PERJ Vol. 6 No.2 (2024), 59-64

PERJ
ISSN 2685 - 6190 (p)
ISSN 2714 - 7746 (e)
Physics Education Research Journal
Department of Physics Education
Faculty of Science and Technology
UIN Walisongo Semarang-Indonesia

Enhancing Problem-Solving Skills in Elasticity and Hooke's Law through Problem-Based Learning with PhET Media and Mechanics Kits

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ARTICLE INFO

Article history:
Submitted : April 22nd, 2024
Revised : June 10th, 2024
Accepted : July 22nd, 2024

Keywords:
Problem-Based Learning; PhET; Mechanics Kit; Problem-Solving Ability

ABSTRACT

This research was conducted in Class IX of SMA Negeri Posigadan. This research aims to determine the influence of the Problem-Based Learning model assisted by PhET media and Mechanics Kit on problem-solving ability in elasticity and Hooke's law. This research employs an experimental method. The population of this research comprises all grade IX students in the odd semester of SMA Negeri Posigadan for the academic year 2023/2024. The research sample was selected using random sampling, consisting of two classes: the experimental class, with 22 students applying the Problem-Based Learning model assisted by PhET media and mechanics Kit, and the control class, with 22 students applying the conventional model. Data for this research were obtained using test instruments in six essay questions. The results indicate that the experimental class received an average pretest score of 35.7 and an average post-test score of 82.1. Meanwhile, the control class obtained an average score of 31.3 and an average post-test score of 62.6. Both classes were found to have a normal distribution (obtained $L_{count} \leq L_{table}$) and homogeneity (obtained $F_{count} < F_{table}$). Subsequently, both classes were given different treatments, and a post-test was administered at the end of the lesson. From the statistical data analysis (one-tailed t-test), it obtained $t_{count} > t_{table}$ or $5.03 > 1.68$, indicating a significant influence of applying the Problem-Based Learning model assisted by PhET media and Mechanics Kit on problem-solving abilities in elasticity and Hooke's law.

Introduction

Education is a system that involves two essential components, namely educators and students. Educators are individuals/people who have the task of educating, guiding, and directing students in the educational process. Meanwhile, students are individuals or people who receive education, guidance, and direction from educators. Educators and students have a very close relationship when carrying out the learning process. An effective learning process occurs when these two components interact and communicate in two directions. Educators act as teachers who provide knowledge and guidance, while students act as people who learn (Ardianti et al., 2022).

Learning essentially involves changing a person's personality, characterized by increasing the quality and amount of behavior. This can take the form of improvements in skills, knowledge, attitudes, habits, understanding, and thinking abilities. Apart from that, learning also involves developing cognitive and creative skills, such as thinking logically, analytically and synthetically, thinking critically, and solving problems (Siboro et al., 2021).

Problem-solving skills are very important for students when solving problems the teacher gives, especially in physics. Physics is a branch of science in Natural Sciences (IPA) that is related to understanding the products and processes around us. In physics, physical concepts and laws are studied as products

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doi: 10.21580/perj.2024.6.2.20822

and observations, experiments and analyzes are carried out as processes to understand these physical phenomena. In physics learning, students are expected to be active subjects directly involved. Therefore, students need to develop problem-solving abilities because without understanding the causes of a problem, the problem cannot be resolved effectively. Teachers must also be able to design effective teaching strategies and methods so that the physics learning process can run optimally (Noviatika et al., 2019).

Based on the results of observations carried out at Posigadan State High School with physics teachers, it is known that the level of students' problem-solving abilities, especially in physics lessons, is still considered very low; this can be seen from the number of students with less than 60% getting a KKM score of 70. One of the common challenges in learning physics is the lack of student's ability to solve physics problems or problems systematically. The physics subject teacher at Posigadan State High School said that students often face difficulties in understanding the essence of the question, determining the relevant physical quantities, understanding the symbols used in the question, and identifying the concepts, laws, or formulas needed to solve the problem. Teachers must help students improve their mathematical problem-solving abilities to overcome this challenge. One learning model suitable for enhancing students' problem-solving skills and learning motivation in physics lessons is the Problem-based Learning (PBL) model.

Problem-based Learning (PBL) is a learning model in which students are given problems relevant to real situations and are challenged to find solutions to these problems. This learning model aims to train students to develop their abilities and skills in solving various issues (Furqan et al., 2019). PBL has the potential to strengthen students' understanding of effective teamwork and help them build a clear relationship between a collaborative attitude and achieving optimal learning outcomes. By involving students in problem-based learning, this model encourages students to improve their ability to collaborate, share ideas, and work as a team. This learning process opens up how to work efficiently in a team to achieve maximum learning results (Ilmiyatni et al., 2019).

One type of learning media that effectively supports the application of the problem-based learning model is virtual simulation. According to Muzana et al. (2021), this virtual simulation is designed to be a strong competitor in providing learning experiences to students. Using suitable media can make learning more exciting and increase students' interest. The virtual learning media that can be used well for directed physics problem-solving is PhET.

PhET (Physics Education Technology) is an interactive simulation via the internet that uses Java and Flash programming languages. This simulation was developed by a team from the University of Colorado, United States, and designed by experts to help physics educators convey learning material more efficiently. Apart from assisting educators in delivering material, PhET facilitates students' understanding, especially in material related to real natural phenomena, and requires laboratory practice (Furqan et al., 2019).

One of the physical materials related to real natural phenomena is elasticity and Hooke's law. This material includes concepts applied in everyday life that require direct practical activities to make it easier for students to solve physics problems. The tool that can be used in practical activities regarding elasticity and Hooke's law is the Mechanics kit. This Mechanics kit is a tool to facilitate understanding of complex concepts more quickly.

Using PhET and Mechanics Kits in learning provides a comprehensive and practical approach. With PhET, students can start with interactive simulations to understand concepts theoretically and visually. Then, using the mechanics kit, students can apply these concepts in real experiments, strengthening understanding and improving practical skills. The use of PhET and Kit not only makes learning more exciting and fun but also increases students' active involvement in the learning process. Students are encouraged to think critically, solve problems, and understand physics concepts more deeply. Thus, using PhET and the mechanics kit, it is hoped that students can develop problem-solving skills more effectively, especially the ideas of elasticity and Hooke's law, which can help improve the quality of physics learning.

Based on the description above, researchers are interested in "The Effect of Problem-Based Learning Models Assisted by PhET Media and Mechanics Kits on the Ability to Solve Problems on the Concept of Elasticity and Hooke's Law." This research aims to determine the effect of the Problem-based learning model assisted by PhET media and the mechanics kit on the ability to solve problems related to the concept of elasticity and Hooke's law.

Methods

This research was carried out at Posigadan State High School. The research was conducted during November-December in the odd semester of the 2023-2024 academic year. In this research, the experimental method is used. The research design used is a Pretest Post-test Control Group Design, as shown in Table 1.

Table 1
Research Design

Group	Pretest	Treatment	Post-test
Experiment	0_1	X	0_2
Control	0_3	Y	0_4

Information :
0_1 : Initial test (pretest) for the experimental class
0_2 : Final test (post-test) for the experimental class
0_3 : Initial test (pretest) for the control class
0_4 : Final test (post-test) for the control class
X : Treatment of the PBL model assisted by PhET media and mechanics kit
Y : Treatment of conventional learning models in schools

This study's population was all 112 class IX odd-semester students at Posigadan State High School, divided into four classes. This research consists of two classes, namely the experimental and control classes, which were taken using random sampling techniques. This research consists of independent variables, such as the PBL (Problem-Based Learning) model assisted by PhET and mechanics kit (X) media. The dependent variable is the problem-solving ability (Y).

The research instrument used in this research was a problem-solving ability test. The test is a selection and evaluation tool expected to produce objective and accurate values or scores (Malik & Chusni, 2018)(Malik & Chusni, 2018). The type of test used is an essay with five questions for each pretest and post-test. The data analysis technique used in this research used several tests: the normality test (Liliefors test), homogeneity test, and Independent Sample T-test.

Result and Discussions

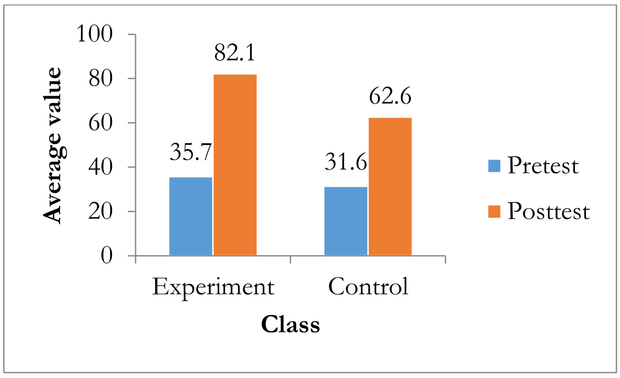
At the start of the research, both classes were given an initial ability test (pretest) to determine students' initial abilities. After learning is complete, a post-test is provided to determine the extent of learning success in the experimental and control classes. The results of the pretest and post-test data analysis for the experimental and control classes can be seen in Table 2.

Table 2
Average Pretest and Posttest Score

Class/Sample	Pretest Score	Post-test Score
Experiment	35.7	82.1
Control	31.3	62.6

Based on Table 2, the average pretest and post-test scores in each class are different. In the experimental class, the pretest score was 35.7, and the post-test was 82.1. Meanwhile, the control class had a pretest score of 31.3 and a post-test of 62.6. These results show that there was an increase before and after learning in both the experimental class and the control class. Let's compare the post-test average scores in terms of receiving different treatments. It can be seen that the experimental class obtained a higher average score than the control class's average score.

Figure 1
Diagram of Increasing Student's Problem-Solving Abilities in Control and Experiment Class



Based on Figure 1 above, it can be seen that there has been a significant increase in the average pretest and post-test scores, and there is a difference in scores in the experimental class and control class, where the highest average score is in the experimental class. This is caused by different treatments being given to each class. In the experimental class, students are directly exposed to concrete problems presented with various physics problems displayed in videos and images, thus encouraging students to learn actively and independently, build new knowledge, and exchange ideas with group friends. Meanwhile, in the control class, the teacher explains the material at the beginning of the lesson and gives examples of practice questions to the students. For every material that the teacher presents, students practice solving the questions given by the teacher, so students tend to be passive in learning and are not trained to solve more complicated problems in real life.

Before determining the statistics used in concluding, a normality and homogeneity test must be analyzed first. The normality test used in this research is the Liliefors test. The results of the data normality test can be seen in Table 3.

Table 3
Data Normality Test Results

Liliefors Test			
Test	L_{count}	L_{table}	Status
Experimental Posttest	0.13	0.18	Normal
Control Posttest	0.10	0.18	Normal

Based on Table 3, it can be seen that $L_{count} \leq L_{table}$ for a significance level of α=0.05, then the hypothesis H_0 (sample with normal distribution) is accepted, and the hypothesis H_a (sample not normally distributed) is rejected. So it can be concluded that the research data is normally distributed.

After the sample is declared normal distribution, homogeneity testing is carried out. The aim is to determine whether the research data has homogeneous variants. The homogeneity test results can be seen in Table 4.

Table 4
Data Homogeneity Test Results

Fisher Test			
Test	F_{count}	F_{table}	Status
Experimental Posttest	1.70	4.32	Homogeny
Control Posttest			

Based on Table 4, student learning outcomes data in the research have a value of $F_{count} < F_{table}$ at a significant level of α = 0.05. This indicates that the data on student learning outcomes comes from a homogeneous population. The F-test requirements have been fulfilled so that it can be used to test the research hypothesis.

Hypothesis testing was carried out to ascertain whether the way teaching was given in the experimental class was more influential than the way teaching was given in the control class. Hypothesis testing was carried out after normality testing and homogeneity of variance testing, resulting in the data in the experimental and control classes being normally distributed and having homogeneous variance. Thus, research hypotheses can be tested using the independent T-test. The results of hypothesis testing using the independent T-test can be seen in Table 5.

Table 5
Hypothesis Test Results

Independent T-test			
Test	t_{count}	t_{table}	Status
Experimental Posttest	5.03	1.68	H_0 Rejected
Control Post-test			

Based on Table 5, it can be seen that. t_{count}= 5.03 > t_{table} = 1.68, this indicates that the significance level α = 0.05 H_0 (no effect) is rejected and H_a (has influence) is accepted. So it can be concluded that the Problem-based learning model, assisted by PhET media and the mechanics kit, influences student learning outcomes regarding the concept of elasticity and Hooke's law.

The results of the research that was carried out based on the initial test (pretest) showed that the problem-solving abilities of experimental class and control class students were still low. This can be seen from the average problem-solving ability test in each class, which is 35.7 and 31.3, as shown in the table. The average initial test score is low because students have not been treated and received elasticity and Hooke's law material. The initial test is conducted to determine students' abilities and courage in answering questions from material that has not been obtained. The test also tests the extent of students' problem-solving skills.

After these two classes received different treatments—where the experimental class used the PBL model with a mechanics kit in the first meeting and PhET Simulations in the second and third meetings, while the control class followed a conventional model—both classes were given a final test (post-test) with the same material and question weight as in the initial test. Based on the analysis of the latest test data, the experimental class obtained a higher average score of 82.1 compared to the control class's score of 62.6. Then, a hypothesis test was carried out to prove whether there was an effect after being given different treatments, and the results obtained were $t_{count} > t_{table}$, which means H_a was accepted and H_0 was rejected. So it can be concluded that using the Problem-Based Learning (PBL) model assisted by PhET media and the mechanics kit positively influences students' problem-solving abilities.

This is in line with the results of research conducted by HS Dyan & Marianus, (2022) which states that the

Problem-Based Learning (PBL) learning model has a better influence on the results of students' problem-solving abilities. Research by Lestari et al. (2022) proves that the Problem-Based Learning learning model accompanied by PhET simulation affects problem-solving skills. Then, research by Jati et al. (2022) stated that learning using the mechanics kit media in the experimental class improved analytical skills more than in the control class, which used conventional learning. Apart from that, according to Riskawati & Rezkawati (2021), applying Problem-based Learning can increase interest in learning physics.

This learning model emphasizes structured learning experiences, including investigation and problem-solving. In each learning session, students will be given relevant problems related to everyday life that must be solved. There are several obstacles faced during the research process. For example, when entering class to learn, you have to wait for the tool used for the learning process, namely the projector. This is due to schools' limited facilities or equipment, so they have to take turns using the tools needed in the learning process. Apart from that, another obstacle during the learning process is that some students do not have internet access, while learning requires internet access. To overcome this, researchers provide internet access so the learning process can run smoothly.

Aris (2019) explains that the PBL model is a teaching model characterized by real problems as a context for students to learn critical thinking and problem-solving skills and gain knowledge. Using the Problem-based Learning model also provides more motivation and opportunities for students to learn actively using their broader knowledge. In this way, students can hone their thinking skills by applying this knowledge.

Conclusions

Based on the results of data analysis that have been obtained on student learning outcomes, the T-Test results indicate that. $t_{hitung} > t_{tabel}$ (5.03 > 1.68). This means that at a significance level of $\alpha = 0.05$, H_a is accepted and H_o is rejected. So it can be concluded that the Problem-based Learning model assisted by PhET Media and Mechanics Kits influences problem-solving abilities.

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