The Effect of Problem-Based Learning Model Assisted by PhET Simulations on Students' Physics Problem-Solving Abilities

Liana*, Kosim, Muhammad Taufik & Hikmawati
Physics Education Study Program, University of Mataram, Indonesia
*Corresponding Author: liana54398@gmail.com

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Abstract *- This study aims to examine the effect of problem-based learning model assisted by PhET simulations on students' physics problem solving ability. This research is Quasi Experimental with non-equivalent control group design. The population of this study were all students of class XI IPA SMAN 4 Mataram with sampling technique using purposive sampling technique, because there were four classes XI IPA, so it was determined that class XI IPA 1 as the experimental class and class XI IPA 2 as the control class. Based on the results of the study, the average value of physics problem solving ability of students in the experimental class was 45.09, while the average value of problem-solving ability of the control class was 39.61. Data Problem solving ability of both classes are normally distributed. Based on the results of the data homogeneity test, the problem-solving ability data are both homogeneous. Problem solving ability data was analyzed using the polled variance t-test and obtained a t_count of 2.24. The t-table value for problem solving ability data is 2.00 at a significant level of 5%. The value of t_count is greater than t_table, meaning that there is an effect of problem-based learning model assisted by PhET simulations on physics problem solving ability of students.*

Keywords: *Problem-based Learning; PhET Simulations; and Problem Solving*

INTRODUCTION

Physics is a branch of Natural Sciences that discusses and studies natural phenomena through a series of scientific processes (Maryam et al., 2022). Physics can be considered a product, a collection of knowledge that deals with the concepts, facts, theories, and laws of physics itself. Additionally, physics can be seen as a process, an activity involving observation, experimentation, and investigation to understand various information and prospects for further development in applying physics to life. As expressed by Gunawan (2015); Hermasyah et al., (2015), the process relates to how learners discover the concepts they are studying, while the product relates to the outcomes of that process, such as principles, laws, concepts, and equations.

A student's mastery of a subject can be seen through their abilities, including their problem-solving skills. This skill is crucial for students as they encounter various issues both in the classroom and in life. Problem-solving forms the foundation for determining solutions to the various issues faced, especially those related to physics (Rangga et al., 2018).

Problem-solving skills involve a student's ability to use the information or knowledge they possess to determine what needs to be done to address a specific problem. As stated by Helmi et al. (2017), problem-solving skills involve the use of knowledge in selecting or identifying the possibilities of a particular phenomenon to be solved.

However, in reality, problem-solving skills become one of the challenges faced by students, leading to a lack of mastery of concepts, difficulty in analyzing and identifying problems for resolution, and resulting in low academic performance.

Based on observations during the Introduction to School Field (PLP) activities at SMAN 4 Mataram in the academic year 2022/2023, the physics learning process implemented in the classroom is still teacher-oriented and tends to use lecture-question-answer methods that do not effectively build on the students' knowledge. The use of teaching models that do not demand student involvement results in uninteresting lessons and contributes to students' inadequate mastery of the taught material, thereby impacting their problem-solving abilities negatively. The consequence of these issues is reflected in the low academic performance of physics students, still below the Minimum Mastery Criteria (KKM). The mid-semester exam results for the odd semester of the academic year 2022/2023, as shown in Table 1, illustrate this point.

Table 1. Middle Semester Assesment Academic Year 2022/2023

No	Group	Average	KKM
1	XI IPA 1	20,84	70
2	XI IPA 2	30,59	70
3	XI IPA 3	44,00	70
4	XI IPA 4	38,24	70

(Archive of Physics' teacher of SMAN 4 Mataram)

Table 1 shows the average values of mid-semester exam scores for students in grade XI IPA that have not yet met the Minimum Criteria Mastery (KKM). In the process of learning physics or any other subject, students' understanding is greatly influenced by the quality of the learning models used by teachers. The quality of a learning model is a determining factor in students' learning outcomes and understanding of a taught subject (Yanti et al., 2019). The objective of the learning process is not only to improve learning outcomes but also to enhance problem-solving skills. If students' problem-solving skills are high, their learning outcomes are also high (Rokhmat et al., 2012). To achieve this, a learning model that supports students' ability to solve problems is needed.

An alternative learning model that can support students' problem-solving abilities is the Problem-Based Learning (PBL) model. As stated by Ulfa et al. (2022), the problem-based learning model significantly helps students improve their problem-solving abilities by requiring them to solve specific problems.

The effectiveness of the problem-based learning model can be maximized when combined with the use of instructional media, whether simple or technology-based. Alternative media that can support optimal learning activities include utilizing PhET simulations, which provide students with ease in conducting experiments. PhET simulations can connect students' ideas with real-world phenomena to understand the real world in Segening et al.'s (2022). The virtual PhET laboratory significantly aids students in improving problem-solving skills, as computer-assisted experiments can enhance generic thinking skills, critical thinking skills, problem-solving abilities, and mastery of physics concepts (Rangga, 2018).

Based on these considerations, the researcher conducted a study on the influence of problem-based learning models assisted by PhET simulations on the physics problem-solving abilities of students. The researcher hopes that the implementation of problem-based learning models assisted by PhET simulations will positively impact the improvement of students' physics problem-solving abilities at SMAN 4 Mataram.

RESEARCH METHODS

The research was conducted at SMAN 4 Mataram during the second semester of the academic year 2022/2023. The research took place from March to April 2023 based on the approved research permit. The study employed a quasi-experimental design with a Non-equivalent Control Group Design. The population of the research included all students in grade XI IPA at SMAN 4 Mataram. Purposive sampling was used as the sampling technique, selecting class XI IPA 1 as the experimental group and class XI IPA 2 as the control group, given that there were four class sections of XI IPA.

Before applying any treatment, both classes underwent a pretest, consisting of five open-ended questions, to measure the initial abilities of each class. Subsequently, the experimental group received treatment with the Problem-Based Learning (PBL) model assisted by PhET simulations, while the control group received traditional instruction for comparison purposes. After the treatment, both classes were given a post-test with the same set of questions to measure the final abilities of each class.

This research involved three variables: the independent variable was the PBL model assisted by PhET simulations, which was the treatment given to the experimental group. The dependent variable was problem-solving ability, which was measured after both groups received the treatment. The control variable was instructional materials, research instruments for both the experimental and control groups, and the content used, which was optics equipment previously validated by experts.

Data processing began with testing the normality and homogeneity of the data. Subsequently, the hypothesis was tested using the t-test with pooled variances at a significance level of 5%. The hypothesis testing aimed to determine the impact of the problem-based learning model assisted by PhET simulations on the physics problem-solving abilities of students. This was achieved by analyzing the results of the post-test for each class to draw conclusions about the influence or lack thereof of the applied treatment.

RESULTS AND DISCUSSION

The results of the pretest and post-test scores for the experimental and control groups can be seen in the following Table 2.

Table 2. Pretest and post-test results for problem solving ability

		Experimental Group	Control Group
Pretest	Number of students	31	31
	Average	33,22	32,51
	Highest Score	48	42
	Lowest Score	14	12
Post-test	Number of students	31	31
	Average	45,09	39,61
	Highest Score	70	60
	Lowest Score	30	30

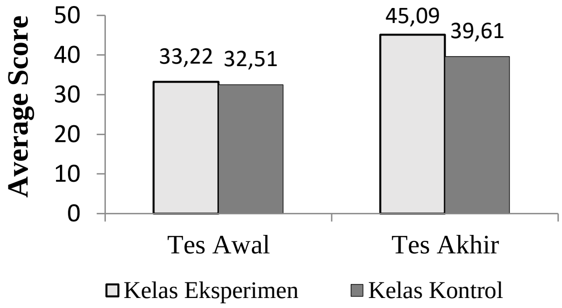

Figure 1. Comparison of the Average Scores of Problem-Solving Ability Test

The average initial abilities in the experimental class are almost the same as those in the control class. After the final test, both classes showed improvement, both in the experimental and control groups.

Figure 1 illustrates that the increase in the average scores of the experimental class is higher compared to the control class.

Discussion

The research sample consists of two groups: students from XI IPA 1 as the experimental group, receiving treatment using the PBL model assisted by PhET simulations, and students from XI IPA 2 receiving treatment using direct instruction. Both classes are taught by the same instructor, the researcher, with the same teaching materials (optical instruments) and an equal amount of learning time, which is four sessions. Before applying the treatment, students in both classes were given a pretest to assess their initial abilities. After the treatment, a post-test was administered to evaluate the improvement in students' physics problem-solving abilities.

The problem-solving abilities of the students under investigation are comprised of four indicators: recognizing the problem, planning strategies, applying strategies, and evaluating solutions. To measure these abilities, students were given a descriptive test consisting of 5 questions covering the four indicators.

Data analysis was conducted based on the results of the pretest and post-test in both the experimental and control groups. The pretest scores for both classes were low because students had not yet received instruction on the optical instruments. Homogeneity testing indicated that both classes were homogenous, and the data were normally distributed. Subsequently, a hypothesis test (t-test) using pooled variance was performed since the number of students in the experimental and control classes who took the post-test was the same. Additionally, the post-test data from both classes met the parametric test criteria, being both homogenous and normally distributed. The purpose of the hypothesis test (t-test) was to determine the impact of the applied teaching model in the experimental class. The calculation results indicate that the calculated t-value obtained from the analysis of the post-test scores in both classes is 2.24. Meanwhile, the critical t-value with 60 degrees of freedom at a 5% significance level is 2.00. Therefore, the calculated t-value (2.24) is greater than the critical t-value (2.00), which means, based on the hypothesis testing criteria (t_calculated > t_critical), the null hypothesis (H_0), stating that there is no effect of the problem-based learning model assisted by PhET simulations on the physics problem-solving abilities of students, is rejected. Simultaneously, the alternative hypothesis (H_a), which suggests that there is an effect of the problem-based learning model assisted by PhET simulations on the physics problem-solving abilities of students, is accepted. This result indicates that there is an influence on the improvement of students' physics problem-solving abilities due to the treatment provided in the experimental group.

The improvement in problem-solving abilities in the experimental class is based on the application of the PBL model assisted by PhET simulations, assessed through five stages according to Sahidu (2018): orienting students to the problem, organizing students for learning, guiding individual and group investigations, developing and presenting work results, and analyzing and evaluating problem-solving processes. In the orientation stage, students are presented with real-life problems to help them understand the practical implementation of the physics material being taught. The problems are assisted by PhET simulations, motivating students to solve the given problems, thus encouraging them to study more diligently and positively impacting their improvement in physics problem-solving abilities. The use of PhET simulations provides students with insights into real-life issues, allowing them to practice problem-solving skills.

Based on the data analysis in Table 1, the average pretest scores for the experimental and control classes are nearly the same. However, the average score for the experimental class is higher at 33.22, compared to 32.51 in the control class. A homogeneity test was conducted on the pretest scores, indicating that both classes had similar abilities. Subsequently, the two classes received different treatments, with the experimental class receiving problem-based learning assisted by PhET simulations, while the control class received direct instruction. After the treatments, the post-test scores for problem-solving abilities in the experimental class showed an average of 45.09, which is higher than the control class with an average of 39.61. The post-test results indicate an improvement in the physics problem-solving abilities for both classes, but the experimental class shows a higher improvement. This suggests a positive influence from the application of problem-based learning assisted by PhET simulations on the physics problem-solving abilities of students in the experimental class.

The PBL model demands active participation from students in the teaching and learning process. Students are presented with a problem at the beginning of the lesson, and they actively seek solutions. As expressed by Rusilawati (2020), problem-based learning (PBL) is a model that starts with providing a problem to students, and then they work to solve the problem to discover new knowledge. This approach demands students to be more active in the teaching and learning process. Based on the research conducted, it is evident that the PBL model can enhance the physics problem-solving abilities of students and contribute to improved learning outcomes.

The findings of study are supported by Suardani et al. (2014), who stated that there is a difference in problem-solving abilities between groups of students who learn using problem-based learning and those who learn using direct instruction. The group of students who learned using problem-based learning showed a more significant improvement than the group using direct instruction. Furthermore, the application of virtual media like PhET simulations also impacts the quality of students' problem-solving abilities, creating a more engaging and effective learning environment. This is consistent with Gunawan's research (2022), which emphasized that PhET virtual labs based on practical simulations are effective in enhancing students' problem-solving abilities.

CONCLUSION

Based on the research findings and data analysis, it can be concluded that there is an influence of the problem-based learning model assisted by PhET simulations on the physics problem-solving abilities of students in the topic of optical instruments. This is evident from the increased average scores of the students. Additionally, the application of the problem-based learning model, in collaboration with PhET simulations, can enhance the conceptual abilities of students.

The researcher suggests that future researchers implementing the problem-based learning (PBL) model assisted by PhET simulations should carefully plan and prepare before applying it in the classroom to ensure that the learning process aligns with the intended goals.

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