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The Influence of the PhET Simulation-Assisted Project-Based Learning Model on Students' Ability to Master the Elasticity Concept

Dian Faisal Hadi[1*], Aris Doyan[1,2], Jannatin 'Ardhuha[1], Ahmad Harjono[1]

[1] Physics Education Study Program, FKIP, Universityof Mataram, Mataram, Lombok, West Nusa Tenggara, Indonesia.
[2] Master of Science Education Study Program, University of Mataram, Mataram, Lombok, West Nusa Tenggara, Indonesia

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Corresponding Author:
Dian Faisal Hadi
dianhadifaisal@gmail.com

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Abstract: This study aims to determine the effect of the PhET simulation-assisted project-based learning model on students' ability to master the concept of elasticity. The type of research used in this study was a quasi-experimental design with a pre-test and post-test control group design. The population in this study were all students of class XI IPA at SMAN 1 Wanasaba East Lombok, totaling 142 students. The research sample was taken using purposive sampling, so that 31 students were selected in class XI IPA 2 as the experimental class and 31 students in XI IPA 1 as the control class. The independent variable in this study was the PhET simulation-assisted project-based learning model used in the experimental class, while the ability to master the concept became the control variable. The instrument used to measure the students' mastery of the concept is a test instrument in the form of a description test on the material elasticity of 6 questions. The results of the pre-test data analysis showed that the students' initial knowledge was almost the same, but after being given treatment, the average post-test score of the experimental class was 79.22 and that of the control class was 72.64. The results of the t test using the Independent Sample T test on the post-test showed a significance (2 tailed) less than 0.050, so it can be concluded that the project-based learning model assisted by the PhET simulation has an effect on students' ability to master the concept of elasticity.

Keywords: Concept mastery ability; Elasticity; PhET simulation; Project based learning

Introduction

Education in Indonesia is inseparable from the role of the government which continues to develop the curriculum which is one of the elements that influences students to develop their potential (Sahidu, 2018). According to Aldi et al. (2022), creating a quality generation that can compete in the 21st century is one of the tasks assigned to teachers. Teachers must think more about the procedures for incorporating knowledge to build students' mastery of concepts in the material being taught, because the success of learning also depends on the depth of concepts possessed by students (Ramdani et al., 2020). The use of appropriate learning models can optimize students' conceptual mastery abilities, so in spectacles learning it is necessary to use learning models that are embedded in students, so that students can be involved intellectually and emotionally, and attract the attention of students to learn from their own awareness (Fajrina et al., 2018).

Based on the results of interviews with physics subject teachers at SMAN 1 Wanasaba East Lombok, the physics lessons used at that school use little discussion and question and answer methods, therefore learning is still teacher-centered. Solving problems carried out by students in learning is still considered unsatisfactory by the teacher because students' mastery of concepts is not too deep. Mastery of the concept is very lacking in the spring arrangement material in the elasticity chapter. The use of learning media such as PhET has been used before, but after the covid 19 pandemic it has never been used again, due to demands from the government which require students to study from home and reduce class hours in class, so students also do not know about the

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application or virtual laboratories such as PhET simulations, because they have never used them for practicum in learning.

The impact of learning at home also results in many not implementing the demands of the 2013 curriculum, students are never given assignments in the form of projects that involve several students in a group, students only solve problems in physics without knowing their relation to everyday life, so students don't really like physics because it is considered difficult and boring (Wirda et al., 2021).

The problems faced by SMAN 1 Wanasaba can be overcome by applying a learner-centered learning model. There are lots of student-centered learning models, one of which is the project-based learning model (Syukri et al., 2021). The project-based learning model is a project-based learning model that requires students to investigate and complete projects that they arrange in groups (Sari et al., 2018). Through project-based learning, students can explore their potential when working on projects as if they were in the real world and gain knowledge and experience to produce real products (Zulyusri et al., 2023).

The use of projects in this learning model can be in virtual or real form, to help students not get bored in learning, they will use a virtual project, namely the Physics Education Technology Simulation or better known as the PhET simulation (Rosmiati et al., 2022). PhET simulation is a very effective learning medium for improving the quality of students' mastery of concepts (Yunita et al., 2020). According to Yulia et al. (2018), PhET simulation is a virtual laboratory that contains all physics material aimed at developing the user's mastery of concepts independently. The development of PhET simulations can make it easier for students to master the physics concepts being studied using dynamic graphics that can display animated visual and conceptual models used by expert physicists (Susilawati et al., 2021).

Figure 1. Initial view of PhET simulation

The application of the project-based learning model assisted by the PhET simulation is expected to improve students' mastery of the concept of elasticity (Figure 1). According to Widia et al. (2020), concept mastery is the ability to interpret something that has been obtained in learning so that the person concerned can apply it in everyday life. Sumarni et al. (2020), put forward concept mastery as an ability in which the performer is able to express a material and apply it in everyday life.

Research conducted by Monika (2018) states that there is a positive effect of learning physics using the project-based learning model on students' mastery of concepts, with an increase in students' scores after being given treatment with project-based learning. Another study conducted by Erlinawati (2020) concluded that the use of the project-based learning model assisted by PhET virtual media is a solution for teachers to improve students' mastery of students' concepts.

Method

This research was conducted at SMAN 1 Wanasaba in the 2022/2023 academic year, class XI IPA which was held 3 times in both classes. The type of research used is quasi-experimental research (quasi-experimental) because it is characterized by the presence of a control group and a treatment designed to change conditions. The research design used was the pretest posttest control group design. This research requires two classes, namely the experimental class and the control class. The experimental class was given treatment, namely learning using the project based learning model assisted by PhET simulations, while the control class used conventional learning. The following is a research design table according to Herfa (2020).

Table 1. Pre-test Post-test Control Group Design

Classes	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Information: X = experimental class treated with PjBL model assisted by PhET simulation; O_1= administration of pre-test to the experimental class; O_2= administration of pre-test to the control class; O_3 = giving a post-test to the experimental class; O_4 = giving a post-test to the control class.

All 142 students of class XI IPA constitute the population used in this study. The sample used was taken using a purposive sampling technique, so that a total of 31 students from XI IPA 1 were obtained as the control class and 31 students from XI IPA 2 as the experimental class.

The instrument used in this study was a test in the form of a description of 6 items. Before the instrument is used in research, its feasibility is first tested with a validity test which aims to see whether a measuring instrument is valid or not (Umar et al., 2020). The reliability test aims to determine the extent to which the instrument can be trusted (Puspasari et al., 2022). The differential power test aims to be able to distinguish

between students who are proficient and students who are not proficient (Amanda et al., 2019), and the level of difficulty test which aims to determine students' views of the questions being tested (Son, 2019). After the test is carried out, the questions that are considered to meet the standard can be used for pre-test and post-test questions.

The test questions were given to the experimental class and control class during the pre-test (before being given treatment) and post-test (after being given treatment). The data obtained will then be analyzed with the normality test and homogeneity test as a form of the conditions for carrying out the hypothesis test. The normality test is carried out with the aim of assessing the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not (Quraisy, 2020). The homogeneity test is used to find out whether some population variants are the same or not (Usmadi, 2020), this test uses the variance test equation or F-test to find out whether data is homogeneous or not, these two tests are assisted by SPSS 21.

Post-test value data then tested the hypothesis. Hypothesis testing is a decision-making method based on data analysis (Mandailina et al., 2022), this test uses parametric statistics where if the data is homogeneous and normally distributed, then the parametric statistics used according to Palupi et al. (2021) are independent sample T-test, to determine the effect of the project-based learning model assisted by PhET simulation on students' ability to master the concept of elasticity.

Result and Discussion

The results of the instrument test on the description questions in this study can be seen in the Table 2.

Table 2. Instrument Test Results

Question	r_{table}	r_{xy}	r_{11}	df	dl	Information
X1	0.36	0.57	0.74	0.46	0.95	Accepted
X2	0.36	0.50	0.76	0.39	0.92	Accepted
X3	0.36	0.81	0.68	0.65	0.60	Accepted
X4	0.36	0.79	0.68	0.63	0.45	Accepted
X5	0.36	0.74	0.70	0.57	0.55	Accepted
X6	0.36	0.62	0.75	0.40	0.88	Accepted

Based on the table to it can be seen in the table description, that all questions are acceptable and can be used in research. On r-table is 0.367 because the way to determine r-table according to Ismiati et al. (2021) is to use the formula degrees of freedom (df) = (n - 2). The six questions above also have a different power level of 5 good and 1 sufficient, this is based on the criteria for different power which refers to research conducted by Ndiung et al. (2020), and lastly, this item instrument has a difficulty level (dl) criterion of 3 easy questions and 3 easy questions moderate, this is based on the difficulty level criteria which refers to research conducted by Fitriani (2021).

Before being given treatment to the two classes, a pre-test was given to both classes, which were then tested for normality and homogeneity, with the aim of knowing the initial abilities and whether the two classes had the same abilities.

Table 3. Pre-test Data on the Ability to Master the Concept of Elasticity

Description	Pre-test	
	Experiment	Control
The highest score	65.00	65.00
Lowest Value	17.00	28.00
Average	36.38	39.00
Normality test	Normal	Normal
Homogeneity Test		Homogeneous

Based on the normality test and homogeneity test, it was found that both classes had the same initial abilities, which means that the data were normally distributed and came from homogeneous samples. Then the two classes were given treatment, the experimental class was given treatment in the form of learning using the project-based learning model assisted by PhET simulations and the control class using conventional learning. After the two classes were given treatment, the researcher gave a post-test to both classes to determine the effect of the treatment given. Student post-test data have been tested for homogeneity and normality and are presented as Table 4.

Table 4. Post-test Data on the Ability to Master the Concept of Elasticity

Description	Post-test	
	Experiment	Control
The highest score	100.00	88.00
Lowest Value	65.00	50.00
Average	79.22	72.64
Normality test	Normal	Normal
Homogeneity Test		Homogeneous

Based on the table above, the experimental class and control class experienced an increase in the ability to master the concept, but the experimental class experienced a higher increase than the control class.

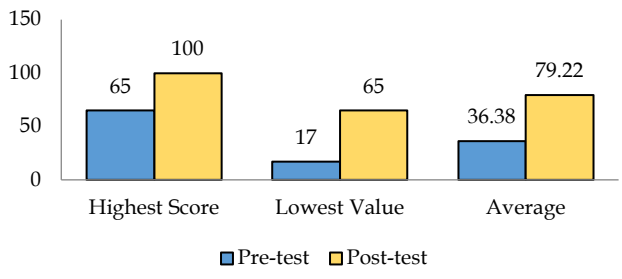

Figure 2. Comparison of pre-test and post-test experiment classes concept mastery abilities

The graph above shows an increase in the value of the ability to master concepts in the experimental class, giving treatment in the form of a project-based learning model assisted by a PhET simulation greatly influences students' ability to master concepts, this can be seen directly, where the highest score before the implementation of the project-based learning model was 65.00 whereas after the treatment was carried out the value increased to 100.00, not only that the lowest value when not given treatment was 17.00 while after being given treatment it was 65.00 or the same as the highest value before being given treatment. The average value of the experimental class also increased by 42.84, from 36.38 to 79.22.

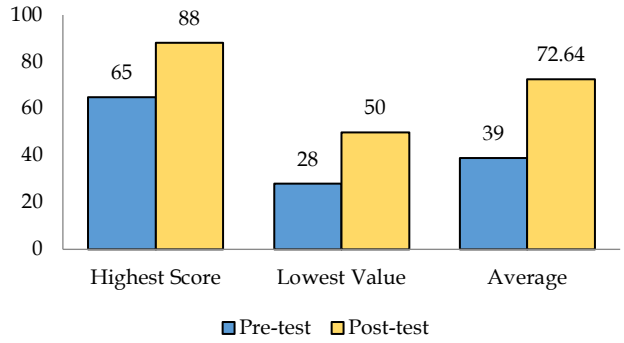

Figure 3. Comparison of pre-test and post-test control class concept mastery abilities

The graph above shows the value of concept mastery in the control class with conventional learning treatment, where the highest score before being given treatment was 65.00 and after being given treatment was 88.00, the lowest score before being given treatment was 28.00 and after being given treatment was 50.00. The increase in the average value in the control class was 33.64, where the increase in the average value of the experimental class was higher than that of the control class.

Then a normality test was performed which was calculated using the SPSS 21 assisted Chi-Square test for both samples, it was found that the post-test values were normally distributed. Testing the homogeneity of the post-test data in the experimental class and control class was carried out by the F-test and it was found that the sample came from a homogeneous population. The data of the two samples were declared normal and homogeneous so that the t-test equation used was the independent sample t-test.

Based on the calculation results, it was found that the significance number was 0.013 which means it is smaller than 0.050. This indicates that H_a is accepted, which means that there is an influence of the project-based learning model assisted by the PhET simulation on the students' ability to master the concept of elasticity material. The results showed that the class that was given treatment with the PhET simulation-assisted project based learning model got better concept mastery scores than the class with the conventional learning model, this is in line with research conducted by Ningrum et al. (2021) which stated that there was a significant influence on class who apply project-based learning to their concept mastery abilities, this is marked by a fairly high increase in grades compared to classes that apply conventional learning.

Increased mastery of concepts in the experimental class because the project-based learning model is a learning model that inspires students to have the courage to express knowledge in making projects and share information with other friends in discussing learning material so that the learning atmosphere will be more effective through group collaboration. This is in line with research conducted by Hasanah et al. (2021) which states that group-based learning is more effective than individual learning. The project-based learning model also requires students to be more active in class, the activeness of students in class has an impact on students' ability to master concepts, this is evidenced in the results of the final test, classes that implement learning using the project-based learning model get higher scores than the class given the treatment is in the form of conventional model learning, this research is reinforced by research conducted by Marlinda (2020), she concluded that the combination of the project-based learning model with PhET simulation is very suitable, this is because in the project-based learning model the teacher acts as a facilitator while students participate in conducting research, This causes students to have more experience and trains them to work together in groups. This model also trains students in working together to solve problems or achieve the desired goals.

Several stages in the project-based learning model make it superior to conventional learning models. The project-based learning model is a project-based learning model. In this lesson each student has their own workload. The division of tasks and preparing presentations and preparing project reports is carried out when completing projects that have been prepared or made (Rochim et al., 2021). The syntax of the earliest project-based learning model, namely determining fundamental questions, where students who will make projects must be interested in what will be done during project creation, this is able to train students in remembering and understanding what they will do in making projects. Second, what determines the making of a project is compiling project planning and compiling activity schedules, this strengthens the strength of students in application, because if students do not understand and do not immediately apply the understanding they have gained, the project they will make will not be completed.

Monitoring students and project progress in this case is very helpful so that students are not negligent in working on the project they are making, evaluating the product, at this stage giving in the form of praise and input to all groups of students, the goal is that students feel motivated and their work is more appreciated, and the last is the evaluation of experience, at this stage students are asked to express their impressions during the making of the project.

Conclusion

Based on the research conducted, it can be concluded that there is an influence of the project-based learning model assisted by PhET simulation on students' ability to master the concept of elasticity.

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