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Implementation of a Simulation-Based Learning Model Using PHET to Improve Learning Outcomes for Class IX MTsN 1 Kuantan Singingi

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Abstract- This research aims to describe and determine the significant differences in the cognitive learning outcomes of class IX MTsN 1 Kuantan Singingi between the experimental class which applies the Simulation Based Learning model using PhET and the conventional class on dynamic electrical material. This research uses a Quasi Experiment type of research using a posttest only control design. The population of this research is students of class IX MTsN 1 Kuantan Singingi for the 2024/2025 academic year which consists of 5 classes and a total of 130 students. The samples taken in this research were class IX.1 as the experimental class and class IX.2 as the control class. The results obtained were analyzed using descriptive analysis and inferential analysis. The results of the descriptive analysis obtained showed that the class that was given treatment by applying the Simulation Based Learning model using PhET got a better average score of 78.65 compared to the class that applied the conventional learning model with an average score of 65.8. The results of the inferential analysis show significant differences in the cognitive learning outcomes of students who apply the Simulation Based Learning model using PhET compared to conventional learning on dynamic electricity material in class IX MTsN 1 Kuantan Singingi.

Keywords: *Simulation Based Learning Model, Phet, Cognitive Learning Outcomes*

1 Introduction

As far as possible, science learning, especially physics, can be taught in real terms using appropriate learning models or media. This aims to ensure that the concepts of the subject matter can be understood by students correctly and that what will be learned is always remembered by students. Physics learning will run smoothly if students are invited to observe natural phenomena systematically, thereby emphasizing the provision of personal experience in learning. Thus, teachers teaching physics to students place more emphasis on mastering physics concepts as a result of the knowledge gained to improve student learning outcomes (Rahayu & Parrangan, 2021: 25). The essence of physics includes "a body of knowledge" namely physics as a product, "a way of investigating" namely physics as a process, and "a way of thinking" namely physics as an attitude. Based on its essence, physics learning is expected to not only consist of theory, memorizing formulas and calculations (Aliyah, R., 2019: 179).

Based on the results of observations and interviews conducted at MTsN 1 Kuantan Singingi, information was obtained that physics is a complicated and feared subject, this can be seen in the results of the daily test on dynamic electricity material in 2023 class IX.I of 24 students, there are 17 students whose daily test scores are still below the KKM, namely below 70. Low learning outcomes can be caused by students' conceptual understanding of the material being taught is still low. Apart from that, teachers also saw a lack of interest in learning from students in learning physics at MTsN 1 Kuantan Singingi

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Low student learning outcomes are a problem. One of the reasons is that the implementation of the curriculum in Indonesia is still dominant in theoretical aspects (Sani, 2014: 6). There are still many schools that eliminate experimental activities at school for various reasons, such as experiments that take a lot of time and unavailability of equipment (Yusuf & Widyaningsing, 2018: 18). In this research, what is used is a simulation-based learning model (Simulation Based Learning). This learning model is intended so that students have a clearer picture of the conditions contained in the lesson material compared to learning that is only explained by the teacher.

The use of learning media and network-based education should be one of the distinctive characteristics visible in learning during Society 5.0 and be able to protect the function of learning at this time (Subakti et al, 2021:6). Nowadays, there are many types of virtual laboratories that teachers can use, one of which is using PhET Simulation media. PhET Simulation is a website-based application that contains simulations of various physics concepts, one of which is direct current electricity. In simulation-based learning, PhET Simulation can be used for experimental activities that cannot be carried out directly.

Based on the description above, it is the basis for researchers to apply a simulation-based learning model (Simulation Based Learning) using PhET media in science learning on dynamic electrical material in class IX MTsN 1 Kuantan Singingi, so that learning is more interactive and makes students understand the materials being studied better taught.

2 Research Methodology

The research was carried out at MTsN 1 Kuantan Singingi class IX and took place in October-December 2024. The population included all students in class IX MTsN 1 Kuantan Singingi, which consisted of 5 classes with a total of 130 students. The sample in this research was class IX students at MTsN 1 Kuantan Singingi in the odd semester of the 2024/2025 academic year, who were taken in only two classes. The sampling technique used in this research was to carry out normality tests and homogeneity tests of daily test scores. After carrying out normality and homogeneity tests, the five classes will be drawn to find 2 classes. Based on the results of the drawing, an experimental class was obtained in class IX.1 which applied a simulation-based learning model using PhET Simulation and a control class in class IX.2 which applied conventional methods. The type of research used is Quasi Experimental, using a Posttest only Control Group Design. The design of the post-test-only Control Group Design can be seen in Table 1.

Table 1. Posttest only Control Group Design

Group	Treatment	*Posttest*
Experiment	X_1	O_1
Control	-	O_2

(Sugiyono, 2022:76)

The data collection technique in this research is by giving tests. The aim of giving tests in this research was to determine differences in students' cognitive learning outcomes. The type of test used is a multiple choice objective test in the form of posttest questions given to the experimental class and control class which is used to measure the extent of students' cognitive learning outcomes in studying dynamic electricity material.

Based on the cognitive learning results, it will be analyzed by describing scores based on benchmark reference research, calculated based on the maximum score achieved by individual students using the formula:

$$Student\ Grades = \frac{total\ score\ obtained}{maximum\ score} x\ 100 \quad (1)$$

The scores obtained are then grouped into five categories, namely very good, good, quite good, not so good and very bad. The categorization of student learning outcomes can be seen in Table 2.

Table 2. Cognitive Learning Outcome Score Scale Categories

No	Value	Category
1	$85 \leq x < 100$	Very good
2	$70 \leq x < 85$	Good
3	$56 \leq x < 69$	Pretty good
4	$30 \leq x < 55$	Not good
5	$x < 29$	Very Not Good

(Hapid. A, 2021: 232)

3 Results and Discussion

This research was conducted to observe the level of cognitive learning outcomes of class IX students at MTsN 1 Kuantan Singingi by providing posttest questions in the form of 20 multiple choice questions which were adjusted to the learning outcome indicators according to the Revised Bloom's Taxonomy. Therefore, a descriptive analysis of the results of the cognitive learning will be carried out.

Descriptive analysis in this research was carried out with the aim of describing data on students' cognitive learning outcomes after implementing different learning models in class IX dynamic electricity material at MTsN 1 Kuantan Singingi. The descriptive results of the posttest in the experimental and control classes stated that the minimum score obtained by the experimental class was 60 and the control class was 45. Meanwhile, the maximum score for the experimental class was 95 and the control class was 90. In accordance with the data, the average score obtained by the experimental class was namely 78.65 and the average value of the control class was 65.8. This means that the average value of the experimental class is greater than the control class, which means that the Simulation Based Learning model using PhET can improve students' cognitive learning outcomes compared to just using the conventional model.

Based on the posttest results, the cognitive learning outcomes of students in the experimental class and control class are as attached in the attachment. Indicators of students' cognitive learning outcomes according to the revised Bloom's taxonomy are divided into six levels, namely knowing, understanding, applying, analyzing, evaluating, and creating. Descriptive analysis was applied to all indicators of cognitive learning outcomes according to the revised Bloom taxonomy as shown in Table 3.

Table 3. Descriptive Analysis of Cognitive Learning Results for Each Indicator

No	Cognitive Learning Outcome Indicators	Experimental Class		Control Class		Average difference
		Average	Category	Average	Category	
1	Remembering (C1)	98,7	Very good	96	Very good	2,7
2	Understanding (C2)	84	Good	73,6	Good	10,4
3	Applying (C3)	85,7	Very good	81,3	Good	4,4
4	Analyzing (C4)	61,5	Pretty good	42	Not good	19,5
5	Evaluate (C5)	63,5	Pretty good	39	Not good	24,5
6	Creating (C6)	100	Very good	92	Pretty good	8
	Average	78,65	Good	65,8	Pretty Good	

Table 3 shows the percentage of cognitive learning outcomes for each indicator in each class. The experimental class has a higher percentage than the control class. The details of the cognitive learning outcome indicators state that the experimental class is superior to the control class. The overall class average score obtained by the experimental class was 78.65 in the good category and the control class was 65.8 in the quite good category. The smallest difference in the average value between the experimental class and the control class is in the remembering indicator (C1) with a difference of 2.7. Meanwhile, the most significant difference in average values between the experimental class and the control class is found in the evaluating indicator (C5) with an average difference of 24.5.

Based on descriptive analysis of cognitive learning outcomes for each indicator listed in Table 3, a comparison of the percentage of average scores for the experimental class and control class was obtained which can be seen in diagram form in Figure 1.

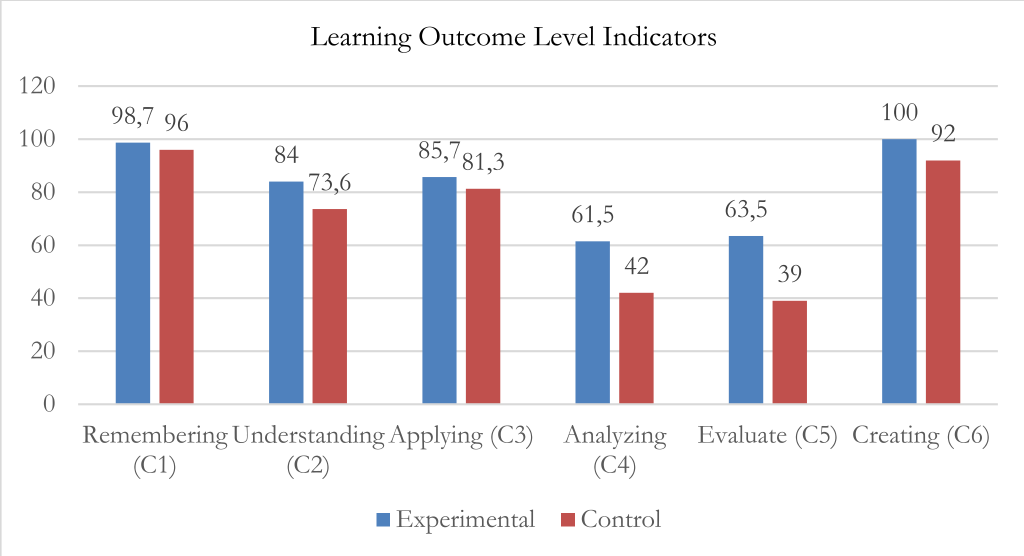

Figure 1. Comparison graph of average indicators of cognitive learning outcomes

Figure 1 shows that the experimental class has an average of superior cognitive learning outcomes than the control class. The six indicators of the level of difficulty of cognitive learning outcomes in each question are described as follows:

1. Remembering (C1)

The first cognitive aspect is remembering. Remembering is the lowest cognitive level. In the posttest questions on the cognitive learning outcomes of students on dynamic electrical material, there are 3 question numbers out of a total of 20 questions whose difficulty level is remembering, namely numbers 1, 6 and 9. Figure 1 proves that the average obtained for the cognitive aspect of remembering (C1) the experimental class, namely 98.7, is greater than the control class, namely 96, with the same category, namely very good. In the remember indicator (C1) there is no large gap in the average value. This is also in line with research (Masril et al, 2019: 20), experimental class students are superior to the control class, because the control class gets information from books, the information is provided and the students capture the information. The experimental class is guided to discover concepts for themselves through the simulations carried out, so that what is simulated is easier for students to remember.

2. Understanding (C2)

The second cognitive aspect is understanding. Understanding is constructing meaning or understanding based on initial knowledge possessed, linking new information with existing knowledge, or integrating new knowledge into existing schemes in students' thinking (Effendi, 2017: 74). In the posttest questions on students' learning outcomes on dynamic electricity material, out of a total of 20 questions there are 5 questions that have a level of difficulty in understanding, namely questions number 4, 11, 12, 19 and 20. Based on Figure 1 as a whole, the average level of understanding (C2) of participants Experimental class students were able to answer questions correctly with an average of 84. Meanwhile, for the control class, students who could answer questions correctly were 73.6 in the same category, namely good. There is a significant average difference between the experimental class and the control class. This is in line with research (Sofian et al., 2022: 183) that this research is to test students' understanding of material facts and concepts. So the experimental class is superior because it is assisted by PhET to increase students' level of understanding.

3. Applying (C3)

Application here can be interpreted as a process of students using procedures to carry out exercises or solve problems that are closely related to procedural knowledge (Effendi, 2017: 75-76). In the posttest questions on the cognitive learning outcomes of students on dynamic electricity material, out of a total of 20 questions there are 3 questions that have a level of difficulty in applying (C3), namely questions number 2, 3 and 15. Figure 1 displays a graph of the average value of the application indicator (C3). obtained by the experimental class was 85.7 in the very good category, while the control class was 81.3 in the good category. The difference in average scores between the experimental class and the control class at the application level (C3) is not much different because there is an equal level of understanding of students in the experimental class and control class regarding the material that has been studied. This is in line with research (Adyan et al., 2019: 153), the advantage of the experimental class is actually because the learning motivation of experimental class students is superior to that of the control class. Apart from internal and external factors of students, the learning motivation of experimental class students is better because students are more enthusiastic about learning using devices.

4. Analyzing (C4)

Analyzing means students' ability to describe a problem or object into its constituent elements and determine how the constituent elements are interconnected with their large structure (Effendi, 2017: 77). In the posttest questions on the cognitive learning outcomes of students on dynamic electricity material, of the 20 posttest questions there are 4 questions with a level of difficulty analyzing (C4), namely questions 5, 13, 14 and 18. Figure 1 displays a graph on the analyzing indicator (C4), where the average value -The average score for the experimental class was 61.5 in the quite good category, while the average score in the control class was 42 in the not so good category. There is a significant difference in average scores between the experimental class and the control class in the level of difficulty of analysis.

5. Evaluate (C5)

Evaluating includes checking and criticizing activities. In the posttest questions on the cognitive learning outcomes of students on dynamic electricity material, of the 20 posttest questions there are 5 questions whose level of difficulty is evaluating (C5), namely questions number 7, 8, 10, and 17. Figure 1 shows the graph that the experimental class has an average which is better than the control class with a very significant difference in average value, namely 24.5. Where the experimental class has an average value of 63.5 while the control class has an average value of 39. This is in line with research (Billa et al., 2023:284) that the experimental class is superior to the control class at the evaluating level (C5) because students in experimental classes have the ability to make decisions based on deep thinking, criticism, and assessment.

6. Creating (C6)

Creating means students work and produce something new. This creative activity includes the activities of formulating, planning and producing. In the posttest questions on students' cognitive learning outcomes on dynamic electricity material, out of a total of 20 posttest questions, there is 1 question that has a level of difficulty in creating (C6), namely question number 16. Figure 1 shows that the average obtained for the level of difficulty in creating in the experimental class is 100 while the control class is 92 in the same category, namely very good. The average score for the experimental class is higher because in the experimental class students use PhET during the learning process, so students can make an electrical circuit easily. This is in line with research (Wulansari et al., 2023: 306) that the experimental class implemented a learning model that enabled them to apply the methods learned correctly. So that they are able to answer questions related to the cognitive level of creating things related to everyday life so that students can easily create answers to these questions.

Based on the results of descriptive and inferential data analysis that have been obtained, it can be explained that cognitive learning outcomes in classes that use the Simulation Based Learning model using PhET are higher than in classes that use conventional models. The normality test and homogeneity test that have been carried out, both classes have a significance value greater than 0.05, which means the data is normally distributed and homogeneous. Then proceed with hypothesis testing using the independent sample T-Test and obtain a sig (2.tailed) value of 0.000, which means it is less than 0.05, so Ha is accepted and Ho is rejected.

The results of this research show that students' cognitive learning outcomes can improve after implementing the Simulation Based Learning model using PhET assistance. The descriptive analysis provided proves that the average value of the cognitive learning outcomes of experimental class students is higher than that of the control class, and the inferential analysis states that there is a significant difference in the cognitive learning test results of students between the experimental class and the control class on dynamic electricity material.

4 Conclusion

Based on data and data analysis techniques related to students' cognitive learning outcomes through the application of the Simulation Based Learning model using PhET in dynamic electrical material for class IX MTsN 1 Kuantan Singingi, the conclusions that can be drawn are:

1. The use of the Simulation Based Learning model using PhET can improve students' cognitive learning outcomes in dynamic electrical material at Class IX MTsN 1 Kuantan Singingi. This can be seen from the average value of cognitive learning outcomes of students, where the value of cognitive learning outcomes in the class treated using the Simulation Based Learning model using PhET is higher than the average value of cognitive learning outcomes of students in the control class. only use conventional learning models.
2. There is a significant difference in cognitive learning outcomes between the class that applies the Simulation Based Learning model using PhET and the class that applies the conventional learning model on dynamic electrical material at Class IX MTsN 1 Kuantan Singingi. This shows that the use of the Simulation Based Learning model using PhET can improve student learning outcomes compared to conventional learning.

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