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THE EFFECT OF IMPLEMENTING PROBLEM-BASED LEARNING (PBL) MODEL ASSISTED BY PROBLEM-BASED LKPD ON STUDENTS' LEARNING OUTCOMES IN MOTION SYSTEMS MATERIAL

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ABSTRAK
Penelitian ini bertujuan mengetahui pengaruh model Problem Based Learning (PBL) berbantuan LKPD berbasis masalah terhadap hasil belajar dan kemampuan kognitif peserta didik pada materi sistem gerak kelas XI SMA Negeri 1 Bahorok Tahun Pelajaran 2025/2026. Penelitian quasi eksperimen dengan desain Pretest and Posttest Control Group ini melibatkan 72 peserta didik yang dipilih melalui Simple Random Sampling. Kelas XI-1 sebagai eksperimen mendapat pembelajaran PBL berbantuan LKPD, sedangkan XI-3 sebagai kontrol menggunakan pembelajaran langsung (ceramah). Hasil penelitian menunjukkan peningkatan. Rerata nilai meningkat dari 37,31 → 72,78 pada kelas eksperimen (ketuntasan 61,11%) dan 41,11 → 55,00 pada kelas kontrol (ketuntasan 19,44%). Secara keseluruhan, N-Gain kelas eksperimen g = 0,57 (57%, sedang), lebih tinggi daripada kontrol g = 0,23 (23%, rendah). Pada level kognitif C4-C6 kelas eksperimen menunjukkan N-Gain C4 = 0,60 (60%, sedang), C5 = 0,51 (51%, sedang), dan C6 = 0,70 (70%, tinggi)—secara konsisten melampaui kelas kontrol (C4 = 0,30; C5 = 0,16; C6 = 0,09).Dengan demikian, penerapan PBL berbantuan LKPD berbasis masalah berpengaruh positif terhadap hasil belajar dan kemampuan kognitif peserta didik.
Kata kunci: *Problem Based Learning, LKPD berbasis masalah, hasil belajar, kemampuan kognitif.*

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ABSTRACT
This study aims to determine the effect of the Problem-Based Learning (PBL) model assisted by problem-based worksheets on the learning outcomes and cognitive abilities of students in the motion system subject in class XI at SMA Negeri 1 Bahorok in the 2025/2026 academic year. This quasi-experimental study with a pretest and posttest control group design involved 72 students selected through simple random sampling. Class XI-1, as the experimental group, received PBL learning assisted by problem-based worksheets, while class XI-3, as the control group, received direct learning (lectures). The results of the study showed an increase. The average score increased from 37.31 to 72.78 in the experimental class (61.11% mastery) and from 41.11 to 55.00 in the control class (19.44% mastery). Overall, the N-Gain of the experimental class was g = 0.57 (57%, moderate), higher than that of the control class, g = 0.23 (23%, low). At the

C4-C6 cognitive level, the experimental class showed N-Gain C4 = 0.60 (60%, moderate), C5 = 0.51 (51%, moderate), and C6 = 0.70 (70%, high)—consistently exceeding the control class (C4 = 0.30; C5 = 0.16; C6 = 0.09). Thus, the application of PBL assisted by problem-based LKPD had a positive effect on the learning outcomes and cognitive abilities of students.
Keywords: *Problem Based Learning, problem-based LKPD, learning outcomes, cognitive abilities.*

INTRODUCTION

Education plays a strategic role in shaping superior and competitive human resources. Education is not merely a means of transferring knowledge but also a platform for fostering critical thinking, problem-solving, and collaboration skills that are essential in the 21st century (Mardapi, 2017). Student learning outcomes are an important indicator of educational success because they demonstrate the extent to which students can understand and apply the concepts they have learned (Sanjaya, 2014). In line with this, the Merdeka Belajar Curriculum, currently implemented in Indonesia, emphasizes the importance of student-centered learning to foster creativity, independence, and higher-order thinking skills (Ministry of Education and Culture, 2020).

However, the reality in the field shows that biology learning still faces obstacles. Observations conducted at Bahorok 1 Public High School indicate that biology learning in grade XI tends to be dominated by lecture methods and individual assignments. The student worksheets used in learning generally only contain material and questions without relating them to real problems relevant to students' lives. Learning media are also still limited to blackboards and textbooks. This condition causes students to be less actively involved in learning, resulting in their understanding of Biology concepts tending to be theoretical and meaningless. Pre-research data were taken from the test score records obtained from the Biology teacher in the odd semester of the current academic year. The results showed that only 41% of students achieved the Minimum Passing Grade (KKM) of 80, while the other 59% did not pass. This indicates that the quality of learning still needs to be improved.

The primary issue in biology learning is the dominance of the teacher-centered approach. This paradigm renders students passive and less likely to engage in discussions and concept exploration (Kurniawati et al., 2021; Rahmawati & Setiawan, 2022). Consequently, students tend to merely receive information from the teacher without the opportunity to construct their own knowledge. This condition results in low conceptual understanding, inadequate critical thinking skills, and poor student learning outcomes. Therefore, a learning model is required that can enhance students' active participation, provide opportunities for exploration, and assist them in connecting Biology concepts to real-world phenomena.

One model that can address these challenges is Problem-Based Learning (PBL). PBL is an innovative learning model that positions students as active subjects in the learning process by engaging them in solving authentic, contextually relevant problems (Bilodi, 2019). Through PBL, students not only master concepts but are also trained to develop critical thinking, communication, and collaboration skills (Kurt & Sezek, 2021). Previous studies have demonstrated that PBL can enhance learning motivation, conceptual understanding, and student learning outcomes (Saleh et al., 2021; Bergstrom et al., 2016).

The implementation of PBL becomes more effective when supported by problem-based Student Worksheets (LKPD). LKPD serves as a learning guide that helps students investigate problems, analyze information, and develop solutions through systematic steps aligned with PBL syntax (Majid, 2019; Arends, 2012). PBL-based LKPD not only contains material summaries and practice questions but also presents contextual problem scenarios that challenge students to think critically and discover concepts through independent and collaborative learning experiences (Aini et al., 2019). Previous studies have demonstrated that using PBL-based LKPD enhances student motivation, engagement, and learning outcomes in Biology (Nasir et al., 2023; Mufidah et al., 2023).

Based on the identified issues, the implementation of the Problem-Based Learning model supported by problem-based worksheets is considered relevant for enhancing the quality of biology learning, particularly in the subject of the human musculoskeletal system. Through this approach, it is expected that students will become more active in the learning process, develop a deeper understanding, and be able to relate concepts to everyday life. Therefore, this research was conducted under the title "The Effect of Problem-Based Learning (PBL) Model Assisted by Problem-Based Student Worksheets on Learning Outcomes in Musculoskeletal System Material Among Grade XI Students at SMA Negeri 1 Bahorok in the 2025/2026 Academic Year.

RESEARCH METHOD

This study employed a quasi-experimental method with a pretest-posttest control group design. This design involved two groups that were not randomly selected at the individual level but were assigned based on existing classes: one experimental class and one control class. Both groups were given a pretest to measure their initial ability. The experimental class then received treatment in the form of instruction using the Problem-Based Learning (PBL) model assisted by problem-based worksheets, while the control class was taught using the direct instruction (lecture) method. After the treatment, both classes were given a posttest to measure the difference in learning outcomes. The research design is presented in Table 1.

Table 1. Research Design

Group	Pre Test	Treatment	Post Test
Experiment	O_1	X_1	O_2
control	O_1	X_2	O_2

Description:

O_1 = Initial test (*Pretest*)

O_2 = Final test (*Posttest*)

X_1 = Learning process treatment using the PBL model with the assistance of problem-based LKPD

X_2 = Learning process treatment not using the PBL model

The research was conducted at SMA Negeri 1 Bahorok, Langkat Regency, in the odd semester of the 2025/2026 academic year. The research population consisted of all 144 students in grade XI, divided into four classes. The sample was determined using simple random sampling, resulting in class XI-1 as the experimental group and XI-3 as the control group, with a total of 72 students.

The research instrument was a test of cognitive learning outcomes on the subject of the human motor system. This test took the form of multiple-choice questions developed based on Bloom's revised taxonomy (C1–C6), covering indicators of the ability to remember, understand, apply, analyze, evaluate, and create. The test contained 40 questions and was piloted on students outside the research sample. The validity test results showed that 30 items were valid, while the reliability test using Cronbach's Alpha produced a coefficient of 0.9239, indicating very high reliability. In addition, the difficulty level analysis showed that there were 5 easy questions, 21 medium questions, and 4 difficult questions. The discrimination test resulted in 6 questions with a very good category, 17 good questions, and 7 sufficient questions, so that 30 selected questions were used as research instruments.

The data analysis conducted in this study is as follows:

1. Normality Test
   A normality test was conducted to determine whether the pretest and posttest data were normally distributed. The test was performed using Kolmogorov-Smirnov with SPSS version 22. The criteria used were that if the significance value (sig.) was > 0.05, the data was normally distributed, whereas if sig. was < 0.05, the data was not normally distributed (Santoso, 2018). If the data is not normal, the analysis is continued using a non-parametric test, namely the Wilcoxon test as an alternative to the paired sample t-test (Sugiyono, 2017).
2. Homogeneity Test
   The homogeneity test was conducted to determine the similarity of variance between sample groups. The test was performed using Levene's Test for Homogeneity of Variance using SPSS version 22 on pretest and posttest data. The test criteria were that if the significance value (sig.) was > 0.05, the data was declared homogeneous, whereas if sig. was < 0.05, the data was not homogeneous (Santoso, 2018).
3. Hypothesis Testing
   Hypothesis testing was conducted to determine the difference in learning outcomes between the experimental class and the control class. The analysis used an Independent Sample t-Test with the help of SPSS version 22, after the data met the assumptions of normality and homogeneity. The testing criteria are that if the significance value (sig.) < 0.05, there is a significant difference between the two groups, whereas if sig. > 0.05, there is no significant difference (Sugiyono, 2017). If the data does not meet the parametric test requirements, a non-parametric alternative test is used.
4. N-gain Test
   To see the improvement in students' critical thinking, it is calculated using the N-Gain formula. The formula is as follows:

$$N - gain = \frac{Score\ posttest - Score\ pretest}{Score\ maximal - Score\ pretest}$$

The N-Gain score categories can be seen in Table 2.

Table 2 N-Gain score categories

Nilai Gain	categories
g > 0,7	High
0,3 < g ≤ 0,7	Medium
g ≤ 0,3	Low

(Arikunto, 2013)

RESULT AND DISCUSSION

Result

Student learning outcomes data were obtained through pre-tests and post-tests in the experimental and control classes. Pre-tests were used to determine initial abilities, while post-tests were used to assess improvements in learning outcomes after instruction. The experimental class used a problem-based learning (PBL) model assisted by problem-based worksheets, while the control class used conventional learning. A summary of the scores is shown in Table 3.

Table 3 Pre-test and Post-test Scores of Student Learning Outcomes

Class	Percentage (%)	
	Pretest	***Postest***
Exsperiment	37,31%	72,78%
control	41,11%	55%

Based on Table 3, the pretest scores of the control class (41.11%) were slightly higher than those of the experimental class (37.31%), indicating that the initial abilities of both classes were relatively similar and still low. After learning, both classes improved, but the experimental class improved more (72.78%) than the control class (55%).

In terms of learning completeness with a minimum passing grade of 70, most of the control class did not achieve completeness (19.44% of students achieved completeness), while the experimental class showed higher completeness (61.11% of students achieved completeness). This shows that the application of the problem-based PBL model assisted by LKPD is effective in improving learning outcomes and the number of students who achieve completeness.

In addition to analyzing overall learning outcomes, this study examined student development based on Bloom's cognitive taxonomy levels. Analysis by cognitive level was conducted to see which thinking skills improved the most after learning.

Table 4 Percentage per Cognitive Level in the Experimental Class

Level of Cognitif	Percentage (%)		
	Pretest	***Posttest***	**Increase**
C1 (Remember)	88	99	89
C2 (Understand)	71	92	73
C3 (Apply)	59	87	68
C4 (Analyze)	31	72	60
C5 (Evaluate)	8	55	51
C6 (Create)	0	48	70

Based on Table 4, it can be seen that the average score for correct answers in the experimental class showed a greater increase than in the control class. A

significant increase occurred mainly at high cognitive levels (C4–C6). For example, at C4 (analyzing) and C6 (creating), the n-gain percentages were 60% and 70%, respectively, indicating that problem-based learning was able to encourage students to engage in critical assessment and generate new ideas.

Table 5 Percentage per Cognitive Level in the Control Class

Level of Cognitif	**Percentage (%)**		
	Pretest	***Posttest***	**Increase**
C1 (Remember)	88	99	89
C2 (Understand)	78	94	73
C3 (Apply)	73	79	23
C4 (Analyze)	35	55	30
C5 (Evaluate)	7	22	16
C6 (Create)	0	11	9

Based on Table 5, the average score for correct answers in the control class increased at each cognitive level after conventional learning. However, the increase was relatively small. At the low level (C1–C3), there was a significant increase, for example, at C3 (applying) the n-gain percentage was 23%. Meanwhile, at the high level (C4–C6), the increase was still limited, with an average n-gain percentage that did not reach 30%. This shows that direct learning (lectures) tends to only reinforce basic conceptual understanding without encouraging higher-order thinking skills.

Table 6 Percentage of Cognitive Levels on the Posttest

Class	**Cognitive Level Percentage on the Posttest (%)**					
	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Exsperiment	99	92	87	72	55	48
Control	99	94	79	55	22	11

When comparing the two classes, it can be seen that both the control and experimental classes experienced an increase in scores at all cognitive levels. However, the increase in the experimental class was much greater, especially at the higher levels. Based on Table 4.5, in the control class, the highest posttest score only reached 99% (C1), while the scores at C5 and C6 were still low (22% and 11%). In contrast, in the experimental class, the posttest score reached 99% (C1) and even at levels C5 and C6, it increased sharply to 55% and 48%.

Thus, it can be concluded that the application of the Problem-Based Learning (PBL) model assisted by problem-based LKPD not only helps improve students' basic skills (C1–C3) but is also more effective in encouraging higher-order thinking skills (C4–C6) compared to conventional learning.

Furthermore, N-Gain analysis of learning outcomes was conducted. This analysis aimed to determine the extent of improvement in learning outcomes achieved by students after participating in learning using the Problem-Based Learning (PBL) model assisted by problem-based LKPD in the experimental class, compared to students in the control class who were taught using conventional learning.

Table 7 N-Gain Learning Outcomes

Class	***Pretest***	**Posttest**	***N-Gain***	***%N-Gain***	**Description**
Exsperiment	37,31	72,78	0,57	57%	Medium
Control	41,11	55	0,23	23%	Low

Based on (Table 4.10), the average N-Gain of the control class was 0.23 (23%) in the low category, while the average N-Gain of the experimental class was 0.57 (57%) in the moderate category. These results indicate that although both classes experienced an increase in learning outcomes after the lesson, the increase in the experimental class was higher than that in the control class.

DISCUSSION

This study was conducted in five meetings, beginning with a pretest in the control and experimental classes to measure the initial abilities of the students. The pretest results showed that the initial abilities of the two classes were relatively the same, although the average score of the control class was slightly higher (41.11%) than that of the experimental class (37.31%). This condition shows that before being given treatment, the cognitive abilities of the students were still low and had not reached the Minimum Completion Criteria (KKM), so that the increase in learning outcomes could be attributed to the learning treatment given.

Next, the core learning was carried out in three meetings. The first meeting discussed the structure and function of the human motor system. In the control class, learning was conducted conventionally through lectures and limited question and answer sessions, followed by individual exercises. In contrast, the experimental class applied Problem Based Learning (PBL) assisted by problem-based LKPD. Students observed the phenomena of the musculoskeletal system, worked in groups to discuss problems in the LKPD, such as the function of joints in daily activities, with the teacher acting as a facilitator.

The second meeting focused on the mechanisms of muscle and bone movement. In the control class, students tended to be passive, while in the experimental class they were given case studies of body movements in sports and asked to explain muscle contractions and the role of bones in supporting movement. This discussion linked concepts to real life and trained analytical thinking skills. The third meeting discussed disorders of the motor system and efforts to maintain health. The control class still used conventional methods, while the experimental class examined cases of osteoporosis and scoliosis through worksheets, encouraging students to analyze causes, symptoms, and prevention, while also training higher-order thinking skills (C4–C6).

The last meeting was used for a posttest, which showed significant differences between the two classes. The control class experienced an average increase from 41.11% to 55%, with only 19.44% of students achieving the minimum competency standard (KKM). Meanwhile, the experimental class increased from 37.31% to 72.78%, with 61.11% of students achieving the KKM. This difference explains that problem-based PBL assisted by LKPD is more effective than conventional learning, which tends to be teacher-centered and makes some students passive. PBL encourages active student involvement in discovering concepts, discussing, analyzing, evaluating, and creating solutions, thereby improving higher-order thinking skills (C4–C6).

The results of the independent sample t-test support these findings, with a Sig. (2-tailed) value of 0.001 < 0.05, indicating a significant difference between the two groups. Pedagogically, this proves that learning that emphasizes active participation, problem solving, and student engagement is more effective than conventional lectures and question and answer sessions.

Analysis based on Bloom's taxonomy shows that the experimental class experienced significant improvements at all cognitive levels, especially at the higher levels (C4–C6), while the control class only experienced limited improvements, especially at the lower levels (C1–C3). For example, in the experimental class, the n-gain percentage for C4, C5, and C6 was 60%, 51%, and 70%, respectively, while in the control class it was only 30%, 16%, and 9%. This shows that problem-based learning not only strengthens basic skills but also develops students' analytical, evaluative, and creative abilities, in line with the Merdeka Curriculum's emphasis on Higher Order Thinking Skills (HOTS).

The theoretical foundations of Piaget and Vygotsky's constructivism explain these findings. According to Piaget, learners construct knowledge through experience and interaction with their environment. In PBL, learners encounter real-world problems, allowing them to connect prior knowledge with new information to construct more meaningful understanding. Vygotsky emphasizes the importance of social interaction in learning through the Zone of Proximal Development (ZPD), where problem-based worksheets function as scaffolding to help learners reach their optimal potential.

These findings are consistent with Arends (2012), who argues that PBL encourages the development of critical thinking and problem-solving skills through direct involvement in real-life situations. The results of this study are also in line with Muslimah (2020), who states that problem-based learning increases student activity and learning outcomes, and with Nurhidayah (2019), who found that PBL improves critical thinking skills and biology learning outcomes. Furthermore, it is relevant to Bruner's theory of discovery learning, in which students discover concepts themselves through exploration, hypothesis formation, and group discussion, which increases curiosity, communication skills, and learning responsibility.

From a 21st-century skills perspective, LKPD-based PBL develops the 4Cs: Critical Thinking, Creativity, Collaboration, Communication. Students analyze problems, formulate creative solutions, work together in groups, and communicate the results of their discussions, so that learning not only improves cognitive achievement but also shapes the competencies needed in real life.

Thus, this study shows that problem-based PBL assisted by LKPD effectively improves student learning outcomes, both quantitatively and in terms of thinking skills. Teachers need to change the learning paradigm from teacher-centered to student-centered, giving students the opportunity to actively construct knowledge through problem solving, and utilizing LKPD to facilitate interaction, active engagement, and learning completion. The application of this model enables more contextual, collaborative, and focused learning, while supporting the development of HOTS and 21st-century skills.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the results of this study, the application of the Problem-Based Learning (PBL) model assisted by problem-based worksheets had a significant positive effect on the learning outcomes and cognitive abilities of grade XI students at SMA Negeri 1 Bahorok in the subject of the movement system. This can be seen from the increase in the average score of the experimental class from 37.31% on the pretest to 72.78% on the posttest, with a learning completeness percentage of 61.11%, which is much higher than the control class, which only scored 19.44%.

Analysis by cognitive level also shows that PBL assisted by LKPD is able to improve all cognitive aspects, both at the low level (C1–C3) and high level (C4–C6), with the most significant increases in the areas of analyzing (C4) by 60%, evaluating (C5) by 51%, and creating (C6) by 70%. These findings prove that problem-based learning not only strengthens mastery of basic concepts but is also effective in encouraging critical, evaluative, and creative thinking skills in students, in line with the demands of Higher Order Thinking Skills (HOTS).

Recommendations

Based on the findings of the study, teachers are advised to use innovative learning models such as problem-based learning (PBL) assisted by problem-based worksheets more often in biology lessons, while modifying the worksheets according to the local context and the needs of students so that learning is more meaningful. Schools are expected to provide support in the form of supporting facilities, contextual learning resources, learning media, and adequate time for group discussions so that teachers can manage their classes effectively and improve the quality of learning. Students are also expected to participate more actively in the learning process, whether through questions, discussions, or expressing opinions, so that their understanding of concepts and critical and creative thinking skills can develop more optimally. For future researchers, it is recommended to develop similar research on other materials or subjects, as well as explore additional aspects such as collaboration skills, communication, or scientific attitudes, so as to obtain a more comprehensive picture of the effectiveness of implementing problem-based learning assisted by problem-based learning worksheets.

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