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THE EFFECT OF PHET SIMULATION-BASED LEARNING ON THE ABILITY TO UNDERSTAND ELEMENTARY SCIENCE CONCEPTS IN WORK AND ENERGY MATERIAL

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Abstract

This research aims to determine the effect of using PhET Simulation on understanding Natural Science concepts in prospective teachers, with a focus on the material "Work and Energy." This research is quantitative research with a quasi-experimental method. This research involved two groups of prospective elementary school teachers, where one group used PhET Simulation-based learning while the other group used conventional learning methods. Data on understanding science concepts was collected through pretest and posttest and analyzed using statistical tests. The results showed that there was a significant increase in understanding of science concepts in both groups, but a greater increase occurred in the group that used PhET Simulation (The experimental class from 57.15 to 83.15, and the control class from 57.61 to 67.96). The implications of this research emphasize the importance of integrating interactive technology in science learning to increase the understanding and involvement of prospective teachers.

Keywords: *PhET Simulation, Understanding Concepts, Work and Energy*

INTRODUCTION

In this digital era, the use of technology in education has become increasingly common and widely accepted as an effective tool in the learning process (Hillmayr et al., 2020; Bahtiar & Ibrahim, 2022). One form of technology used is interactive simulation, such as PhET Simulation, which can help prospective teachers understand complex scientific concepts through visualization and direct interaction.

PhET Simulation, developed by the University of Colorado Boulder, is a platform that provides a variety of interactive simulations for science and mathematics learning (Putranta & Kuswanto, 2018; Haryadi & Pujiastuti, 2020; Bahtiar et al., 2022). These simulations are designed to model real phenomena in a way that is easy for prospective teachers to understand (Gani et al., 2020). With interactive features, prospective teachers can conduct virtual experiments that allow them to explore scientific concepts without physical and material limitations. This interactive simulation allows prospective teachers to conduct virtual experiments and observe scientific phenomena directly, so they can understand abstract concepts better. Apart from that, PhET Simulation can also increase prospective teachers' involvement and motivation in learning, because they can learn through direct experience and independent exploration (Batuyong & Antonio, 2018; Mallari & Lumanog, 2020).

Science education in elementary schools aims to equip prospective teachers with basic knowledge and understanding of scientific concepts which will become the foundation for learning at a higher level (Fauth et al., 2019; Sukma et al., 2020). One of the important materials in the elementary school science curriculum is work and energy. This concept is often difficult for prospective teachers to understand because it involves abstractions that

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are not easy to visualize with conventional teaching methods (Hussein et al., 2019).

Traditional teaching methods that rely on textbooks and lectures are often less effective in explaining the concepts of work and energy to prospective elementary school teachers (Ibrahim et al., 2017; Farashahi & Tajeddin, 2018). Prospective teachers may have difficulty imagining how energy works or how effort can be measured and seen in everyday life (Gunawan et al., 2021). This is where the role of interactive simulations such as PhET Simulation becomes very relevant.

By using PhET Simulation, prospective teachers can see firsthand how effort and energy interact in various situations (Prima et al., 2018). They can change certain variables in the simulation and observe the effects directly, making their understanding of these concepts more concrete. The interactivity offered by these simulations also increases prospective teachers' engagement in the learning process, which can lead to deeper and longer-lasting understanding (Salame & Makki, 2021).

Previous studies have shown that the use of interactive simulations in science learning can improve prospective teachers' conceptual understanding and motivate them to become more interested in the subject. However, specific research examining the impact of PhET Simulation on understanding Work and energy concepts at the elementary school level is still limited, so this research is expected to make an important contribution in this field.

RESEARCH METHOD

This research uses a quasi-experimental method to evaluate the effect of using PhET Simulation on the ability to understand the concepts of work and energy in prospective teachers. The population of this study was prospective undergraduate teachers at PGMI UIN Mataram, with a sample of 50 prospective teachers. This quasi-experimental research design involved two groups, namely an experimental group that used PhET Simulation in learning, and a control group that used conventional teaching methods. The research design is presented in the form of Table 1 below.

Table 1. Research Design

No.	Group	Pretest	Treatment	Posttest
1	Experimental	O_1	Phet Simulation	O_2
2	Control	O_1	Conversional	O_2

Data was collected through a 20-question multiple choice test designed to measure understanding of the concepts of work and energy. The test results were analyzed using data analysis techniques with SPSS software to identify significant differences between the experimental and control groups. This analysis includes a t test to test the hypothesis whether the use of PhET Simulation has a significant impact on increasing concept understanding compared to traditional teaching methods.

RESULTS AND DISCUSSION

This research aims to determine the effect of using PhET simulation on prospective elementary school teachers' understanding of science concepts in Work and energy material. Conceptual Understanding of science is the ability of prospective teachers to understand and apply the basic principles of natural science comprehensively (Thahir et al., 2020). This understanding involves the ability to understand definitions, relationships between concepts, and the application of these concepts in various contexts, both through theoretical analysis and practical experiments (Sagala et al., 2019). A good understanding of concepts allows prospective teachers to explain natural phenomena, solve scientific problems, and relate the knowledge gained to everyday life, so that they can develop critical and analytical thinking skills (Niebert & Gropengiesser, 2018). Below (Table 2) are presented the results of descriptive analysis related to prospective teachers' understanding of science concept.

Tabel 2. Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Pretest_experimental	27	45	65	57,15	1,067	5,545
Postest_experimental	27	77	88	83,15	,699	3,634
Pretest_control	28	43	67	57,61	1,404	7,430
Postest_control	28	60	77	67,96	,903	4,780
Valid N (listwise)	27					

Table 2 shows that the average initial understanding of science concepts for prospective teachers between the experimental class and the control class is almost the same, namely 57.15 for the experimental class and 57.61 for the control class. The initial understanding of both classes in I is included in the low category. The low understanding of science concepts in both classes is because they have just forgotten the material they have studied in middle school/high school. Apart from that, not all prospective teachers are alumni of the science department.

In the table above it can also be seen that the average understanding of concepts between the two classes is different when the posttest is carried out. Where the experimental class obtained an average of 83.15 while the control class obtained 67.96. This posttest was carried out afte the learning process for Work and Energy material was carried out in the two classes, only with different learning media. In the experimental class, the Work and Energy learning material was based on PhET simulation, while the control class only used conversional learning. The PhET simulation display used during learning in the experimental class is presented as shown in the following Figure 1.

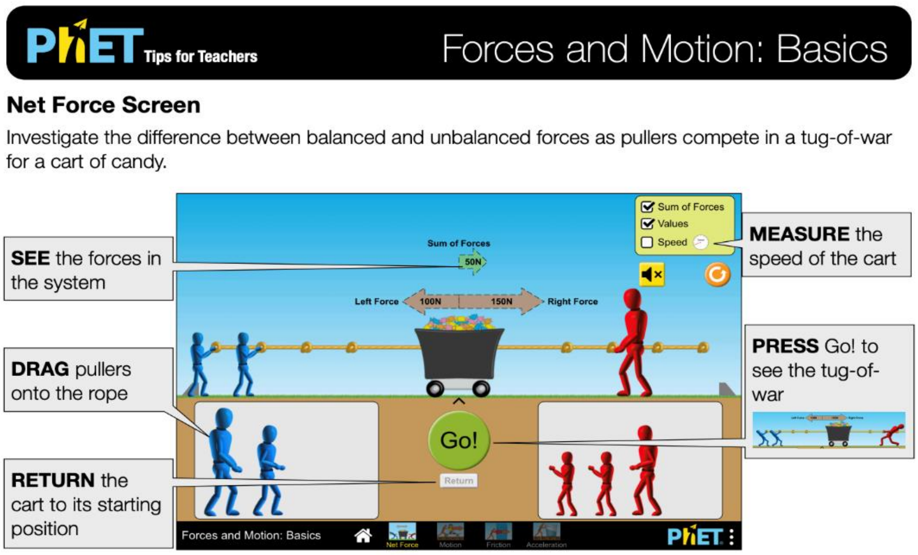

Figure 1. PhET Simulation of Work Materials by Several Styles

Figure 1 shows the PhET Simulation used when learning Work material with Work sub-material in several styles. PhET Simulation on "Forces and Motion: Basics" is an interactive learning tool that allows prospective teachers to understand the basic concepts of force and motion. This simulation is designed to help prospective teachers explore how force affects

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the movement of objects in a variety of situations through intuitive and engaging virtual experiments. PhET Simulation "Forces and Motion: Basics" has a close relationship with the concept of work in natural sciences (IPA), especially in understanding how forces applied to an object can cause changes in the object's energy and motion.

By using PhET Simulation, prospective teachers can develop a deeper understanding of the relationship between force, displacement, and work (Rahmawati et al., 2022). They can actively engage in learning by trying out different scenarios, recording results, and analyzing data, all of which strengthens understanding of Work concepts. PhET Simulation, with its interactive features as well, increases prospective teachers' involvement in the learning process. Teacher candidates can actively participate in virtual experiments, which makes them more interested and motivated to learn (Subiki et al., 2022). This active involvement is important because prospective teachers who are involved are more likely to understand and remember the material being taught. Below (Figure 2) is also presented PhET Simulation for the energy sub-material.

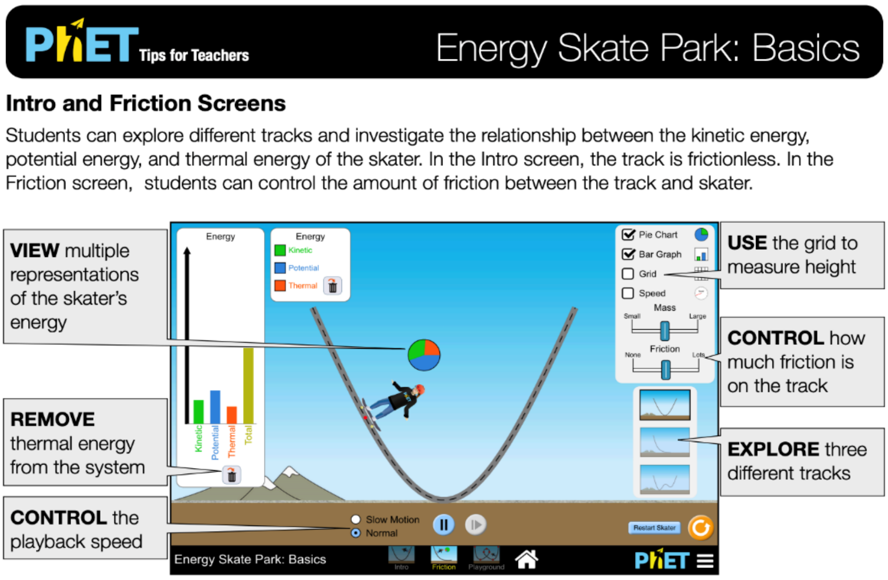

Figure 2. PhET Simulation of Energy Material

Figure 2 shows the PhET Simulation "Energy Skate Park: Basics" which is an interactive learning tool designed to help prospective teachers understand the concepts of potential energy, kinetic energy, and the law of conservation of energy through virtual experiments involving a skater in a skate park. These simulations allow teacher candidates to explore how energy changes as skaters move on various tracks, such as slopes, hills, and loops.

This simulation allows prospective teachers to see live visualizations of changes in potential and kinetic energy as skaters move along various tracks. This visualization helps prospective teachers overcome difficulties in understanding energy concepts which are usually abstract and invisible (Inayah & Masruroh, 2021). Through graphs and animations that show energy changes in real-time, prospective teachers can more easily understand how energy changes from one form to another.

By understanding how potential and kinetic energy work in simulations, prospective teachers can more easily apply these concepts in real situations. For example, they can relate the energy changes they observe in the simulation to everyday events, such as going up and down a roller coaster or riding a hill. Below (Figure 3) is also a comparison picture of the average understanding of science concepts for prospective teachers.

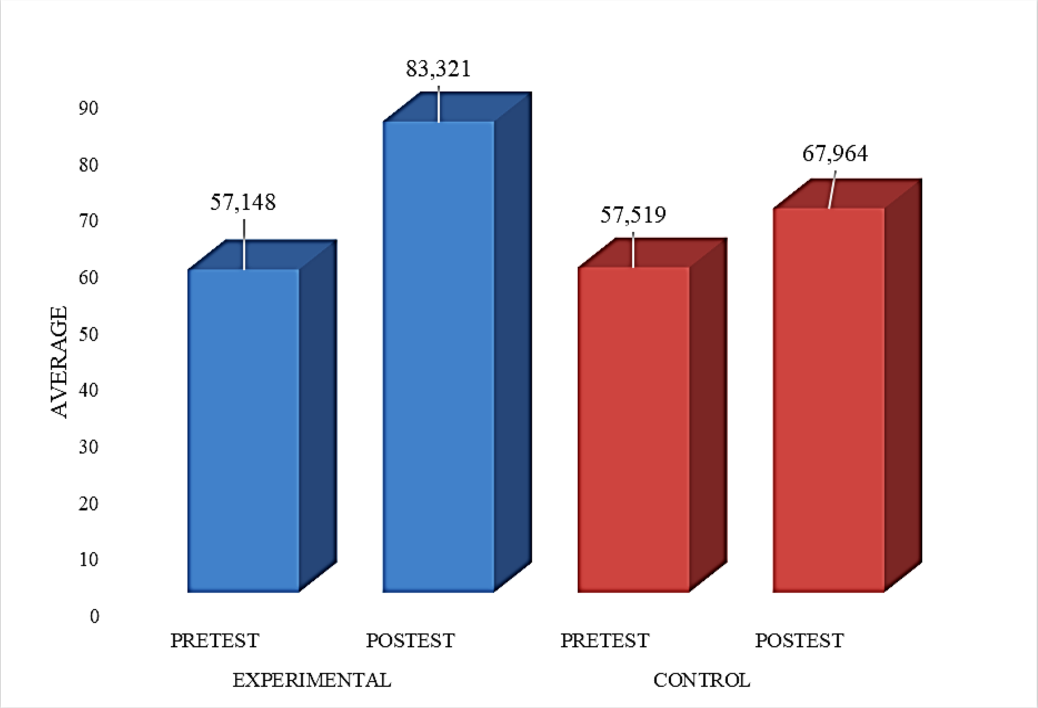

Figure 3. Comparison of Average Understanding of Science Concepts for Prospective Teachers

Figure 3 shows a comparison of the average understanding of concepts obtained between the two classes, both pretest and posttest. In the picture, it can be seen that the average understanding of concepts in the experimental class in the posttest is higher than the control class. The high understanding of experimental class concepts is due to the use of PhET Simulation in learning Work and Energy material.

To determine the effect of using PhET Simulation on prospective teachers' understanding of science concepts, hypothesis testing was carried out. Before testing the hypothesis, homogeneity and normality tests are first carried out. The results of homogeneity and normality testing show that the two data are homogeneous and have a normal distribution. Hypothesis testing requirements are met, then continue with hypothesis testing using Paired Samples t-test. The results of hypothesis testing are presented in the following table.

Tabel 3. Paired Samples Test

		Paired Differences					**T**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
Pair 1	Pretest experimental Postest experimental	-26,000	6,214	1,196	-28,458	-23,542	-21,741	26	0,000
Pair 2	Pretest control Postest control	-10,357	9,032	1,707	-13,859	-6,855	-6,068	27	0,000

Table 3 shows that the output of Pair 1 obtained a Sig value. (2-tailed) of 0.00. The Sig (2-tailed) value obtained is smaller than 0.05. This indicates that there is a difference in the average understanding of science concepts for prospective teachers for the experimental class pretest and experimental class posttest (use of PhET Simulation). In other words, the use of PhET Simulation in learning "Work and Energy" has had a significant positive impact on prospective teachers' understanding of science concepts.

Table 3 also shows that the output of Pair 2 obtained a Sig value. (2-tailed) of 0.00. The Sig (2-tailed) value obtained is smaller than 0.05. This indicates that there is a difference in the average understanding of science concepts for prospective teachers for the experimental class pretest and experimental class posttest (without the use of PhET Simulation).

By comparing the results from the experimental class and the control class, it is clear that the use of PhET Simulation produces a more significant increase in understanding compared to conventional methods. The experimental class that used PhET Simulation showed a greater improvement (from 57.15 to 83.15) compared to the control class that only used conventional methods (from 57.61 to 67.96). This shows the superiority of PhET Simulation in helping prospective teachers understand science concepts more deeply and effectively.

The increase in the average understanding of science concepts from pretest to posttest in the experimental class shows that PhET Simulation is an effective learning tool. Before using PhET Simulation, the initial understanding of prospective teachers was in the low category, with an average score of 57.15. After using PhET Simulation, the average score increased to 83.15, indicating that prospective teachers were able to understand the concepts taught better. The interactivity and hands-on visualization of PhET Simulation allows prospective teachers to internalize the concepts of “Work and Energy” more effectively.

PhET Simulation provides a dynamic and interactive learning environment, which is different from conventional learning methods (Susilawati et al., 2022). Teacher candidates can conduct virtual experiments and see changes in potential and kinetic energy in real-time, which helps them understand the relationship between force, work, and energy (Oktaviana et al., 2020). By seeing the immediate results of their actions, teacher candidates more easily connect theory to practice, which improves understanding and knowledge retention.

The results of this research emphasize the importance of choosing the right learning method to improve understanding of science concepts. Although conventional methods are still effective, the integration of interactive technologies such as PhET Simulation can provide better results. Therefore, educators are advised to combine conventional methods with interactive technology in the learning process. In this way, prospective teachers can gain a more comprehensive and in-depth understanding of science concepts, which will support them in further learning and practical application in the future.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the use of PhET Simulation influences prospective teachers' understanding of science concepts. The average understanding of the concepts of the experimental class taught using PhET Simulation was higher than the average understanding of the control class. The experimental class that used PhET Simulation showed a greater improvement (from 57.15 to 83.15) compared to the control class that only used conventional methods (from 57.61 to 67.96).

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