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The Impact of Using PhET Simulation Through a Multiple-Representation Approach on Students' Learning Outcomes and Interests

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ABSTRACT

This study aims to determine the learning outcomes and interests of students with the use of PhET Simulation media through a multiple-representation approach to motion concept. The research method used is a quasi-experiment with a one group pretest and posttest design. The research subjects were taken using a random sampling technique involving 45 grade XI students at SMA Negeri 6 Banda Aceh. The research data was obtained from learning outcomes and student interest questionnaires. Data analysis using a gain test. Based on the results of the study, student learning outcomes were obtained with an average value of multiple representation in verbal, mathematical, graphic formats, and experienced a significant increase. While the overall student interest in learning is in the good category. This study can make students happy, interested, and have attention and direct involvement in the learning process so that it can be suggested to teachers or related parties to consider the use of PhET Simulation through a multi-representation approach in the physics teaching and learning process.

1. INTRODUCTION

Physics is a process and a product. Process means a procedure in order to produce physics products such as facts, concepts, principles, laws or theories obtained through scientific steps (Hanna et al., 2017). To achieve the scientific step, the teaching and learning process guides teachers to be able to innovate in learning. One of the innovations demanded in physics learning is the implementation of virtual media in learning. The use of virtual media is very important, besides being easily obtained from the internet, it also makes it easier for teachers to deliver materials that are difficult to explain conventionally. So the use of virtual media in physics learning is very effective from abstract things to concrete in the teaching and learning process.

The research media used is a virtual laboratory application or Physics Education Technology (PhET) simulation. Team PhET (2015) explains that PhET is a site that provides learning simulations of physics, biology, chemistry, and mathematics, which is provided for free by the University of Colorado for the benefit of learning in the classroom or can be used for the benefit of individual learning. The simulation is designed interactively, so that the user can do the learning directly. PhET media has been proven to improve student learning outcomes as per relevant previous research (Yuafi & Endryansyah, 2015), (Rasyidah et al., 2018), (Hasbullah & Nazriana, 2017)., (Hasbullah et al., 2018), (Muzana et al., 2021)., (Subiki et al., 2022)., (Arifin, 2011)., (Muna et al., 2023)., (Wilujeng, at al., 2024).

In addition to the use of media, the use of strategies, methods, and even approaches are also very influential on the results and interest in learning. Interest is a feeling of preference and interest in a thing or activity, without anyone telling (Slameto, 2010;180). In order to achieve results and students' interest in learning, an approach in teaching is also needed. Approaches in learning have two types, according to Nasution (2013), a learning approach that is student centered approach and a learning approach that is oriented teacher centered approach. A good approach is to use a multiple-representations approach.

Multiple-representations that is specifically used in learning physics has three ways. The three methods are: (a) as a way or tool to explain the problem that occurs when students create or draw a sketch of a physical situation and complete the information, (b) as the subject of the problem when the student is explicitly asked to make a graph or find the value of a physical quantity using graphics, and (c) as a formal step or procedure when the student is asked to draw a free object diagram as one of the initial steps in applying the concept to solve the problem (Dufresne et al., 1997).

Therefore, the use of media in the form of multiple-representations of students in understanding physics needs to be brought up by educators in various forms of information presentation so that students are able to understand an abstract problem into a concrete one in all areas of review as presented by (Mahardika, 2013) in learning, students are required to master different representations such as experimental results, graphics, conceptual, formulas, pictures, diagrams. Lucas & Lewis, (2019) found that teachers rarely use graphics, pictures or diagrams as other forms of representation of a concept, but teachers tend to use verbal explanations more, and students are not challenged to explain the same physics concept by using other representations. So in line with some of the relevant research above, it is expected to improve learning outcomes and student interest after the learning process as in the previous literature (Indriani & Dharmautama, 2016), (Charli et al., 2019) and (Muna et al., 2023).

2. METHODS

The research was conducted by giving pretest questions and then continued by giving action (treatment) using PhET Simulations through a multiple-representations approach. The design of the research using one group pretest and posttest in the experimental class can be formulated in Table 1. The population in this research is the students of SMA Negeri 6 in Banda Aceh, with the research sample being classes X-IA1 and X-IA2 which were chosen randomly that is by self-determining the class chosen by the researcher. According to (Fraenkel et al., 1993;91) random sample selection in experimental research is expected to assume that the selected groups have understanding or equivalence of abilities. The research sample consisted of 45 randomly selected students. For the data collection process using interest questionnaires and multiple-choice questions to see student learning outcomes that have been validated by experts in their fields and tested for their feasibility. And data processing using the gain equation for learning outcomes and student questionnaire data is analyzed using the percentage equation and statistical test t-test.

Tabel 1. One Group Pretest and Posttest Design (Fraenkel et al., 1993;269)

Pretest	*Treatment*	*Posttest*
O	X	O

3. RESULT AND DISCUSSION

3.1 Result

The purpose of the research is to find out how learning outcomes and students' interest in linear motion concept by using PhET Simulations through a multiple-representations approach, for the instrument in collecting research data is the form of multiple-representation questions in verbal, mathematical, graphic and picture formats and student interest questionnaires in learning. description of student learning outcomes after treatment with PhET Simulations through a multiple-representations approach through movement material as in table 1.

Table 1. Student learning results through a multiple-representations approach with PhET Simulation.

Sub-Topics	Indicator Test	No. Test	Format Test	Means Result		*Gain Indicator*
				Pre-test	Post-test	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Linear motions	Explain the meaning of straight motions	1	Verbal	68.89	71.11	0.07
	Differentiate between distance and displacement of objects in straight motions	5	Picture	42.22	62.22	0.35
	Differentiate between speed and velocity of objects in straight motions	7	Picture	51.11	53.33	0.05
	Determine the average speed and average velocity of an object	9	Table	40.00	53.34	0.22
		8	Math			
Uniform Rectilinear Motions	Defines the meaning of regular linear motions	4	Verbal	47.78	64.45	0.32
		11	Graph			
	Determining the characteristics of regular rectilinear motions	3	Verbal	61.11	65.56	0.11
		4	Verbal			
	Analyzing Regular Motion Graphics	14	Verbal	28.89	64.44	0.50
	Formulating the Equations of Linear Motions	2	Math	50.00	61.12	0.22
		12	Verbal			
Linear motion changes regularly	Identify the characteristics of regular linear motions	10	Graph	30.56	53.34	0.49
		13	Verbal			
		15	Graph			
		16	Math			
	Connecting between velocity (v), acceleration (a), and time (t) in linear motion changes regularly	17	Graph	37.78	62.22	0.39
	Relating between displacement (s), acceleration (a) and time (t) in linear motion varies regularly	18	Graph	40.00	57.78	0.30
	Connecting between displacement (s), velocity (v) and acceleration (a) in linear motion varies regularly	19	Graph	24.44	62.22	0.50
	Using linear equations of motion to solve problems	20	Graph	28.89	44.44	0.22

The description of students' learning interest after applying PhET Simulations through a multiple-representations approach through movement material in an experimental class was measured by using a questionnaire instrument with positive statements validated by experts in the field. To obtain data, questionnaires were given to respondents after learning with the use of a multiple-representations approach through the use of PhET Simulations. Questioner data was analyzed with a likert scale referring to value categories 4 (very good), 3 (good), 2 (less), 1 (very less). Data from the questioner test can be seen in Figure 1.

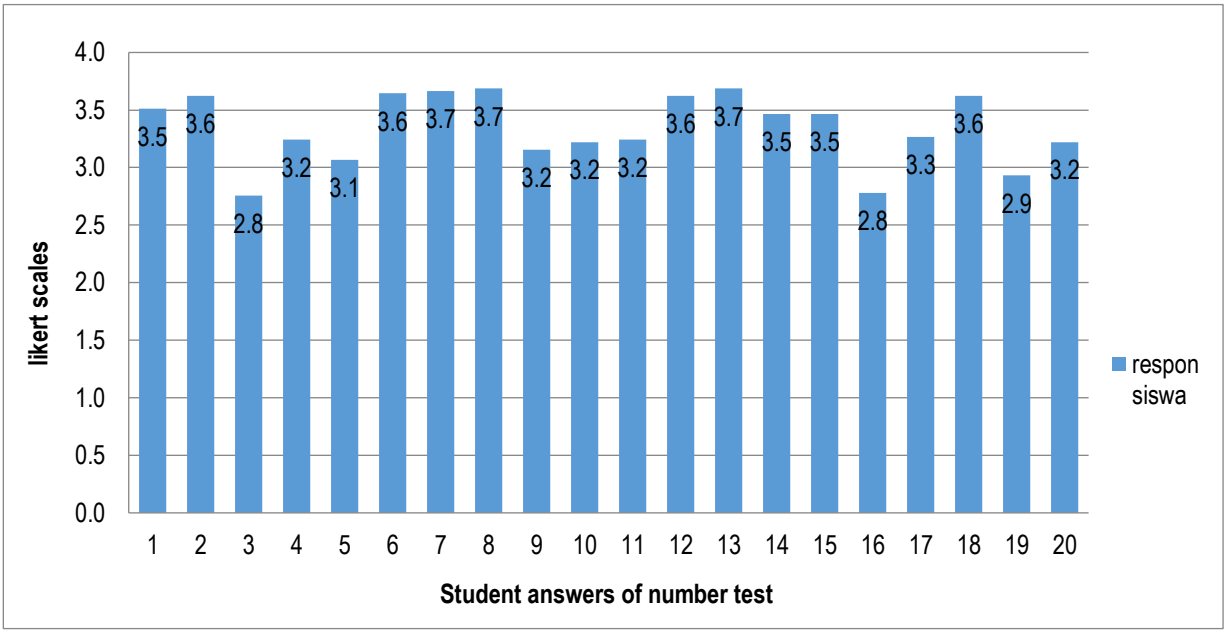

Figure 1. Student's interest in the details of the statement after treatments

Based on the data of picture 1. obtained the results of each statement on the first indicator, the feeling of happiness when following the lesson was obtained on a likert scales, that is, the students feel happy when the physics learning takes place, a gain of 3.5 is obtained in the good category, as long as the teacher is in the class, students feel comfortable learning physics, a gain of 3.6 is obtained in the good category, during the three meetings before learning physics in the class, students first study the material that will be taught, a gain of 2.8 is obtained in the less category, working on the practice questions is my own initiative, I obtain a gain of 3.2 in the good category, I diligently working on the tasks given by the teacher obtained a gain of 3.1 in the good category.

The second indicator, interest in learning is obtained on a likert scales, namely; with the method, approach and strategy used by the teacher, he can easily understand the subject matter, he obtained a gain of 3.6 in the good category, students felt that the hours of physics learning in class were very little, he obtained a gain of 3.7 in the good category, students felt fully concentrated when following the physics lesson, he obtained a gain of 3.7 in the good category, during this time, students actively discussed while following physics learning, a gain of 3.2 in the good category, and students often asked questions when they did not understand the explanation given by the teacher, he obtained a gain of 3.2 in the good category.

The third indicator, student attention to learning is obtained on a likert scales, namely; students feel interested in learning physics with the teacher's teaching method obtained a gain of 3.2 in the good category, students listen well when the teacher is explaining the subject matter obtained a gain of 3.6 in the good category, students do all the activities given by the teacher well gain a 3.7 in the good category,

students understand all the teacher's explanations from beginning to end in the learning process obtained a gain of 3.5 in the good category, and students feel happy when the teacher solves our difficulties in learning 3.5 in the good category.

The fourth indicator, students apply physics concepts in everyday life 2.8 in the poor category, students can perfect ideas with physics learning media obtained a gain of 3.3 in the good category, students can learn physics with PhET simulation media 3.6 in the good category, students can integrate the theoretical concepts of physics with their application obtained a gain of 2.9 in the poor category, and the multi-representation approach through PhET simulation can support the understanding of the concept of linear motion obtained a gain of 3.2 in the good category.

Based on picture 1. it can be seen that the indicator of student interest after being treated with the use of PhET simulation through a multiple-representations approach obtained results for the indicator of feeling happy when following the lesson obtained an average score of 3.24 in the good category, interest in the lesson obtained an average score of 3.48 in the good category, student attention to learning obtained an average score of 3.50 in the good category, student involvement in learning obtained an average score of 3.16 in the good category.

Students' interest in learning after applying the multiple-representation approach through the use of PhET simulations on movement material is obtained from the results of a one-sample t-test with the criterion of rejecting Ho if t_test=t_table at a significant level of 0.05 and dk = (n – 1) = (45 – 1) = 44 and the hypothesized value of value 3 in the good category is obtained as a result of price t_table = 1,682 and t_test = 2,897 criteria of results, so rejecting Ho means the use of a multiple-representation approach through the use of PhET simulation on movement material has an effect on students' interest in learning.

4.2 Discussion

Learning Outcomes of Students After Treatment

Based on the results of the data analysis in the picture, it can be interpreted that the students' learning results with the average value of multiple-representations in the verbal format experienced an increase from 52.70 to 63.49 with a gain of 22.82, as well as in the mathematical format becoming an increase from 40.00 to 57.04 with a gain of 28.39, and then the graphic format from 30.79 to 56.19 with a gain of 36.70, the picture format became 45.92 57.04 with a gain of 20.55. The result above the average posttest value of students experienced an increase with the gain of verbal format in the low category, low mathematics, medium graphics, and low pictures.

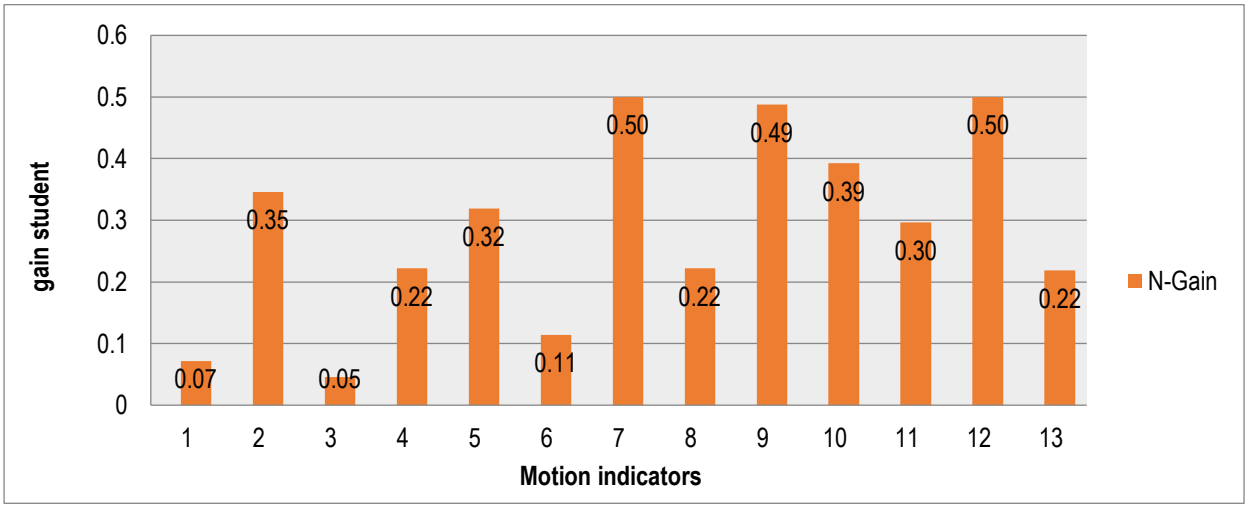

Figure 2. Result gain indicator of pre-test dan post-test

Based on Figure 2. The learning outcomes of each indicator experienced a significant increase. This indicates that the use of PhET media with a multi-representation approach is effective and efficient in treatment, does not make teachers bother in preparing teaching materials, is easy to obtain and easy to access via the internet or virtual materials that have been downloaded. Based on the research conducted, it can be said that the Problem Based Learning model accompanied by PhET simulation has an effect on student learning outcomes in the subject of physics, the topic of Elasticity and Hooke's Law (Ulumiyah, W., et al. 2021).

Based on research results, interest is an important factor in the learning process according to Astuti, (2015) research, interest is one of the determining factors in educational success. A student will be successful in his studies when the student has a desire to learn. Therefore, the interest of students in learning as a whole in this research by using PhET simulation through a multi-representation approach can be seen from the following indicators;

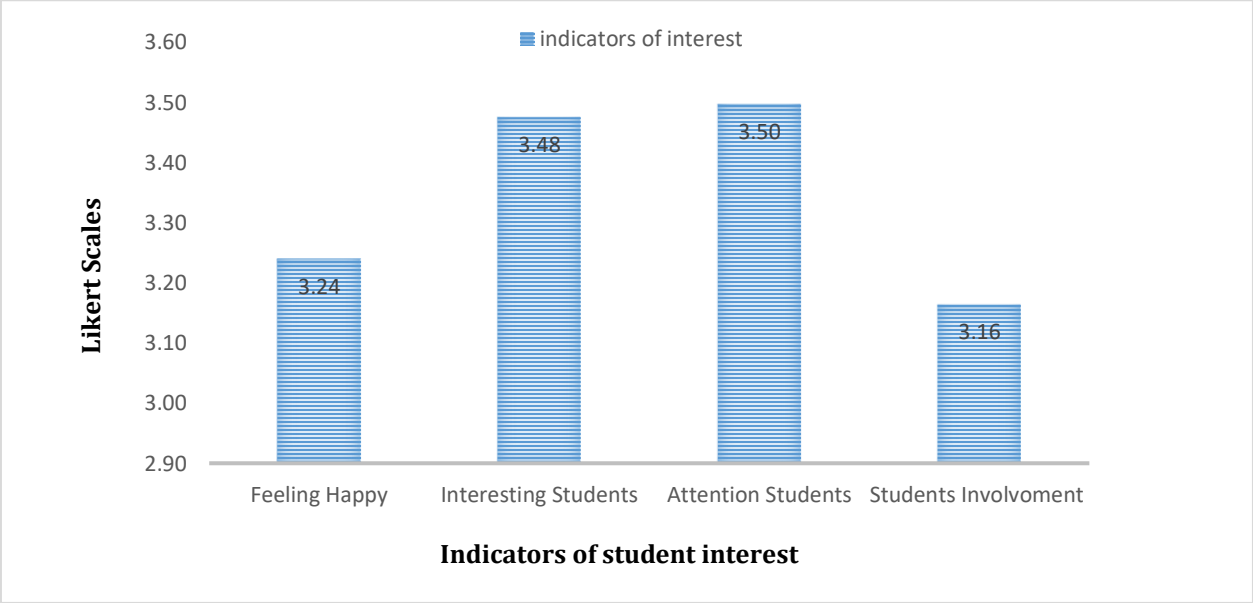

Figure 3. Indicator of students interest after treatment

Feeling Happy

There is a feeling of joy when students follow physics learning without any coercion from anyone. Students' interest in the happy indicator is obtained on a Likert scale of 3.4 in the good category. Students' feelings of joy in learning can be observed from the focus of students during the learning process, which usually often asks for permission to go out almost never, focuses on watching the PhET simulation, stays in class from beginning to end. Students' attitudes conclude the form of student pleasure in learning. Therefore, the feeling of feeling happy after treatment by showing students' open and enthusiastic attitudes in class and outside the classroom. In line with the research results of Santoso et al., (2022) said that simulation can be a fun learning experience for students.

Student Interesting

There is a tendency for students to feel attracted to objects and activities that take place. Student interest in the indicator of student interest in the lesson was obtained with an average score of 3.48 in the good category. In this indicator, students' interest in learning can be seen from the students' activeness in learning the multi-representation approach with the help of PhET simulation can make students interested in learning.

Attention Students

There is full attention and concentration of students on the ongoing lesson. On the indicator of students' attention to learning, the average score on the Likert scale of 3.50 was in the good category. The attention of movement learning students is due to something different from the usual such as the use of strategies, approaches, methods and the use of media. A multi-representation approach through the use of PhET simultion is one way of focusing students' attention on learning.

Student Involvement

There is a feeling of wanting to do the activity and students feel involved in doing tasks during learning. On the indicator of student involvement in learning, an average score of 3.16 was obtained in the good category. Student involvement in this learning is like active students in filling out the portfolio by referring to the animation display on the PhET simulation, illustrating graphics, working on verbal questions, using mathematical equations in doing exercises so that students are directly involved in the learning process with a multi-representation approach with the help of PhET simulation.

Based on the results of the indicator analysis, it is known that each indicator of interest has increased, so it can be explained that the multiple-representations approach through the use of PhET simulation on movement material can increase student interest. The same thing was also found by Saregar, (2016) in his research, the results of the implementation of physics learning actions with a scientific approach with the help of PhET simulation and portfolio media experienced an increase in student interest in each cycle. Because it can be concluded that learning with a multi-representation approach through the use of PhET simulation can make students happy, interested, have attention and have direct involvement in the learning process.

Based on the analysis of interest questionnaire data, there are two indicators that have a high average score, namely student attention to learning with an average score of 3.50 and interest in learning with an average score of 3.48 in the good category. The high average score of student interest is because students feel happy when the teacher solves difficulties in learning, understand all the teacher's explanations from beginning to end in the learning process, do the activities given by the teacher well, listen well when the teacher is explaining the subject matter. Coupled with the fact that students feel fully concentrated when following physics learning, feel that the hours of physics learning in class are very less, and the approach and strategy used by the teacher can be easily understood in the lesson.

While the lowest indicator is followed by the indicator of student involvement in learning with an average score of 3.16 and the feeling of happiness when following lessons with an average score of 3.24 is in the good category. The low average score of the students is due to the fact that the students are not yet able to apply the concepts of physics in their daily lives, are unable to integrate the theoretical concepts of physics with their applications, then before learning physics in class the students first do not study the material that will be taught.

Based on the results of the synthesis of students' interest in rectilinear motion material with the multi-representation approach with the help of PhET simulation, it was concluded that overall students' interest is in the good category. Therefore, the multi-representation approach with the help of PhET simulation can be considered in learning physics, especially in the matter of motion.

Based on the results of the hypothesis test to reject Ho with criteria $t_{test} \geq t_{table}$ obtained results of 2,897 > 1,682, means accept Ha hypothesis of a significant influence of student learning interest after applying a multi-representation approach through the use of PhET simulation on movement material, student interest after applying learning in the good category so that there is relevance between research of Saregar, (2016) with the title of learning introductory quantum physics by utilizing PhET simulation and portfolio through a scientific approach obtained the results of student interest during learning with an assisted scientific approach PhET and portfolio media, experienced an increase in each cycle.

In line with the research of Isa, (2010) the application of the guided inquiry learning method with the help of multimedia can increase the interest and understanding of class X-I semester II students of SMAN 14 Semarang. Therefore, the use of multimedia, one of which is PhET simulation, can increase student interest. Based on the results of the research description after the learning has been applied, it

can be concluded that there is a significant positive influence of the PhET simulation -assisted multiple-representations approach on students' interest in movement material.

4. CONCLUSION

The learning outcomes of students with the average value of multi-representation in the verbal format experienced an increase from 52.70 to 63.49 with a gain of 22.82, as well as in the mathematical format becoming an increase from 40.00 to 57.04 with a gain of 28.39, and then the graphic format from 30.79 to 56.19 with a gain of 36.70, the picture format from 45.92 to 57.04 with a gain 20.55. Meanwhile, students' interest in learning with a multi-representation approach through the use of PhET simulation as a whole in the good category. This research can make students happy, interested, have attention and direct involvement in the learning process. There is a significant influence after applying the multi-representation learning approach through the use of PhET simultion on motion material, the result is 7,412 > 1,682 at a significant level of 0.05, reject Ho, accept Ha. Therefore, it is recommended that teachers or related parties consider using PhET Simulation media through a multiple-representation approach in the physics teaching and learning process.

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