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Efforts to Increase Students' Problem-Solving Abilities Through the Application of PBL Assisted by Virtual Laboratory on the Hydrostatic Pressure Concept

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Abstract: This research aims to enhance the problem-solving abilities of class XI students at MAS Wahdah Islamiyah Tilongkabila using a problem-based learning (PBL) model through the Classroom Action Research method. The collected data includes students' problem-solving abilities, student activities, and teacher activities. The instruments used were observation sheets for teacher and student activities, final tests (post-tests) on students' problem-solving abilities, and interviews. The average percentage of teacher activity observations increased from 65.6% in cycle I to 93.7% in cycle II, marking a 28.1% improvement. Student activity rose from an average of 56.75% in cycle I to 89% in cycle II, reflecting a 32.2% increase. Additionally, students' problem-solving abilities improved from an average of 58.6% in cycle I to 84.3% in cycle II, a 25.7% increase. The application of PBL, assisted by a virtual laboratory on the concept of hydrostatic pressure, significantly enhances students' problem-solving skills.

Keywords: Hydrostatic pressure; PBL; Problem-solving abilities; Virtual laboratory

Introduction

Education aims to foster an environment and learning process that encourages students to actively realize their potential, developing religious and spiritual strength, self-discipline, character, critical thinking, dignity, and the skills necessary for both personal growth and societal contribution (Halimi, 2023; Sulaiman, 2023; Hossain, 2023). Physics is one of the most complex and interdisciplinary scientific fields, closely connected to areas like chemistry, biology, astronomy, mathematics, engineering, and computer science (Siddique & Adeli, 2016; Crease, 2010). Physics is applied in numerous areas, including technology, medicine, industry, environmental science, and energy (Leitenstorfer et al., 2023; Malik et al., 2023). Physics is a scientific discipline that examines the fundamental properties of the universe, including matter, energy, space, and time and explores how these elements interact with one another (Uzakov & Rustam, 2024; Oghly, 2023).

A common issue faced by students, particularly at the educational level, is the challenge of mastering physics material. Efforts to improve mastery of the material continue to be ensured by schools and teaching staff, including by developing new paradigms by implementing different learning patterns (Mykolaiko, 2023; Okono, 2023).

The results of the PISA survey show, Indonesian children were ranked 62nd out of 70 countries with a score of 403 in 2015 (OECD, 2016). According to the 2018 PISA survey, Indonesia's ranking dropped to 70th out of 79 countries. This proves that science grades and scores are decreasing, so students' skills on problem-solving are relatively low (OECD, 2019). One of the important abilities is the ability to solve problems, which is also one

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of the mandatory skills in the 2013 curriculum. With problem-solving skills, students will have the ability to think critically and creatively in overcoming problems and will be required to be more independent (Alfika & Mayasari, 2018; Orakci, 2023; Anggraeni et al., 2023; Setyosari et al., 2023; Alt et al., 2023).

From observations made on Madrasah Aliyah school at MAS Wahdah Islamiyah Tilongkabila, many problems resulted in students' low problem-solving abilities. One of the reasons for the low problem-solving skills of students is the learning model applied by the teacher. According to Manik & Sinuraya (2019), problem-solving is a process that requires logic or high-level thinking skills to find a way to solve a problem. Students can have problem-solving abilities if teachers teach them effectively. In learning physics, students really need problem-solving skills because solving problems can help them gain additional knowledge and make learning physics easier. Problem-solving is one type of extraordinary thinking ability that must be learned (Ramadayanty et al., 2021; Pristianti & Prahani, 2023; Batlolona & Diantoro, 2023).

For this reason, efforts need to be made to implement certain learning models in the classroom that can train students' abilities to solve problems. A learning model that can be developed and implemented to center the educational process around students is by implementing a problem-based learning (PBL) model (Ramadani & Nana, 2020). According to Setyo et al. (2020) and Supartin et al. (2022), the PBL model can require students to take an active part in the teaching process so that students can form problems and design their solutions. The PBL model is a learning model that focuses more on students by posing real problems at the beginning of learning. This is in line explanation that PBL is not designed to assist teaching staff in conveying a greater amount of information to students. Instead, it is intended to help students in developing critical thinking and problem-solving abilities (Manik & Sinuraya, 2019; Birgili, 2015; Carlgren, 2013; Rahmadita et al., 2021).

The PBL model can also be applied with the help of learning media such as virtual l Laboratory. Virtual laboratory is a physics laboratory simulation created with the aim of providing instructions to students on how to use laboratory facilities. A virtual laboratory is a computer simulation laboratory that looks, works, and produces results similar to a real lab (Ramadani & Nana, 2020; Zulkifli et al., 2022; Syam et al., 2023).

One laboratory that can be used is PhET Simulation. PhET is a simulation developed by the several University that emulates science learning for individual and classroom learning needs. This simulation focuses on the interaction between real-world events and basic science, promotes learning through interactive and constructivist approaches, provides criticism, and provides an environment for creativity (Haryadi & Pujiastuti, 2020). According Abdjul & Ntobuo (2019), state that PhET simulations are visual representations or moving animations that are created as games that students can learn by exploring. This simulation focuses on the correspondence between computer simulations and real events and then presents them in a physical conceptual form that is easy for students to understand.

Ramadani & Nana (2020) using the PhET Virtual Laboratory media, the PBL model can make the learning process more interesting and satisfying. The concepts of the subjects being taught become clearer and easier to understand, and it allows teachers to present a large amount of material in a single setting so that time is used more effectively and can enhance students' comprehension of physics concepts and encourage them to achieve success in their learning (Ramadani & Nana, 2020).

One of the physics materials supported by practical activities is Hydrostatic Pressure. It is generated due to the force that exists in a fluid that acts at a certain depth of pressure (Zulfa et al., 2020). Nurjanah & Arisona (2021) believe that hydrostatic pressure concept is difficult for students to understand. To digest this material, students need help building the knowledge that underlies the concepts to be studied. This research hopes that the application of PBL assisted by a virtual laboratory on the concept of hydrostatic pressure can increase students' problem-solving abilities.

Method

Researchers use the Classroom Action Research method to achieve research objectives. Teachers will collaborate with researchers to carry out classroom teaching and learning activities using a PBL model assisted by a virtual laboratory to increase students' problem-solving abilities.

Classroom Action Research involves teachers working together with researchers (or acting as researchers/observers themselves) to enhance the quality of classroom learning (Suharsimi, 2015). This research was carried out at MAS Wahdah Islamiyah Tilongkabila, which is located in Tilongkabila District, Bone Bolango Regency. This research was conducted from February to March 2024. The research subjects were class XI students of MAS Wahdah Islamiyah Tilongkabila for the 2023/2024 academic year, consisting of 18 students.

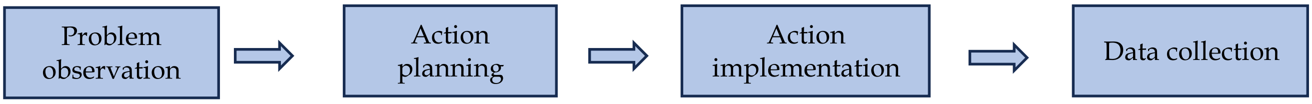

Figure 1. Flowchart of research

The data collected using the form of students' problem-solving abilities, student activities, and teacher activities. The tools employed in this research included observation sheets for monitoring teacher and student activities, final tests (post-tests) on students' problem-solving abilities, and interviews. Flowchart of research from problem observation until data collection in Figure 1.

The data analysis technique used is quantitative analysis using the equation (1).

$$S = \frac{R}{N} \times 100\% \tag{1}$$

Information for S is predicted value, R is total score of questions answered correctly, and N is highest score on the test. Students' problem-solving abilities are said to increase if they reach a percentage of 70% or ≥ of the Minimum Completeness Criteria of 70. And teacher and student activities are said to be good if they get results with a percentage of > 70%.

Result and Discussion

Data for this research was gathered from class XI MAS Wahdah Islamiyah Tilongkabila over two cycles and observed by two observers. The collected data includes observations of teacher and student actions/activities during the learning process, as well as data on students' problem-solving abilities.

Teacher Activities

Teacher engagement during the learning process with the PBL model in cycle I was 67.2% and was in the sufficient category. Data obtained from teacher activities in Figure 2. Based on the diagram shown in Figure 2 was an increase in teacher activity at meeting 1 and meeting 2. At meeting 1 the percentage was 63.5% (enough), while at meeting 2 was 67.7% (enough). So, the average percentage in cycle I was 65.6% (enough). These data show that teacher activity increased in cycle I, namely 1.0%. The teacher's activities are still in the sufficient category, so several things need to be improved in the next cycle. In cycle I, several aspects received a poor category because teachers should be more active in guiding and directing students. Data from observing teacher activity in cycle II in Figure 3.

Figure 3, shows the learning activities carried out during two meetings in Cycle II showed quite satisfactory improvement. Teachers can fully master the PBL model. The results of observations of teacher activity for the first meeting, which was 90.6% (very good) and an increase of 6.2%, so the percentage at the second meeting was 96.8% (good very). So, the average percentage in cycle II was 93.7% (very good). In cycle II, teacher activity percentage increased by 28.1% from cycle I. It shows that the implementation of teacher activity has had a very good impact on the learning process.

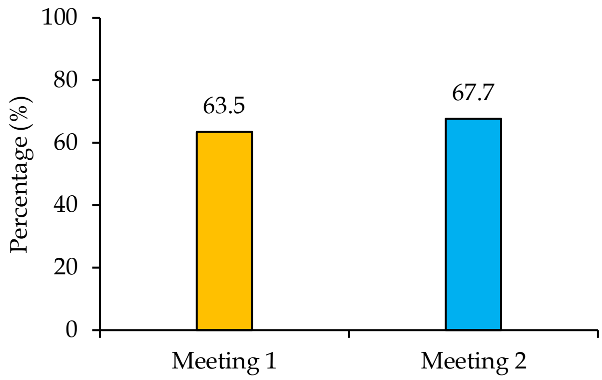

Figure 2. Observation Results of Teacher Activities in Cycle I

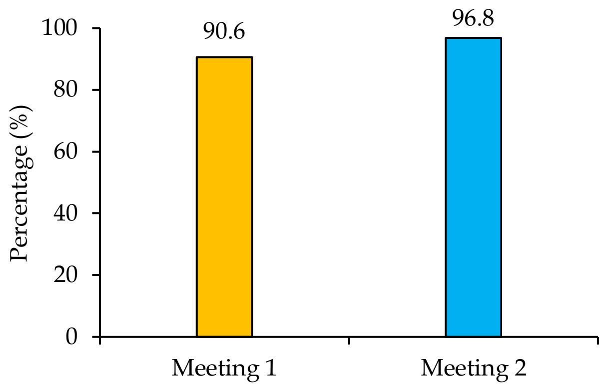

Figure 3. Observation Results of Teacher Activities in Cycle II

Student Activities

In cycle I, observations of student activities were carried out twice in 2 meetings. This observation was carried out when students participated in learning activities in class, which were based on the PBL model. Observation results were obtained from student activity observation sheets.

Data from observations of student activities in Figure 4. Judging from Figure 4, the results of observing student activities in meetings 1 and 2 in cycle I using the PBL model have been carried out well, although there are still aspects that need to be improved. The percentage at the first meeting was 51.0% (less), and the percentage at the second meeting was 62.5% (enough). So, the average percentage in cycle I was 56.75% (less). Cycle I showed an increase in student activity, namely 11.5%. Student activities in cycle I are still in the insufficient category. Data from observations of student activity can be seen in Figure 5.

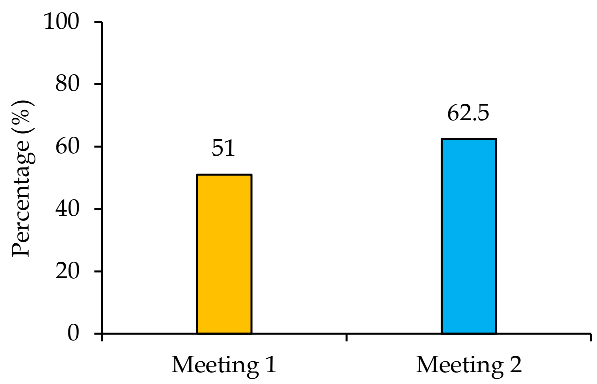

Figure 4. Observation Results of Student Activities in Cycle I

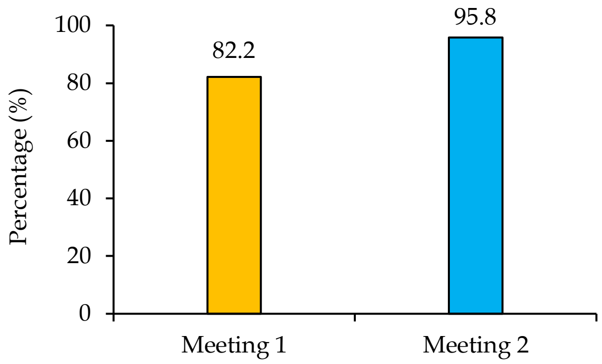

Figure 5. Observation Results of Student Activities in Cycle II

Figure 5 illustrates the results of observing student activities in cycle II. During the first meeting, student engagement was 82.2% in the good category. By the second meeting, student activity improved to 95.8%, placing it in the very good category. Therefore, the average percentage of student activity in cycle II was 89% (very good). The first and second meetings in cycle II saw an increase of 13.6%, demonstrating that students excelled in their learning activities during this cycle.

In cycle II, student activity increased by 32.2% from cycle I. The increase from cycle I to cycle II was because students had begun to be motivated to take part in learning using the PBL model. This is in line with the opinion of Sellavia et al. (2018) and Santoso et al. (2020), that the PBL model is a learning approach that brings learning experiences to life in the real world, encourages students to participate in learning actively, and naturally integrates educational contexts into real-life situations (Santoso et al., 2020).

Problem-Solving Ability

Students' problem-solving abilities are assessed through a written exam consisting of five questions. The assessment is carried out based on the problem-solving ability index according to Patricia Heller & Kenneth Heller which consists of 5 indicators, namely: focus on the problem, describe the problem in physics concepts, plan a solution, carry out the plan, and evaluate the answer.

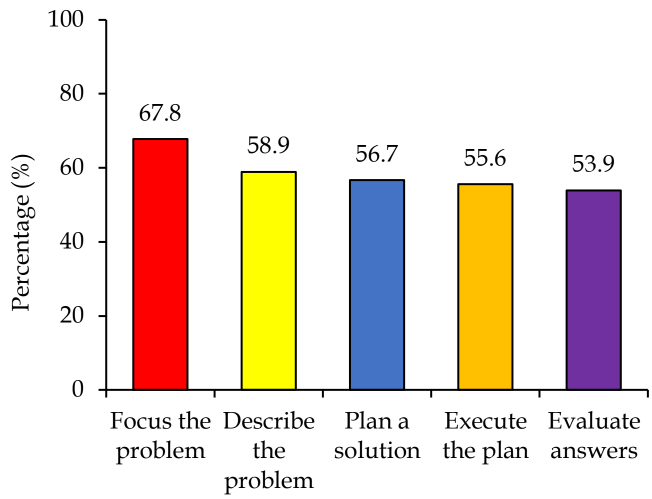

Figure 6. Students' Problem-Solving Ability in Cycle I

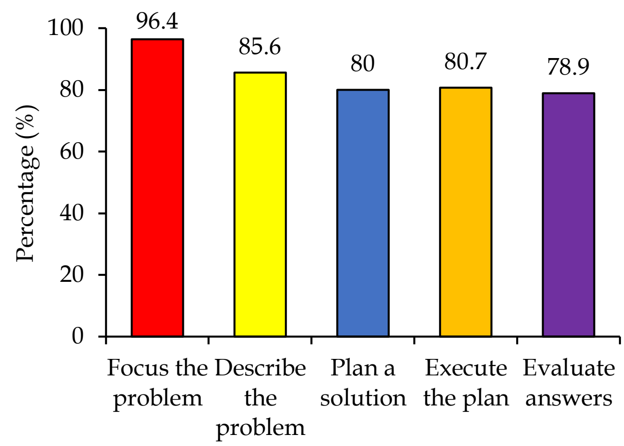

Figure 7. Students' Problem-Solving Ability in Cycle II

Figure 6 presents data on students' problem-solving abilities for each indicator in cycle I. The first indicator, focusing on the problem, was rated as good, with 67.8% of students' responses meeting the criteria. The second indicator, describing the problem using physics concepts, achieved 58.9%. The third indicator, planning a solution, reached 56.7%. The fourth indicator, executing the plan, had 55.6%, and the fifth indicator, evaluating answers, reached 53.9%. Overall, these five indicators fall into the sufficient category with an average of 58.6%.

Meanwhile, in cycle II, students' problem-solving abilities for each indicator increased from cycle I. The results of students' problem-solving skills in cycle II for each indicator can be seen in Figure 7. Students' problem-solving abilities in cycle II were carried out to improve or enhance students' problem-solving skills in cycle I. The evaluation carried out in cycle II was the same as the evaluation in cycle I, namely using a written test of 5 questions based on problem-solving indicators.

Data in Figure 7 derived from the results of evaluating students' problem-solving abilities using a written test with five questions in cycle II experienced an increase. Data from the results of class XI students' answers in cycle II increased. The first indicator, namely focus on the problem, increased to 96.4%, the second indicator, describe the problem in physics concepts, increased to 85.6%, the third indicator, plan a solution, increased to 80%, the fourth indicator, execute the plan, increased to 80.7%, and the fifth indicator, evaluating answers, increased to 78.9%. These five indicators reach the sufficient category with an average of 84.3%.

In cycle II, student activity rose by 25.7% compared to cycle I. This improvement resulted from employing a PBL model supported by a virtual laboratory. This aligns with the theory proposed by Manik & Sinuraya (2019), which states that PBL in the classroom when combined with a virtual laboratory, enhances students' abilities to solve physics problems.

Conclusion

Tests of students' problem-solving abilities demonstrated an improvement from cycle I to cycle II. The average percentage of teacher activity observations increased from 65.6% in cycle I to 93.7% in cycle II, reflecting a 28.1% increase. Similarly, student activity rose from 56.75% in cycle I to 89% in cycle II, marking a 32.2% increase. The average percentage of students' problem-solving abilities improved from 58.6% in cycle I to 84.3% in cycle II, a 25.7% increase. The implementation of PBL assisted by a virtual laboratory on the concept of hydrostatic pressure significantly enhances students' problem-solving skills.

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Author Contributions

Indrawati Lasumbu: Conceptualization, methodology; Dewi Diana Paramata: Writing—original draft preparation; Tirtawaty Abdjul: Validation; Abdul Haris Odja: Methodology; Dewa Gede Eka Setiawan: Curation; Wahyu Mu'zizat Mohamad: Writing—review and editing, formal analysis.

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Conflicts of Interest

The authors declare no conflict of interest.

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