expected learning objectives. This improvement shows that students not only obtained higher scores but also demonstrated better understanding of concepts, problem analysis, and application of knowledge. In addition, the consistent increase in learning outcomes reflects a more interactive and student-centered learning process.

Overall, the increase in learning outcomes from pre-cycle to cycle II reflects the success of implementing active learning strategies in improving learning quality. This strategy has been proven to increase student motivation for learning, strengthen student involvement in the learning process, and help students build a more meaningful understanding of concepts. This gradual and consistent improvement also shows that the process of reflection and learning improvement in each cycle contributes greatly to improving student learning outcomes. It is further strengthened by the data visualization in **Figure 2**, which shows the trend of continuous improvement in student learning outcomes across the learning stages implemented.

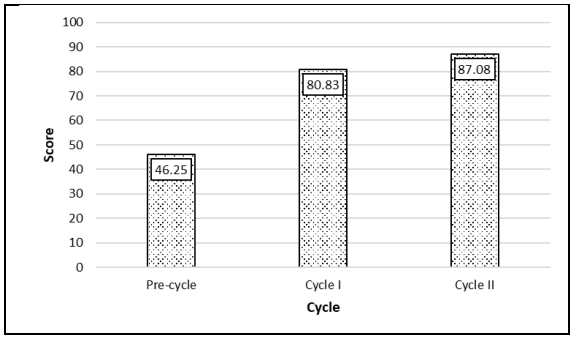

Figure 2. Comparison diagram of cognitive learning outcomes

Table 3. Categories of students' cognitive learning outcomes

Categories	Pre-cycle	Cycle I	Cycle II
Excellent	0	8	13
Good	0	8	7
Sufficient	4	8	4
Low	9	0	0
Very low	11	0	0

Note: Values represent the number of students.

Based on **Figure 2,** the average pretest score increased from 46.25 in the first cycle to 87.08 in the second cycle. It shows that students' initial understanding of the material increases when the PBL model is applied sustainably. The average posttest score also increased from 80.83 to 87.08, indicating an increase in students' understanding of the excretory system. Overall, the continuous implementation of PBL can shift most students into the high-learning-outcomes category.

These findings are in line with research by Ghani et al. (2021) and Tanjung et al. (2023), which affirm the effectiveness of PBL in improving analytical thinking skills and cognitive learning outcomes. Thus, the PBL model is a worthy approach for Biology learning because it has been proven to strengthen students' learning activities and conceptual understanding. Details on improving students' cognitive learning outcomes, by category and cycle, are presented in **Table 3.**

Based on **Table 3,** in the pre-cycle stage, most students are in the Very Low and Low categories, showing a low initial understanding of the material. After implementing PBL in the first cycle, the Very Low and Low categories disappeared entirely, and the majority of students moved into the Good and Excellent categories. In cycle II, the improvement continued with all students reaching the minimum sufficient category, and more than half (13 students) were in the Excellent category.

Applying the PBL model has successfully fostered students' interest, engagement, and enthusiasm for learning through direct involvement in solving real problems. Overall, the comparison of the results of the two cycles shows that the application of PBL is effective in improving the cognitive learning outcomes of grade XI students on the Excretory System material. The increase to 100% completeness in cycle II was influenced by increased student involvement in discussions, the use of

contextual problems, and more targeted teacher guidance.

In the first cycle, there are still obstacles, such as students who are not accustomed to problem-based learning and uneven participation in discussions. Therefore, in cycle II, improvements were made by providing clearer directions and teacher assistance during discussions, thereby increasing student participation and understanding. The application of PBL, when accompanied by effective guidance, also strengthens student cooperation and helps them understand concepts more deeply (Ghani et al., 2021). Thus, PBL can be an effective learning strategy for biology teachers to improve students' cognitive learning outcomes (Anila et al., 2015).

The improvement in learning outcomes through PBL is due to the investigative and discussion process that encourages students to understand concepts in depth rather than just memorize. The application of PBL can simultaneously improve learning outcomes through contextual learning experiences relevant to daily life (Andaryanti, 2023). Zevender et al. (2023) found that PBL significantly improved problem-solving skills and learning outcomes.

This study indicates that applying the PBL model can improve students' cognitive learning outcomes; however, it has several limitations, including a small sample size from a single class, a focus limited to cognitive aspects of the excretory system material, and a short implementation period of only two cycles, so the results cannot be generalized or reflect long-term impacts.

Therefore, further research is recommended to involve a larger sample and be conducted across several schools, so that the results of the study have a higher level of generalizability. Subsequent research can also examine the influence of the PBL model on various other aspects of learning, such as students' problem-solving skills, creativity, and scientific attitudes. In addition, further research can combine the PBL model with technology-based learning media or other learning approaches to provide a more innovative and effective learning experience.

Further research is recommended to involve larger samples and multiple schools to enhance generalizability, as well as to examine the influence of the PBL model on other learning aspects such as problem-solving skills, creativity, and scientific attitudes. In addition, future studies may integrate PBL with technology-based learning media or other approaches to create more innovative and effective learning experiences.

CONCLUSION

The application of PBL improved students’ cognitive learning outcomes in

excretory system material, as shown by an increase in the average score from 46.25 in the pre-cycle to 87.08 in the second cycle, with 100% learning completeness. The model encouraged active participation, critical thinking, and collaborative problem-solving, while helping create a more interactive and meaningful learning environment. However, the study was limited by a small sample size and a single setting, so further research involving larger samples, multiple schools, and other learning aspects is recommended, and teachers are encouraged to implement PBL with careful planning and appropriate learning support.

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