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Improvement of High School Students' Physics Problem Solving Skills Through Problem Based Learning Assisted by LKPD (Student Worksheets)

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Abstract

This study employed classroom action research with the aim of enhancing students' physics problem-solving skills using Problem-Based Learning (PBL) supported by student worksheets (Lembar Kerja Peserta Didik/LKPD). The research targeted 10th-grade high school students focusing on the topic of Measurement. The methodology followed a cycle comprising four stages: planning, action, observation, and reflection. At the end of each cycle, evaluations were conducted using a validated test instrument consisting of four essay questions. The success criterion was set at a minimum of 70% of students achieving a mastery level, defined by a score of at least 65. During the pre-cycle phase, before applying PBL, the initial test results revealed no students achieved mastery, with an average problem-solving score of 54.67. Subsequently, two cycles of PBL implementation were carried out. In the first cycle, 15 students reached the mastery criterion, representing 41.17% improvement in problem-solving skills, with an average score of 63.75. Building on this progress, the second cycle was implemented, resulting in 29 students achieving mastery. This represented 80.05% of the class, categorized as a moderate improvement, with an average problem-solving score of 70.05. These findings indicate a significant enhancement in students' physics problem-solving abilities through the integration of PBL and LKPD. This approach effectively facilitated active student engagement and critical thinking, demonstrating its potential as an impactful instructional strategy in high school physics education.

Keywords: Problem-based learning; Students' worksheet; Classroom action research; Problem solving.

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INTRODUCTION

Education plays a crucial role in advancing the life of a nation. The current curriculum requires every student to collaborate with others to solve existing problems. It emphasizes several learning model options that support the 4C program: critical thinking, creativity, communication, and collaboration—the four skills that students in the 21st century are expected to possess. These skills can be cultivated through the learning process. Physics has become one of the high school subjects that can be directed to enhance these skills. Therefore, it is very important for educators to prepare relevant physics lessons so that the teaching and learning process becomes more optimal and aligned with the objectives (Faresta et al., 2024). Learning activities should guide students to interact with peers through collaboration, which encourages communication skills, critical thinking, and creativity.

Observations and interviews conducted at a high school in Merauke show that the current learning process still lacks activities that involve students in acquiring knowledge, both individually and in groups. Physics learning is predominantly delivered through a mathematical approach, making it seem like physics is just calculations with existing formulas. The social learning theory proposed by Vygotsky emphasizes that the learning process originates from an individual's active role in the learning environment, as well as guidance from those who are more knowledgeable. Thus, it can be concluded that learning will be meaningful if students are active in the process. Teachers must be creative and innovative in finding real-life connections to the subject matter (Simangunsong et al., 2024). This can be achieved, among other ways, through the utilization of student worksheets (lembar kerja peserta didik/LKPD).

LKPD has become one of the learning media that guides students to learn theoretically and implement it practically with their peers under the guidance of a teacher. LKPD helps students interact with the material through learning activities and receive guidance to discover concepts (Rahmatin et al., 2022). The worksheet plays a role in enhancing students' problem-solving skills (Maysaputri & Admoko, 2024). Through problem-solving activities, students gain deeper information, construct it, and determine the final outcome (Putri et al., 2023). Polya stated that problem-solving ability is a high-level skill involving finding solutions to problems using the knowledge already possessed. Problem-solving is an important skill to be fostered in students so they become accustomed to finding solutions through processes that align with correct theoretical concepts. One of the factors contributing to the low problem-solving abilities of students is their lack of involvement in learning activities (Simangunsong et al., 2023).

Polya formulated stages to stimulate problem-solving abilities, namely: 1) understanding the problem; 2) planning the problem-solving; 3) executing the problem-solving stages; and 4) reviewing (Simangunsong et al., 2022). These stages can be applied to guide students in problem-solving during the classroom learning process. These steps align with the syntax of the Problem-Based Learning (PBL) model, namely: 1) orienting students to the problem; 2) organizing students; 3) guiding students; 4) developing and presenting results; and 5) analyzing and evaluating the final results. PBL is designed, among other things, to make students better at problem-solving (Hidayah et al., 2018; Simangunsong, 2013). Results show a moderate improvement in problem-solving abilities for the class that utilized LKPD-PBL (Risamasu & Pieter, 2024). Another finding states that Problem-Based Learning assisted by LKPD is effective in improving students' science learning outcomes (Swiyadnya et al., 2021).

Study objectives

This study aims to improve high school students' physics problem-solving skills through the implementation of Problem-Based Learning (PBL) assisted by Student Worksheets (LKPD). By integrating PBL with LKPD, the research seeks to create a learning environment that encourages active student participation, collaboration, and critical thinking, particularly in the core material of Measurement. The approach is designed to address the lack of student involvement observed in physics classes in Merauke, fostering deeper understanding and application of physics concepts. Through this method, the study intends to enhance educational outcomes in the Southern Papua region by providing a practical and interactive learning framework that aligns with the 4C skills required in the 21st century.

Novelty of the current study

While previous research has highlighted the benefits of Problem-Based Learning (PBL) assisted by Student Worksheets (LKPD) in enhancing students' problem-solving skills (Maysaputri & Admoko, 2024; Risamasu & Pieter, 2024), this study is unique in its focus on the core physics material of Measurement for high school students in the Southern Papua region. The implementation of PBL assisted by LKPD in this specific geographical context provides new insights into educational practices in the easternmost region of Indonesia, where educational challenges and cultural contexts may differ significantly from other regions.

Moreover, this study emphasizes the role of facilitators within student groups, which has been found to be highly beneficial for improving students' abilities (Simangunsong et al., 2024). By designing learning activities that involve conducting experiments, collaborating to solve problems, and drawing conclusions from learning outcomes, the research contributes to a deeper understanding of how PBL and LKPD can be effectively integrated. This facilitation method through LKPD specifically addresses the observed lack of student involvement in physics classes in Merauke. Therefore, the study adds to the existing body of knowledge by exploring the integration of PBL and LKPD in a new context and subject matter, enhancing the educational experience in physics education focused on Measurement.

METHOD

This study utilized classroom action research (CAR) based on the model proposed by Kemmis and Taggart (in Usman et al., 2019), which emphasizes a cyclical process involving planning, implementation, observation, and reflection. Conducted at a high school in Merauke during the odd semester of the 2023/2024 academic year, the research involved 32 tenth-grade students as subjects. The study focused on improving students' problem-solving skills in the physics topic of Measurement by employing Problem-Based Learning (PBL) integrated with student worksheets (LKPD). The research was conducted in two cycles, with each cycle aiming to refine the teaching approach and enhance student learning outcomes through an iterative process. The procedural flow of the research is depicted in Figure 1, which illustrates the interconnected stages of CAR, including a feedback loop that determines whether the cycle achieves its goals or requires further refinement.

In the planning phase, the researcher and teacher collaboratively developed lesson plans and instructional materials based on the PBL model. LKPDs were designed to guide students through problem-solving activities that aligned with Polya's four-step framework: understanding the problem, planning a solution, solving the problem, and reviewing the results. A problem-solving ability test was prepared to assess student progress and consisted of four essay questions. These questions were validated by a physics lecturer and a high school teacher to ensure alignment with the curriculum and research objectives.

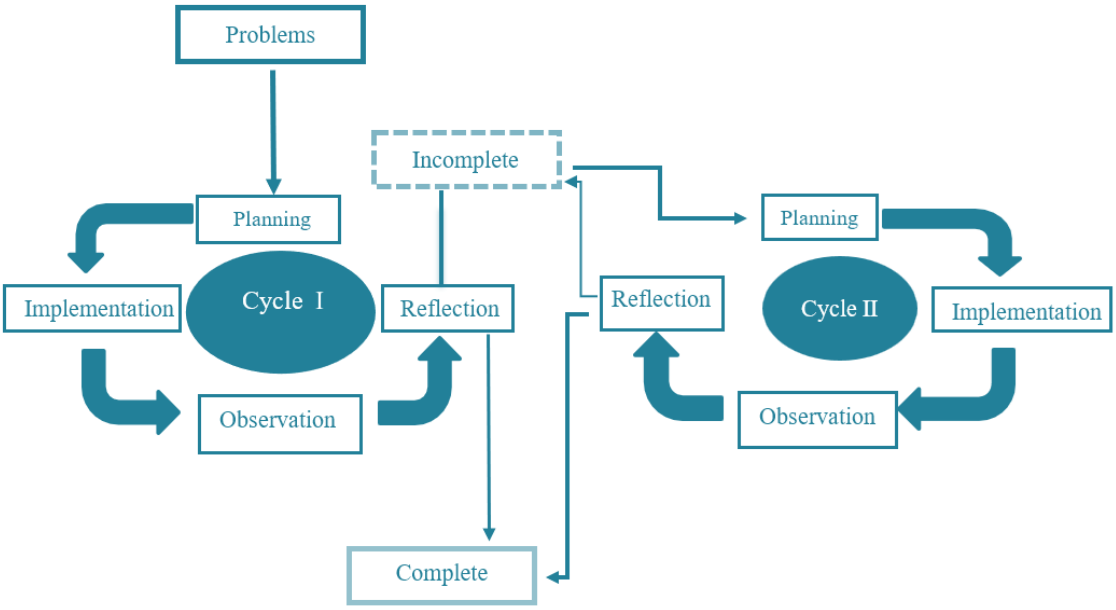

Figure 1. The cycle of classroom action research

The scoring rubric for the test, shown in Table 1, provided a detailed evaluation framework for assessing student performance across key problem-solving indicators. The rubric used specific criteria to assess students' ability to comprehend the problem, formulate a solution plan, execute the solution, and verify the final outcome, with scores ranging from 0 (no attempt) to higher values for complete and accurate answers.

Table 1. Criteria for scoring problem-solving ability tests

Aspect	Indicator	Description
Understanding the problem	Given Asked Data Sufficiency	3: Given, asked, complete 2: Completely 1: Incomplete 0: Not writing
Planning Problem Solving	Process	4: Complete formula 3: Write the formula, but incomplete 2: Formula was wrong, but complete 1: Formula was wrong, but incomplete 0: Not writing
Problem Solving	Resolution Process	5: The right rules, correct results, and done 4: The right rules, correct results, but not finished 3: Almost right, and complete 2: Formula was wrong, and done 1: Formula was wrong, but not fiinished 0: Not writing
Checking	Checking	3: The answer was correct, and complete 2: The answer was correct, but unit was wrong 1: The answer was incorrect, but unit was correct 0: Not writing

During the implementation phase, the lessons were conducted in the classroom, emphasizing active student participation. Students worked collaboratively in small groups, solving physics problems using the LKPD as a guide. The PBL approach encouraged students to explore, discuss, and apply concepts, with the teacher acting as a facilitator rather than a direct instructor. This method aimed to foster critical thinking, collaboration, and communication skills, which are integral to 21st-century learning. Observations during this phase focused on student engagement, group dynamics, and the clarity of their reasoning processes. The observation data provided insights into the effectiveness of the instructional approach and student interactions with the LKPD.

At the conclusion of each cycle, a problem-solving ability test was administered to evaluate student progress. The test results were analyzed descriptively to measure improvements in students' problem-solving skills. Success indicators were established based on two criteria: a measurable increase in the average test scores from the pretest to Cycle II, and at least 70% of students achieving a minimum completeness criterion (MCC) score of 65. The problem-solving levels were categorized into five performance bands, as shown in Table 2, ranging from "Very Low" (0%-54%) to "Very High" (90%-100%). These benchmarks provided a structured framework for assessing the impact of the interventions across the two cycles.

Table 2. Problem-solving level

Level	Criteria
90%-100%	Very High
80%-89%	High
65%-79%	Medium
55%-64%	Low
0%-54%	Very Low

The observation and test results from each cycle were reviewed during the reflection phase to identify areas of improvement. For example, after Cycle I, the data revealed challenges such as insufficient clarity in LKPD instructions and variability in student participation. These insights informed revisions to the instructional approach in Cycle II, including simplifying LKPD instructions and introducing more engaging problem scenarios. The iterative process, as outlined in Figure 1, ensured that each cycle built on the strengths and addressed the weaknesses of the previous one. By the end of Cycle II, improvements in both student engagement and problem-solving skills were evident, as reflected in higher test scores and increased levels of collaboration during group activities.

Ethical considerations were also integral to the research process. Students and teachers were informed about the research objectives, and their participation was voluntary. The use of validated instruments and triangulation of data from observations, tests, and teacher reflections ensured the reliability and validity of the findings. The study's emphasis on iterative improvement and systematic evaluation aligns with the goals of CAR, providing a structured yet flexible framework for enhancing teaching and learning outcomes. Through the integration of PBL and LKPD, this study successfully addressed the observed gaps in student engagement and problem-solving skills, contributing to a deeper understanding of effective instructional practices in physics education.

RESULTS AND DISCUSSION

The first step was to conduct an initial test in the form of a problem-solving ability test. Based on the results of the initial test, it was found that no students passed; the students' ability to solve problems was very low, with an average score of 54.67. There were 4 students in the moderate interval, 6 in the low interval, and 26 in the very low scale. The results of the initial test can be seen in Table 3.

Table 3. Pretest results

Percentage	Level Ability	Number of Students	Percentage	Average Score of Ability
90 – 100	Very High	0	0%	54.67 (Very Low)
80 – 89	High	0	0%	
65 – 79	Medium	4	11.11%	
55 –64	Low	6	16.67%	
0-54	Very Low	26	72.22%	
Total		36	100%	

Based on problem-solving indicators, only 55.25% of students correctly understood the problem (low criteria), 50.30% of students correctly planned the problem-solving, 50.61% of students executed the problem-solving, and 30.45% reviewed their work. This means that, in general, the aspect of the indicator for students' physics problem-solving abilities is still very low. The description of students' problem-solving abilities is obtained in Table 4.

Table 4. Results of the pretest problem-solving test based on problem-solving indicators

Indicator	Percentage of Student Ability	Criteria
Understanding Problem	55.25%	Low
Planning Problem Solving	50.30%	Very Low
Implementing Problem Solving	50.61%	Very Low
Checking	30.45%	Very Low

Then, treatment was given in the first cycle, through PBL assisted by LKPD. In the planning stage, the researcher discussed with subject teachers, communicated the learning scenario, LKPD, and prepared test instruments that were first validated by an expert team (lecturers and teachers). The implementation stage was carried out by implementing PBL assisted by LKPD. The researcher acted as the instructor, while the teachers and several research team members acted as observers. The observation stage is focused on observing students' activities while carrying out LKPD activities. Some students are confused and not focused on reading the instructions on the LKPD. The facilitator approaches the group, then guides them. Next, a reflection is conducted, followed by a test for the students, which then serves as a basis for the team to observe the changes that occur. The test results in cycle I showed that 15 students met the completion criteria, with an average problem-solving ability score of 63.75, which is at a low level, as detailed in Table 5.

Table 5. Results of the test in Cycle I

Percentage	Level Ability	Number of Students	Percentage	Average Score of Ability
90 – 100	Very High	0	0%	63.75 (Low)
80 – 89	High	5	13.89%	
65 – 79	Medium	10	27.78%	
55 –64	Low	15	41.67%	
0-54	Very Low	6	16.67%	
Total		36	100%	

Based on the explanation of the answers, the percentage of students who are already able to understand the problem is 68.56%, able to plan the problem is 67.78%, able to implement problem-solving is 56.47%, and able to review is 55.08%. The results are detailed in Table 6.

Table 6. Results of the Cycle I problem-solving test based on problem-solving indicators

Indicator	Percentage of Student Ability	Criteria
Understanding Problem	68.56%	Medium
Planning Problem Solving	67.78%	Medium
Implementing Problem Solving	56.47%	Low
Checking	55.08%	Low

The results in cycle I, which did not meet the success indicators, necessitated the researchers to conduct cycle II. The team once again created a learning scenario plan, the test instruments were changed in terms of numbers (without altering their alignment with the expected learning outcomes), and similarly for the LKPD, which were differentiated in terms of images and numbers (but still within the same concept as the LKPD in Cycle II). In the Implementation and Observation stage, the class received PBL treatment assisted by LKPD, with the researchers acting as the instructor, subject teacher, and the research team acting as observers. Reflection stage, students were given a test instrument consisting of 4 questions, which were different from the previous test but still aimed at the same objective. The reflection results showed that 29 students achieved learning completeness, with an average test score of 70.15, which falls under the moderate criteria. A more detailed description is listed in Table 7.

Tabel 7. The Results of Cycle II test

Percentage	Level Ability	Number of Students	Percentage	Average Score of Ability
90 – 100	Very High	1	2.78%	70.15 (medium)
80 – 89	High	8	22.22%	
65 – 79	Medium	20	55.56%	
55 –64	Low	5	13.89%	
0-54	Very Low	2	5.56%	
Total		36	100%	

Based on the answer description in cycle II, it was found that the percentage of students who were able to understand the problem was 75.36%, able to plan the problem-solving was 72.46%, able to execute the problem-solving was 68.89%, and 65.58% were able to recheck. This is explained in Table 8.

Table 8. Results of the Cycle II problem-solving test based on problem-solving indicators

Indicator	Percentage of Student Ability	Criteria
Understanding Problem	75.36%	Medium
Planning Problem Solving	72.46%	Medium
Implementing Problem Solving	68.89%	Medium
Checking	65.58%	Medium

The results of the pretest, cycle I, and cycle II, when compared in terms of average results, will be visually represented in a graph, showing that there is an improvement in students' physics problem-solving abilities with the use of PBL assisted by LKPD. This improvement is visually evident in Figure 2

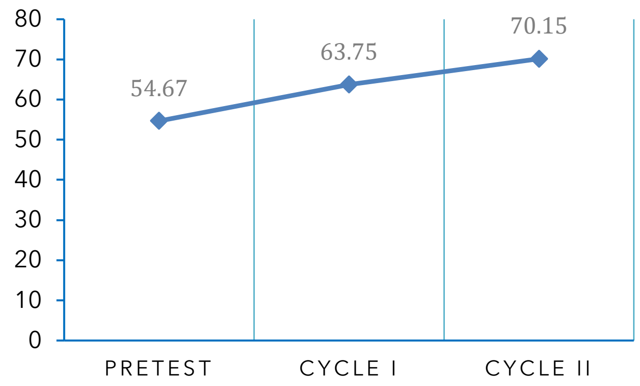

Figure 2. Comparison of average scores of pretest, Cycle I, and Cycle II

The line formed on the graph interprets that there is an increase in students' physics problem-solving abilities in that class. Meanwhile, the comparison of the percentages of the detailed problem-solving indicators can also be seen in Figure 3.

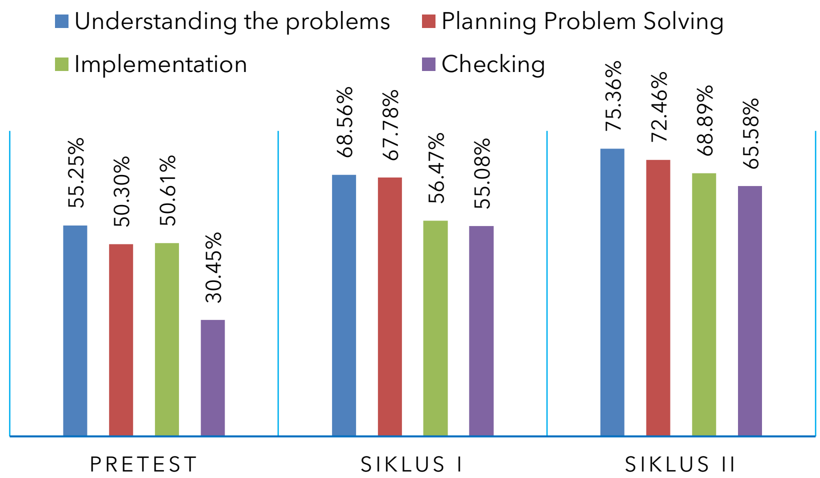

Figure 3. Comparison of problem-solving ability indicators

The indicator "understanding the problem" has a higher percentage compared to the other 3 indicators in every situation, which is consistent with previous researchers' findings (Fitriadi & Medriati, 2023), which found that the highest sequence of indicators starts with understanding the problem, planning the problem, executing the solution, and finally reviewing. Other research also confirms this relevance, with a recap of the sequence of mastery of problem-solving ability indicators, namely understanding, planning, executing, and ending at the reviewing stage (Agusta, 2020). If students understand the problem, they will then be able to plan and execute the solution, and finally conclude the process by reviewing what has been done. However, the researchers observed that some students were hindered in solving the problems due to inaccuracies in mathematical calculations. This has an impact on the next indicator. It cannot be denied that physics is quite closely related to numbers, and it involves calculations. So, students are also expected to have good mathematical skills in order to solve problems in Physics. What makes Physics a complicated subject is that, in addition to understanding Physics concepts, students must also master mathematical concepts (Hasyim, 2018). This also affects the students' learning completeness, which reached the minimum threshold in the second cycle with a percentage of 80.05%. The comparison of completeness in the three research conditions is presented in Table 9.

Table 9. Learning completeness

Aspect	Pretest	Cycle I	Cycle II
Completion	-	15 students	29 students
Percentage of Completion	-	41.17%	80.05 %

Reflection on cycle I is not only to see the test results but also to serve as a means to improve the implementation in cycle II. The improvements include: 1) Adding more facilitators, so that each group has 1 facilitator who will accompany the guidance process in the LKPD, 2) Increasing the number of example questions and exercises. The results show that in cycle II, 29 students achieved learning completeness. LKPD helps students guide them to follow scientific steps, write down the descriptions of the problems, determine the solution planning, conduct solution analysis, and perform verification. This process aligns with the values contained in PBL. This learning process becomes meaningful because it is derived from personal experience. According Vygotsky's constructivist theory, where students analyze and answer a question, meaning they are in the phase of developing responsibility towards the learning process and also becoming problem solvers. Collaboration skills with peers and teachers positively impact initial understanding and problem-solving abilities. Another finding also states that collaboration skills have an impact on students' problem-solving abilities (Anggelita et al., 2020). Students who actively engage in discussions understand things more quickly because they have the opportunity to express and listen to ideas in a scientific context. The learning environment in the form of grouping will influence a person in acquiring knowledge as well as problem-solving skills.

The results show that in cycle II, 29 students achieved learning completeness. In line with these results, out of 20 students, 17 students improved their problem-solving skills through PBL based on LKPD, or experienced an 85% improvement (Sari et al., 2024). LKPD that aligns with the curriculum needs is highly needed by students (Isrokijah, 2015) .It has been proven that problem-solving skills using PBL assisted by LKPD will have a better impact (Putri et al., 2024). PBL and LKPD have similar characteristics, stimulating students to explore their knowledge through real-world learning. When both are combined in a series of learning scenarios, they impact the improvement of students' problem-solving abilities.

CONCLUSION

Problem Based Learning has become a learning model that is currently one of the options used to improve students' abilities in physics. Problem-solving skills play an important role for students in the era of society 5.0 so that they become a solution-oriented generation in the future. LKPD as a medium helps teachers deliver lessons directly to students through systematic activities, peer collaboration, and also with the guidance of tutors. Rock-based PBL LKPD can enhance students' physics problem-solving skills.

RECOMMENDATION

Some suggestions for future researchers, it is very important to divide students evenly based on their abilities, so that study groups can be interactive and productive. Time management in learning management is also something that needs to be considered, given that LKPD provides activities that sufficiently guide students to explore their thinking abilities.

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