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# The Influence of the Problem-Based Learning Model Assisted by PhET Simulations on Students' Problem-Solving Abilities and Mastery of Physics Concepts

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**Abstract:** This study aims to examine the effect of problem-based learning model assisted by PhET simulations on problem solving ability and mastery of physics concepts of students. This type of 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, while the average value of concept mastery of the experimental class was 70 and the control class was 51.15. Data on problem solving ability and concept mastery of both classes are normally distributed and both are homogeneous. Data on problem solving ability and concept mastery were analyzed using the polled variance t-test at a significant level of 5% and obtained $t_{\text{count}}$ of problem solving ability of 2.24, while concept mastery obtained $t_{\text{count}}$ of 6.18 and obtained $t_{\text{table}}$ of 2.00, with hypothesis testing criteria if $t_{\text{count}}$ is greater than $t_{\text{table}}$ then $H_0$ is rejected and $H_a$ is accepted. Based on the results of this study, it shows that there is an effect of problem-based learning model assisted by PhET simulations on problem solving ability and mastery of physics concepts of students.

**Keywords:** Concept Mastery; PhET Simulations; Problem Solving; Problem-based Learning.

## Introduction

Physics is an online branch of natural sciences which studies objects in the universe physically and can also be written mathematically so that humans can understand them and can be used for the welfare of mankind (Mega and Nana. 2021). Apart from that, physics also discusses and studies natural phenomena through a series of scientific processes (Maryam et al., 2022). Based on this statement, learning physics cannot be separated from mastering concepts, working scientifically, and applying them in solving problems. However, current physics learning tends to only emphasize mastery of concepts and ignores the ability to solve a problem or it could be said that students' ability to solve problems is still relatively low so that it has a low impact on student learning outcomes (Hudha et al. 2017)

In Permendiknas No. 23 of 2006 for SMA/MA physics learning, students are required to be able to carry out experiments and have the skills to formulate problems, propose hypotheses, determine hypotheses, determine variables, design and draw conclusions, and communicate experimental results orally and in writing. In other words, students must have good skills, understanding and reasoning power regarding physical

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phenomena, therefore, physics learning must provide direct learning experiences through the use and development of skills. Apart from concept mastery skills, physics is also very much needed so that students can apply their understanding in life. Students' mastery of material can be seen from their abilities, including the ability to solve problems. Problem solving skills are very important for students, because students will be faced with various problems, both in the classroom and those found in everyday life. Apart from that, problem solving is the basis for determining solutions to various problems faced, especially problems related to physics.

Problem solving ability is the ability of students to use the amount of information or knowledge they have to determine what should be done about a particular problem. Then (Rokhmat, et al. 2017) also stated that problem solving ability is the ability to use knowledge in selecting or identifying the possibility of a certain phenomenon to be solved, so it can be said that there is a positive and significant relationship between mastery of concepts and ability to solve problems. , the concepts mastered by students will not be obtained without practice solving problems or finding solutions to questions related to the material being taught and vice versa, without good mastery of the material being taught, students will have difficulty identifying or solve a problem.

However, in reality, this problem-solving ability is one of the obstacles experienced by students, so that students do not master the concept and this creates difficulties in analyzing, identifying and solving a problem, so that students' learning outcomes are poor. Based on the results of observations during the Introduction to School Field activities at SMAN 4 Mataram for the 2022/2023 academic year, the physics learning process implemented in class is still teacher-oriented and tends to use the question-and-answer lecture method which does not build the knowledge possessed by students. The use of learning models that do not require student activity results in less interesting learning and results in a lack of students mastering the material being taught well, thus impacting students' low problem-solving abilities. The impact of these problems is on students' low physics learning outcomes.

In the physics learning process, students' understanding is greatly influenced by the quality of the learning model used by the teacher, because the quality of a learning model is one of the factors that determines students' learning outcomes in understanding the material being taught (Yanti et al., 2019). The aim of the learning process, apart from improving learning outcomes, is also to improve problem solving abilities. If students' problem-solving abilities are high, then students' learning outcomes will also be high (Rokhmat et al). So, to make this happen, a learning model is needed that can support students' problem-solving abilities and mastery of concepts.

An alternative learning model that is able to support problem-solving abilities and improve students' mastery of concepts is the problem-based learning model or what is abbreviated as PBL. As stated by Yanti, et al. (2019), the problem-based learning model, apart from being an effort to improve students' mastery of concepts, the problem-based learning model can also encourage students to learn and work together in groups to find solutions to problems related to physics and other problems. As stated by (Nursita et al.,) the problem-based learning model really helps students in improving their problem-solving abilities, because it requires students to solve a problem. Problem-based learning, abbreviated as (PBL), is a learning model that begins by giving problems to students, then students solve these problems to discover new knowledge, and students are required to be more active in the process of teaching and learning activities Rusilawati (2020).

The problem-based learning model will be maximized if it is collaborated with the use of learning media in the form of simple or technology-based media. Alternative media that can support the implementation of optimal learning activities is by utilizing PhET simulations which make it easier for students to carry out practicums. The PhET virtual laboratory can also connect students' ideas with real world life using scientific phenomena to understand the real world in everyday life Segening, et al. (2022). PhET simulations are a virtual laboratory medium that can be used to continue interesting physics learning and require a relatively short and practical time. Astuti et al (2018) also explained that virtual practicums carried out using computer technology can support the implementation of physics practicums, both for understanding concepts, collecting data, presenting and concluding data. Apart from that, virtual laboratories really help students in improving problem solving abilities, because computer-assisted practicums can improve generic thinking abilities, critical thinking skills and dispositions, problem solving abilities, as well as mastery of physics concepts, especially in abstract material (Rangga, 2018).

Based on the description above, this research aims to determine the effect of the PhET-assisted problem-based learning model on students' problem-solving abilities and mastery of physics concepts.

## Method

This research was carried out at SMAN 4 Mataram, even semester of, the academic year 2022/2023, with the research time being carried out from March-April 2023. This type of research is a quasi-experiment with a Nonequivalent Control Group Design. The population of this study was all students in class XI Science at SMAN 4 Mataram with a sampling technique using purposive sampling technique, because there were four classes to measure problem-solving abilities, students were given questions in the form of 5 description questions and 20 multiple choice questions to measure mastery of the concepts of both classes. Furthermore, the experimental class was given treatment with the PBL model assisted by PhET simulations, while direct learning was applied to the control class as a comparison.

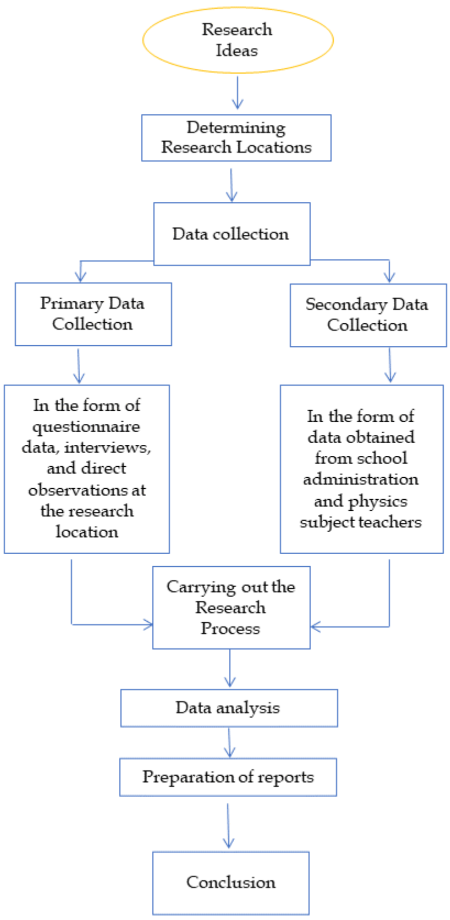


**Figure 1.** Research flow

## Result and Discussion

*Problem solving skill*

A comparison of students' physics problem solving abilities for the initial test and final test scores in the experimental class and control class can be seen in table 1.

The average initial ability score for the experimental class was almost the same as the control class. After being given the final test, students' abilities in solving physics problems increased in both classes. Figure 2 shows that the average score for the experimental class is higher than the control class.

Based on the analysis in table 1, it shows an increase in the average value in both classes, both in the experimental class and in the control class, with the average value for the experimental class increasing from 33.22 to 45.09 and for the control class increasing from 32.51 to 39.61. Based on these results, the increase in the average value of physics problem solving ability in the initial test was almost the same between the two classes and in the final test the ability of both classes increased. However, the increase in the average score of the experimental class was higher than that of the control class.

**Table 1.** Results of the Initial Test and Final Test of Problem-Solving Ability

| | | Experimental Class | Control Class |
|---|---|---|---|
| Pre-test | The Average score | 33.22 | 32.51 |
| | The highest score | 48.00 | 42.00 |
| | The Lowest score | 14.00 | 12.00 |
| Post-test | The Average score | 45.09 | 39.61 |
| | The highest score | 70.00 | 60.00 |
| | The Lowest score | 30.00 | 30.00 |

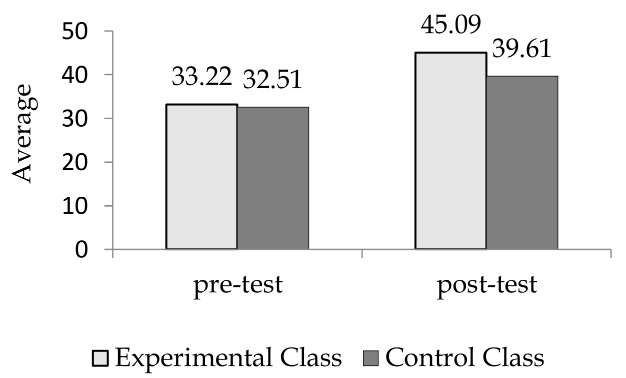


**Figure 2.** Comparison of Average Scores on Problem Solving Ability Tests

Based on the results of the homogeneity test, the two classes are homogeneous and the data is normally distributed. Next, a hypothesis test (t-test) was carried out using the polled variant t-test, to find out the effect of the learning model that had been implemented in the experimental class. The results of the statistical test (t-test) that was carried out showed that the increase in the average score of the experimental class was higher than that of the control class, which means that the learning model applied in the experimental class influenced students' physics problem-solving abilities.

Increasing problem solving abilities in the experimental class is based on the application of the PBL model assisted by PhET simulations which is viewed from the 5 stages that are passed during implementing the model according to Sahidu (2018), namely, orienting students to the problem, organizing students to learn, guiding individual and group investigations, develop and present work results, and analyze and evaluate the problem solving process. At the problem orientation stage, problems are raised based on the realities of life, so that students can understand the implementation of the physics material being taught, the problems raised are assisted by virtual media PhET simulations which encourage students' enthusiasm to solve the problems given, so that students are motivated to be more active learning and have an impact on increasing students' abilities in solving physics problems. The existence of virtual media PhET simulations can provide students with an overview of real problems in everyday life.

Based on these stages, students can train their thinking skills in solving problems. The results of this research were confirmed by Suardani, et al. (2014) who state that there are differences in problem-solving abilities between groups of students who study using the problem-based learning model and groups of students who study using the direct instruction model. Likewise, research conducted by Dwi & Rahman (2020) also stated that students who were given learning using the PBL model improved their problem-solving abilities significantly better than students who were given direct learning. Apart from that, the application of PhET simulations in virtual media also influences the quality of students' problem-solving abilities and can create a more interesting and effective learning atmosphere. This is to research conducted by Gunawan, (2022) which states that, the PhET virtual laboratory is based on practical simulations. and effective in improving students' problem-solving abilities.

Based on the results of the final hypothesis test, it was obtained that tcount>ttable was 2.24 > 2.00 at a significance level of 5%, indicating that there was a difference in students' physics problem solving abilities between students who learned using the problem-based learning model assisted by PhET simulations and students who learned using the model. direct learning (Direct instruction).

*Mastery of concepts*

A comparison of students' mastery of physics concepts for the initial test and final test scores in the experimental class and control class can be seen in table 2.

The initial ability of the experimental class was better than the control class, as seen from the average initial test score of the experimental class and the average initial test score of the control class. Both the experimental class and the control class experienced improvement after the learning process. However, if you look at the table above, the experimental class experienced better improvement than the control class. The results of the N-gain test analysis of students' concept mastery can be seen in Table 3 which shows that the experimental class has a higher N-gain value compared to the control class, namely 53% for the experimental class and 34% for the control class.

**Table 2.** Results of the Preliminary Test and Final Test of Concept Mastery

| | | Experimental Class | Control Class |
|---|---|---|---|
| Pre-test | The Average score | 36.77 | 25.32 |
| | The highest score | 60.00 | 50.00 |
| | The Lowest score | 20.00 | 10.00 |
| Post-test | The Average score | 70.00 | 51.15 |
| | The highest score | 85.00 | 70.00 |
| | The Lowest score | 40.00 | 30.00 |

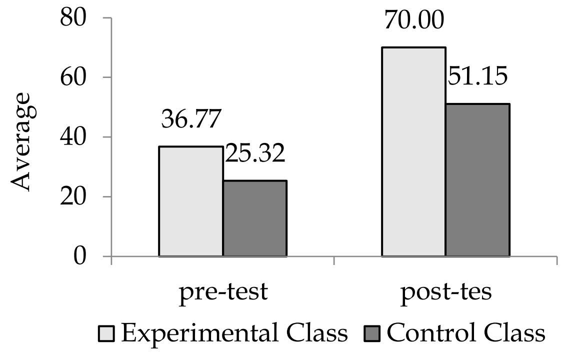


**Figure 3.** Comparison of Average Scores on Concept Mastery Tests

Based on data analysis in Table 2, the initial abilities of the experimental class were better than those of the control class, seen from the average initial test score for the experimental class 36.77 and the average initial test score for the control class 25.32. Both the experimental class and the control class experienced improvement after the learning process. However, if you look at the table above, the experimental class has improved better than the control class, this is based on the average score of the initial test and the average of the final test, where the experimental class increased from 36.77 to 70 and the control class increased from 25. .32 to 51.15. Based on the results of statistical tests (t-test) that have been carried out, show that the increase in the average score of the experimental class is higher than that of the control class, which means that the learning model applied in the experimental class which is assisted by PhET simulations has an influence on students' mastery of concepts. The results of this research were strengthened by Yoesoef (2015) who stated that the problem-based learning model can improve students' mastery of physics concepts. Apart from that, previous research conducted by Isti (2017) also stated that the mass-based learning model (PBM) had a positive and significant effect on students' mastery of concepts and had an impact on students' learning outcomes because, in the application of the PBM, model students gained knowledge not by remembering. but rather by understanding the material being taught.

**Tabel 3**. Normalized gain (g) Mastery of Physics Concepts

| Class | Average | | Maxsimum Score | (g) |
|---|---|---|---|---|
| | Pos-test | Pre-test | | |
| Experimental | 70.00 | 36.77 | 100.00 | 53.00% |
| Control | 51.15 | 25.32 | 100.00 | 34.00% |

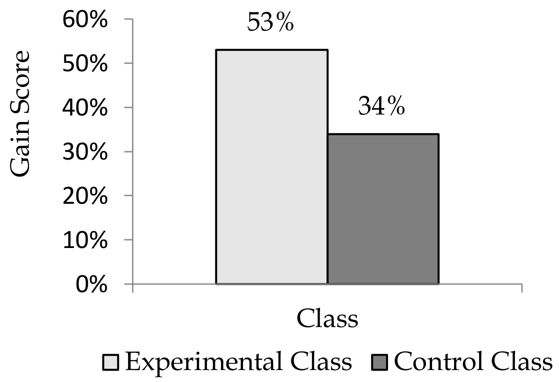


**Figure 4.** Comparison of N-gain Values for Concept Mastery

Students who are directly involved in solving problems during the learning process can master concepts well. The results of this research are strengthened by research by Shinta (2016) which states that there is a higher increase in concept mastery in the experimental class with a very significant difference compared to the increase in concept mastery in the control class by implementing a problem-based learning model.

Mastery of concepts can also be increased by the problem-based learning model in collaboration with PhET simulations because students are faced directly with problems, so it can encourage students to learn actively and independently, build new knowledge by exchanging ideas and helping each other in completing assignments or LKPD which is accompanied by the help of virtual media PhET simulations which functions to visualize abstract concepts in optical equipment material. Not only that, utilizing the PhET virtual laboratory media can help students more easily understand the material taught by Nur Aisyah et al, (2023). The results of previous research also found that there was an influence of the use of virtual laboratory media on students' conceptual understanding Nur Hikmah (2017). Previous research also found information that learning with the help of PhET simulations can support students in mastering physics material, especially in mastering physics concepts (Lestari et al, 2022).

Increased mastery of physics concepts can be seen based on the results of the N-gain test. The results of the N-gain test in the experimental class showed a higher value than the control class as a whole, namely 53% for the experimental class and 34% for the control class. This increase is the influence of the learning that has been carried out. Based on the research results, it was found that the problem-based learning model assisted by PhET simulations had an effect on students' mastery of physics concepts. The results of hypothesis testing in the final test obtained $t_{count} > t_{table}$, namely 6.18 > 2.00 at the 5% significance level, indicating that there is a difference in concept mastery between the experimental class and the control class. The results of this research are strengthened by previous research, namely according to Hastuti. et al, (2016) stated that the problem-based learning model assisted by virtual media had an effect on students' mastery of physics concepts. In line with research by Shinta (2016) which states that problem-based learning models assisted by virtual simulations can further improve students' mastery of concepts compared to direct learning models.

## Conclusion

Based on the results of research and data analysis, it can be concluded that there is an influence of the problem-based learning model assisted by PhET simulation on students' problem-solving abilities and mastery of physics concepts in optical instruments. This can be seen based on the average value of students who have increased.

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