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Application of *Virtual Laboratory PhET Simulation* on Dynamic Fluid Material to Improve Cognitive Learning Outcomes of Class XI Students at SMA Negeri 4 Pekanbaru

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ABSTRACT

The research objective to be achieved from this research is to determine the increase in student learning outcomes through the application of learning using *Virtual Laboratory media PhET Simulation* on dynamic fluid materials at SMAN 4 Pekanbaru. This research was conducted in semesters even semester of the 2023/2024 academic year. The samples were classes XI.1 and XI.2, the number of students was 72. Descriptive and inferential analysis was used to analyze the data. The learning outcomes of students in the experimental class which used the PhET Virtual Lab simulation in dynamic fluid learning averaged 80.6, while the average learning outcomes of students in the control class which used conventional learning only 68.4. Inferential analysis shows that the use of Virtual Lab PhET Simulation improves student learning outcomes compared to conventional learning .

Keywords: *Learning outcomes, PhET Simulation, Conventional Learning*

1 Introduction

Education is an effort to improve human life through the development of a dynamic learning environment and learning processes that enable the development of individual potential. This potential includes various things, such as intelligence, morality, spirituality and self-development, as well as skills that are relevant for a person, society, nation and state (M & Sarkity, 2023:23) . In the educational context, the learning process not only aims to increase knowledge, but also to shape students' character and skills. Therefore, education has a significant role in changing a person's behavior and attitudes for the better through the learning process (Laila Puspita, Yetri, 2017:78). Science education is a learning activity that can help students develop logical, creative, critical and innovative thinking abilities. Science learning, especially physics, is a subject that discusses natural phenomena by solving problems using formulas to prove natural events by developing thinking through experiments that direct students to memorize, remember and understand material or information that is connected to everyday life (Khasanah et al. al, 2023:262) . Physics is a branch of natural science and science that studies natural phenomena, physics describes and analyzes structures and events in nature, their applications, techniques and the world around us (Amin and Sulistiyono, 2021) (Saktioto et al., 2020). According to Permana & Desianna (2023:29) Physics is a branch of science that investigates phenomena using scientific methods and produces scientific products consisting of concepts, principles and theories that apply to everyone.

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learning , students tend to only understand Science as a product, by memorizing relevant concepts, theories and laws (Rize et al., 2023:38) . This causes students not to understand the real purpose of studying physics, so that the learning process becomes tedious and boring. Teachers have an important role in the learning process, and they are expected to provide students with interactive and quality learning experiences (Isty, 2023:9) . The use of media is needed to help the teaching and learning process, for example experimental media. The results of the interview with the physics teacher at SMAN 4 Pekanbaru said that the lack of KIT equipment was the reason there were no experiments with students, so learning was only carried out conventionally without conducting experiments. Some students also said that they wanted practicum activities to strengthen their understanding of the material and increase student involvement in learning. Based on the results of a questionnaire on students' interest in physics which was conducted at SMAN 4 Pekanbaru which can be seen in Appendix 8, information on students' perceptions of learning physics from 180 students showed that 67% of students did not like physics lessons, almost 92% of students answered that learning physics can be applied to everyday life, 68% of physics lessons are not easier to understand compared to other material, 93% of students understand physics lessons after working on the questions, 74% of students have difficulty learning fluid dynamic material, many students agree 53%, strongly agree 21%, disagree 21% and strongly disagree 5%. Calculation errors in dynamic fluid physics questions were around 79% of students, then 85% of students answered that dynamic fluid material was easy to understand if this material was put into practice, 73% of students wanted the teacher to use interesting physics learning media, then 47% of students felt bored if the teacher didn't using learning media. Students' fluid dynamic lesson scores were almost 47% low during learning.

This is in accordance with research by Nurdini et al (2022: 137) which states that the concepts and formulas that have been conveyed by teachers are usually only used in solving problems and students tend to get bored and find it difficult to understand these concepts, as a result of students' knowledge of physics concepts. very low. Another problem is that students' interest in physics is not high so the scores obtained are still far below the KKM, indicating that learning outcomes are still low. According to Prameswari & Wahyudi (2019) , there are symptoms that cause a lack of attention from students towards teachers, especially in the context of physics learning, especially in Dynamic Fluid material, namely that students tend to be more passive in the teaching and learning process, often only listening to what is being said. by teachers then difficulties arise when students are faced with physics formulas, causing their lack of involvement in learning. In order to improve physics learning, a more practical and real approach is needed, such as involving practical activities to support understanding of physics concepts. In addition, student learning outcomes can be improved through learning strategies that combine theory, technology and practice in a balanced manner.

Technological developments in the current digital era have resulted in many applications that teachers can use to support their teaching process. Educators don't need to worry because technology offers many innovations in the field of learning (Chyntia Clarinda et al., 2022) . We cannot avoid the benefits of technology in everyday life. Technology not only makes things easier, but also helps people complete tasks. With increasingly sophisticated technology and increasingly modern lifestyles, this shows its practical value (Delviandri, 2023) . Along with this development, physics as part of science and technology is also developing, both in theory and application. Physics is the basic science of technology. Facts of life such as motion, light, optics, heat, waves and other materials that humans use every day are studied in physics (Junaidi, 2016: 130) . With this virtual simulation, it makes it easier for the learning process in class to prove the theory put forward. The problem of students not understanding can be caused by one thing, namely the learning resources or media used. If the media used is boring, it will not motivate students to learn. Meanwhile, using virtual simulation is easy to use, cheap and has an attractive appearance. Attractive media must be aligned with the use of appropriate learning models, one of which is the scientific learning model. *Virtual lab* simulations is suitable for dynamic fluid material, where in this material many students still experience misconceptions because there are no experiments shown directly to students so students only understand the material from reading without being able to see directly how it is applied in everyday life(Herfana et al., 2021).

2 Research Methodology

2. 1 Time and Place

Virtual Laboratory PhET Simulation media on dynamic fluid material to improve student learning outcomes was carried out in class XI Senior High School at SMAN 4 Pekanbaru. This research was carried out in the odd semester of the 2023/2024 academic year.

2. 2 Research Subject

The subjects in this research were students in class XI Engineering 1 and Engineering 2 at SMAN 4 Pekanbaru, with a total sample size of 72 students.

2. 3 Research Design

This research uses *Quasi Experimental Design* , namely a design that has a control group but does not function fully to control external variables that influence the implementation of the experiment with one experimental class and one control class (Hidayah & Yuberti, 2018) .

The research design used was *Post-test Only* , *Nonequivalent Control Group Design* , in this design using two subjects. Researchers provide *experimental treatment PhET Simulation* only uses the experimental group and provides *a post-test* to see the differences between the two groups. The research design can be seen in Table 1

Table 1. Research Design

Group	Treatment	Post-test
Experiment	X	O_1
Control	-	O_2

Information:

X : Given treatment by applying a scientific approach assisted by *the Virtual Laboratory PhET Simulation*

O_1 : The final test is carried out after students are given treatment in applying the scientific approach assisted by *the Virtual Laboratory PhET Simulation*

O_2 : The final test is carried out after students are given treatment on applying a scientific approach without the help of *a Virtual Laboratory PhET Simulation*

2. 4 Re search Instruments

The learning tools used consist of learning modules, Dynamic Fluid PPT, LKPD and PhET Simulation

2. 5 Data Collection Instruments

The research instrument used was a written test on dynamic fluid material to assess student learning outcomes in the cognitive domain. This test consists of 15 questions in multiple choice form. Question creation is based on the levels of Bloom's taxonomy regarding cognitive learning outcomes.

2. 6 Data Collection Techniques

The data collection technique in this research uses tests. The test consists of 15 multiple choice questions. The sample was divided into two class groups in the research design: group XI Engineering 2 was used as the experimental group and group XI Engineering 1 was used as the control group. The experimental class gained knowledge about dynamic fluid materials through PhET Virtual Laboratory simulations. In contrast, the control group only received a demonstration of the same material without using the PhET Laboratory simulation. After completing the delivery of the material and treatment, students are given a final test (*post-test*) (Rahma. 2020) . The post-test aims to measure the increase in students' understanding of the topic of global warming symptoms. Each correct answer received a score of 6.67, while incorrect answers received a score of 0.

2. 7 Data Analysis Techniques

The data analysis method applied in this research includes descriptive and inferential analysis, using hypothesis testing to see the differences in the cognitive learning outcomes of students who apply PhET Simulation with the cognitive learning outcomes of students who use conventional learning on dynamic fluid material.

3 Results and Discussion

3.1 Descriptive Analysis Results

Based on the results of data analysis , a comparison of students' cognitive learning outcomes after using *the Virtual Laboratory* PhET Simulation and conventional learning methods in the context of dynamic fluid material can be seen in Table 2.

Table 2. Students' Cognitive Learning Results

No	Value Interval (%)	Category	Experimental Class		Control Class	
			The number of students	Percentage (%)	The number of students	Percentage (%)
1.	85< M ≤100	Very good	15	42	0	0
2.	70< M ≤85	Good	16	44	13	36
3.	50< M ≤70	Pretty good	5	14	22	61
4.	M ≤50	Not good	0	0	1	3
	Average		80.2		68.4	
	Category		Good		Pretty good	

Table 2 shows the percentage differences between the cognitive learning outcomes of experimental class and control class students. In the experimental class, the average percentage of learning outcomes obtained by students was 80.2 in the good category, while the average cognitive learning outcomes of control class students was 68.4 in the quite good category. In this study, significant differences in cognitive learning outcomes were found between the experimental class and the control class, with the learning outcomes of the experimental class being significantly higher than those in the control class.

In Table 2 it can be concluded that there is a significant difference in the average cognitive learning outcomes of students between classes that apply PhET Simulation and classes that only use conventional learning methods. These results are in line with research by Nefrita (2019: 52) , showing that after participating in learning with PhET Simulation, students' cognitive abilities increased by 30%. This shows that the use of information technology-based simulation media in the learning process is known to have the potential to improve students' learning experiences and improve their critical and creative thinking abilities. This research provides additional information on the effectiveness of PhET Simulation as a learning tool that can improve students' cognitive learning outcomes. These results also show that an IT-based learning approach is very important for optimizing students' cognitive development. Thus, this learning approach can be considered as an approach that can be used to improve the quality of education and teaching in various learning contexts.

Analysis of the distribution of cognitive domains for each posttest question related to dynamic fluid material, along with the achievement of learning outcomes at each aspect level in the experimental class and control class can be seen in Table 3.

Table 3. Achievement of Learning Outcomes at each Cognitive Aspect Level

No	Tingkat Kesulitan	Nomor Soal	Kelas Eksperimen		Kelas Kontrol	
			Jumlah Benar	Capaian Kelas (%)	Jumlah Benar	Capaian Kelas (%)
1.	Mengingat (C1)	1, 3	70	97.22	60	83.33
2.	Memahami (C2)	2, 4	66	91.66	64	88.88
3.	Mengaplikasikan (C3)	5, 6, 7, 11	121	84.03	119	82.64
4.	Menganalisis (C4)	12, 13, 15	82	75.93	46	42.59
5.	Mengevaluasi (C5)	8, 9, 10	63	58.33	48	44.44
6.	Mencipta (C6)	14	33	91.66	31	86.11

Table 3 above explains the cognitive level of the questions and the number of test questions on students' cognitive learning outcomes on dynamic fluid material. In this table you can see the comparison of student learning outcomes between the experimental class and the control class for each level of difficulty of the questions. A comparison of students' achievement of learning outcomes in each cognitive aspect can be seen in graphical form in Figure 1

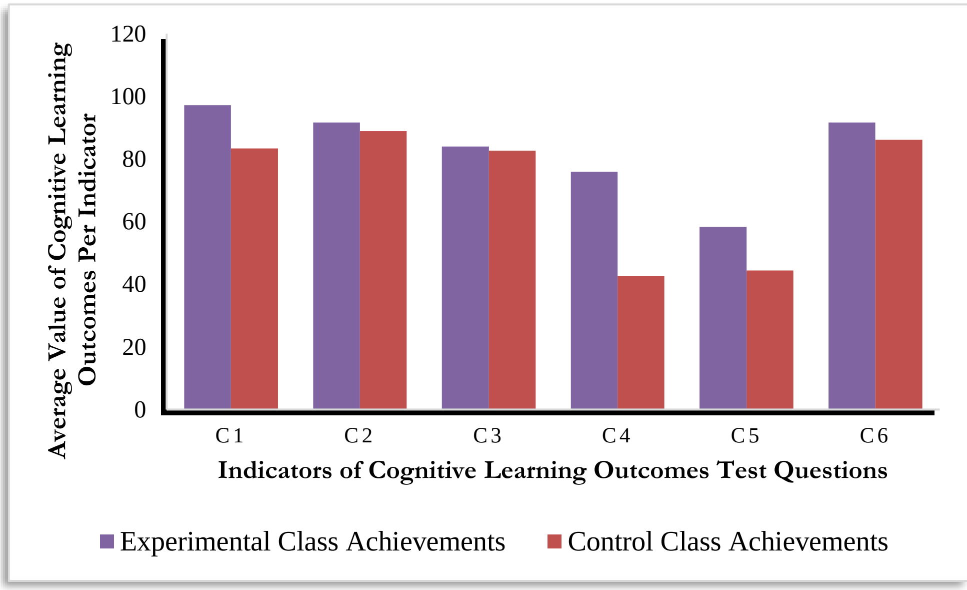

Figure 1. Comparison graph of learning outcomes per indicator

The level of achievement of student learning outcomes in cognitive aspects (C1, C2, C3, C4, C5, and C6) is higher in the experimental class compared to the control class, as shown in Figure 1. This phenomenon can be explained by the use of supported scientific learning methods by PhET This simulation is an engaging and effective learning approach that helps students run experiments without the need for KIT tools. The application of constructivist learning principles is another factor that can compare the two classes. The principles of this scientific approach encourage students to think critically and creatively while building their understanding. They have the ability to organize ideas and give meaning to the material they study. In this case, the differences between the two classes can be understood through a learning approach that encourages students to actively participate in the learning process and build higher thinking skills (Mubarok & Sofiana, 2022:39) .

3.2 Inferential Analysis Results

version 23 software , involving normality tests, homogeneity tests, and hypothesis tests (t-test).

Table. 3.3 Results of Inferential Research Analysis

Learning outcomes	Types of Inferential Analysis	Group	Test Type	Sig	Test results
Dynamic Fluid Matter	Normality test	Experiment	*Kolmogrov*	0.151	Normal Data
		Control	*Smirnov*	0.200	Normal data
	Homogeneity Test	Experiment and control	*Test of homogeneity of variances*	0.479	Both classes are homogeneous
	Hypothesis Test (T-test)	Experiment and control	*Independent sample t test*	0.000	Ho is rejected and Ha is accepted

This normality test was carried out using the Kolmogorov Smirnov test assisted by the SPSS application. Based on the results of the Kolmogorov-Smirnov test, a significance value was obtained for the experimental class of 0.151 and for the control class of 0.200. Because both significance values exceeded 0.05, it can be concluded that the data increased learning outcomes in the experimental class and control class are normally distributed . The next step is a homogeneity test using the Levene test, as seen in Appendix 12 with a significance value of 0.479. Therefore, it can be concluded that both classes have homogeneous variance because the significance value exceeds 0.05.

The requirements for carrying out hypothesis testing using the Independent t-test have been fulfilled, so the test method used is the Independent Samples T-test. The Independent Samples T-test was used to assess whether there was a difference in the average score between students' cognitive learning outcomes between the experimental class which implemented *Virtual Laboratory* PhET *Simulation* while the control class only used conventional learning. Based on the results of the Independent Sample T-Test on columns assuming equal variances, a significance value of 0.000 was found, as recorded in Appendix 13. In accordance with the criteria, if the significance value is <0.05, then Ho is rejected while Ha is accepted. The statistical hypothesis in this research is:

Ho: There is no difference in the cognitive learning outcomes of students who apply a scientific approach using *PhET Simulation* with the cognitive learning outcomes of students who apply learning without the help of *PhET Simulation* on dynamic fluid material.

Ha: There is a difference in the cognitive learning outcomes of students who apply the assistance of PhET simulation and the cognitive learning outcomes of students who apply learning without the assistance of *PhET simulation* on dynamic fluid material.

Thus, it can be concluded that there are differences in students' cognitive learning outcomes between those using the Virtual Laboratory PhET Simulation and the control class which only applies conventional learning on Dynamic Fluid material.

4 Conclusion

Based on research that has been carried out in class The average score was 80.6, while the control class which used conventional learning only achieved an average score of 68.4. These results indicate that the experimental class achieved better cognitive learning outcomes than the control class.

There is a significant difference in student learning outcomes between the experimental class, namely class XI Engineering 2, which applies Virtual Lab PhET Simulation and the learning outcomes of students in the control class, namely class This shows that the use of Virtual Lab PhET Simulation improves student learning outcomes compared to conventional learning. Therefore, it has been proven that students' cognitive learning outcomes at SMAN 4 Pekanbaru can be improved by implementing the PhET Virtual Lab simulation on dynamic fluid material.

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