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The Effect of Guided Inquiry Accompanied by Virtual Laboratory on Students' Physics Learning Outcomes and Motivation

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ABSTRACT

This research purpose was to examine the effect of applying the guided inquiry learning model accompanied by a virtual laboratory on the results and motivation of studying physics in high school students. The chosen physics material is static fluid. The type of research used is a true experiment with the Posttest Only Control Group design. The population of this study was students of class XI MIPA at one of the public high schools in Mojokerto Regency. The sample was selected by cluster random sampling technique and assigned to class XI MIPA 1 as the control class and class XI MIPA 4 as the experimental class. The treatment was carried out three times and the next meeting was used for the post-test and questionnaire filling. Data on learning outcomes were obtained from post-test scores which were analyzed using the independent sample t-test technique, while motivational data were obtained from filling out questionnaires which were analyzed using the independent sample t-test technique. Based on the results of the research, it can be concluded that there is an effect of applying the guided inquiry learning model accompanied by a virtual laboratory on the results and motivation of studying physics in high school students. The results of this research are expected to be useful for teachers who experience problems in learning physics, especially in terms of the need for practical implementation.

INTRODUCTION

Education has a role as one of the main aspects in shaping the young generation in the future. The spearhead of the progress of a nation is in the hands of the younger generation in the future, with education it is hoped that the younger generation will have a virtuous personality. Education is very influential in changing lives in a positive direction which includes attitudes and patterns of human life. The development of education is accompanied by the development of science and technology [1]. The rapid development of science and technology requires the world of education to adapt to existing technological developments in an effort to improve the quality of education, for example in terms of

efforts to improve the quality of education by meeting the needs of effective and efficient learning methods [2]. Utilization of technology can be used to organize interactive learning with various models.

Physics is a branch of science that studies natural phenomena. Physics is not only studying facts but also studying how to think and work scientifically [3]. Physics has a goal for students to master science concepts and be able to apply them in everyday life and in technology [4]. Physics also plays a role in contributing to the development of technology [5]. Physics learning obtained from scientific processes that directly involve students will help students understand concepts [6]. Learning physics does not only require students to memorize mathematical formulas, but how students can act, understand, and understand these concepts and be able to relate the relationship between one concept and another. Physics learning is designed to foster students' critical thinking skills which are useful for students in dealing with problems in everyday life. The specific objective of learning physics is to prepare students to face the rapidly growing developments in technology and science [7].

Based on the results of interviews with physics subject teachers at one of the State High Schools in Mojokerto Regency regarding physics learning, information was obtained that students often feel bored with physics subjects. This problem is evidenced by the lack of enthusiasm and participation of students during the learning process. Frequent students who have permission to go to the toilet when studying physics are an indication that students lack the motivation to study physics. Students also feel afraid when physics lessons begin because they have been indoctrinated from the start that physics is difficult and full of mathematical formulas. This makes students' learning motivation low in the type of extrinsic motivation because encouragement from the people closest to the learning process, namely the teacher is very low [8].

Another problem that occurs is the factor of readiness and resources of the physics laboratory. Physics practicum tools are available but have not been used for a long time so some practicum tools require recalibration which takes time. With the construction of the school building, the physics laboratory room was converted into a classroom, making it impossible to carry out the practicum directly. Conditions like this make students prone to misunderstanding the material explained by the teacher, so that during daily tests, UTS, UAS, or doing LKPD assignments in their completion the majority of students still experience great difficulties. Low motivation to learn physics which can affect students' physics learning outcomes.

Statements related to problems in physics learning were reinforced by explanations from sources who said that students' physics learning outcomes had decreased due to the impact of physics learning that had never carried out practicum during the school building construction process and the Covid-19 pandemic which required learning to be carried out online. This is in accordance with research conducted by Nurjanah and Sunarto [9] which states that several factors can affect students' learning difficulties in learning physics, namely the teacher's delivery method is not clear, the learning method is monotonous, the learning media is boring and less interactive, readiness students and minimal resources, and a lack of motivation in students to study physics. Another factor that causes the low quality of learning is the lack of stimulation from the teacher so that students are more serious about participating in the learning process [10].

The right learning model is expected to be able to overcome various learning problems. Based on field studies, learning physics in class is still dominated by the teacher-centered approach, where the teacher is the only source of learning [11]. Various kinds of learning models have been made by experts and have been implemented in schools. The learning model is a tutorial learning plan that is arranged systematically and forms a pattern that is used as a guide in planning learning in class [12]. One of the known learning models is guided inquiry. Physics learning should be carried out by means of inquiry so that the ability to think, work, and act scientifically arises [13]. The guided inquiry learning model emphasizes student-centered learning with syntax namely: (1) orientation, (2) formulating problems, (3) formulating hypotheses, (4) collecting data, (5) testing hypotheses, and (6) formulating conclusions [14]. The guided inquiry model is very suitable for physics subjects which cannot be separated from

practicum, this is evidenced by research by Harjilah et al [15]; Pulungan & Simanjuntak [16]; and Hosnah et al [17] who examined the effect of the guided inquiry learning model on motivation and physics learning outcomes of high school students.

Practical activities play an important role in guided inquiry learning. There are practical activities that can move students to be able to collect data, test hypotheses, and answer existing problems. The existence of constraints on school readiness in carrying out hands-on practicum in the laboratory requires teachers to innovate in their learning. One alternative software that can support practicum activities is a virtual laboratory. Students need learning media that can attract students' attention and focus so they can be interested in learning and understanding physics lessons. Media that can help students in getting a real form of learning is a simulation application or virtual laboratory [18]. This software was chosen because the data obtained is accurate, time efficient, and uses existing technology. The free virtual laboratory is the Ministry of Education and Culture Learning House Portal and PhET Simulation. PhET simulation is a form of visual simulation that has several advantages compared to real-world experiments using props [19]. Both of this software can be used as a complement to the guided inquiry learning model. The Kemdikbud Learning House Portal is an official learning portal from the Ministry of Education and Culture which is managed by the Center for Educational Information Technology and Communication (Pustekkom). The Learning House Portal has a virtual laboratory facility to facilitate virtual practicum. Darwis and Hardiansyah's research [20] concluded that there was a significant effect of the physics learning method using a virtual laboratory on student motivation and learning outcomes.

Misconceptions often occur in learning physics with the field of mechanics being at the top. One of the areas of mechanics where misconceptions often occur is fluid statics [13]. The concept of static fluid is often encountered in everyday life, for example, hydraulic jacks, water in a glass, swimming pool water, and so on. Static fluid material has abstract characteristics and many formulas that must be memorized [21]. This is in accordance with the results of research conducted by Wahyuni [22] on high school students in Banda Aceh to obtain data that the highest percentage of students experienced misconceptions about one of the indicators of Archimedes' Law material 52%, the percentage of students who did not understand the concept of hydrostatic pressure was proportional to the mass fluid type. Sofiuddin et al [23] in his research obtained data on students having misconceptions of 81% of the concept in a type of fluid all points that are aligned horizontally have the same hydrostatic pressure, from this study it can be seen that the percentage of students experiencing misconceptions is very large. This is what underlies the choice of static fluid material as the subject of discussion.

Education, which is the spearhead of the progress of the nation, has a very vital role. Education consists of various kinds of knowledge, one branch of science that has a big role in the development of science and technology is physics. Physics is the most basic aspect of the natural sciences because many branches of science depend on and interact with physics, therefore an appropriate learning model is needed to achieve the goals of learning physics. The appropriate learning model to be applied to physics learning is the guided inquiry model. The guided inquiry learning model has stages that support the physics learning process which is accompanied by a practicum, but with limited resources in schools, virtual laboratory media is needed which can support the practicum process efficiently. Based on this description, this research discusses "The Effect of Guided Inquiry Accompanied by Virtual Laboratory on Students' Motivation and Physics Learning Outcomes".

METHOD

This research is a true experiment with the Post-test Only Control Group design. In this design, there are two groups, each of which is randomly selected [24]. The form of the research design can be seen in Figure 1 below.

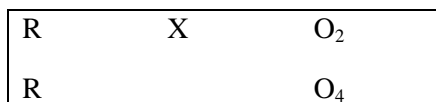


Fig 1. Research design

Information:

- X = Treatment (implementation of the guided inquiry learning model accompanied by a virtual laboratory)
- O₂ = Post-test in the experimental class
- O₄ = Post-test in the control class

The population in this study were students of class XI MIPA one of the high schools in Mojokerto Regency for the academic year 2022/2023 and the samples selected using the cluster random sampling technique were class XI MIPA 1 as the control class and XI MIPA 4 as the experimental class. The control class applies a model previously used by physics teachers, namely the problem-based learning model. In the experimental class using the guided inquiry learning model accompanied by a virtual laboratory by dividing students into six groups, each group received a worksheet which was used as an assignment. The use of a virtual laboratory is in accordance with the static fluid material contained in PhET Simulations and the Kemdikbud Learning House Portal. PhET Simulations were used to carry out Pascal's Law experiments and the Kemdikbud Learning House Portal was used to experiment with hydrostatic pressure and Archimedes' Law.

The treatment was carried out for three meetings during physics class hours. After the treatment was carried out in each class, at the fourth meeting a post-test was carried out to obtain data on learning outcomes. In addition, questionnaires on students' physics learning motivation were also distributed. The post-test questions are based on the cognitive domain using a written test instrument in the form of five multiple-choice questions and two description questions. The student test indicators were adapted to Anderson and Krathwohl's revised Bloom's Taxonomy in 2001. Multiple choice questions numbered 1-5 used the C4 level (analyzing) and descriptions numbers 6 and 7 respectively used the C5 level (evaluating) and C6 (creating).

The motivational questionnaire to study physics uses the ARCS (Attention Relevance Confidence Satisfaction) indicator. The indicators of motivation to learn physics that will be measured use indicators on the ARCS aspect which include: (1) attention to the learning process, (2) students' willingness to seek and find information related to physics material, (3) linking concepts from the material, (4) mentioning the application of physics concepts in everyday life, (5) expressing opinions and answering questions, (6) solving physics problems independently, (7) being active in physics learning, and (8) working on questions, projects, and assignments complete physics. The motivation to study static fluid physics was measured by a questionnaire with a Likert scale which was distributed to the control and experimental classes. The learning motivation questionnaire contains eight statements adapted to the indicators of learning motivation in the ARCS aspect. There are five categories of answers to the 33 students' learning motivation questionnaire, namely: always (SL), often (S), sometimes (KK), rarely (JS), and never (TP).

The technique used to analyze the data is the independent sample t-test if the data obtained is normally distributed and the Mann-Whitney test, if the data obtained is not normally distributed. The test technique was carried out with the help of IBM SPSS 23 software. The data analyzed were data obtained from working on pos-test questions and questionnaires that had been distributed to the control and experimental classes.

RESULTS AND DISCUSSIONS

The research was conducted for two weeks. There were four face-to-face meetings in teaching and

learning activities in the control and experimental classes. Three meetings were used to deliver material and treatment while one meeting was to collect post-test data. The research schedule can be seen in Table 1 below.

Table 1. Research schedule

Date	Time	Activity
Tuesday, November 8, 2022	08.30-10.00	Meeting 1 (Experiment Group)
Tuesday, November 8, 2022	10.15-11.00	Meeting 1 (Control Group)
Wednesday, November 9, 2022	07.00-08.30	Meeting 2 (Experiment Group)
Thursday, November 10, 2022	14.00-15.30	Meeting 2 (Control Group)
Tuesday, November 15, 2022	08.30-10.00	Meeting 3 (Experiment Group)
Tuesday, November 15, 2022	10.15-11.00	Meeting 3 (Control Group)
Wednesday, November 16, 2022	07.00-08.30	Post-test (Experiment Group)
Thursday, November 17, 2022	14.00-15.30	Post-test (Control Group)

Based on Table 1, the first treatment was carried out on Tuesday, 8 November 2022 at 08.30-10.00 WIB for the experimental class and 10.15-11.00 WIB for the control class. The submitter that was discussed in the first meeting was the hydrostatic pressure that objects experience when they are submerged in water. The second meeting for the experimental class was held on Wednesday, 9 November 2022 at 07.00-08.30 WIB, while the control class was held on Thursday, 10 November 2022 at 14.00-15.30 WIB. The sub-matter discussed at the second meeting was Pascal's Law. The third meeting for the experimental class was held on Tuesday, 15 November 2022 at 08.30-10.00 WIB, while the control class was held on Tuesday, 15 November 2022 at 10.15-11.00 WIB. The sub-matter discussed at the third meeting was Archimedes' Law. At the fourth meeting, the control class and the experimental class carried out the post-test questions. The work on the post-test questions was carried out within 90 minutes. The results of the post-test questions are summarized in Table 2 below.

Table 2. Summary of student physics learning outcomes data

Group	Total Students	Highest Score	Lowest Score	Average
Control	31	85	15	55.13
Experiment	32	91	25	67.34

Based on Table 2 regarding data on student learning outcomes, it can be seen that the highest score in the control class, which consisted of 31 students, was 85 and the experimental class, which consisted of 32 students, was 91. The lowest score obtained by the control class was 15 and the experimental class was 25. Data in Table 2 can be obtained from a graph of the average percentage of student physics learning outcomes shown in Figure 2 below.

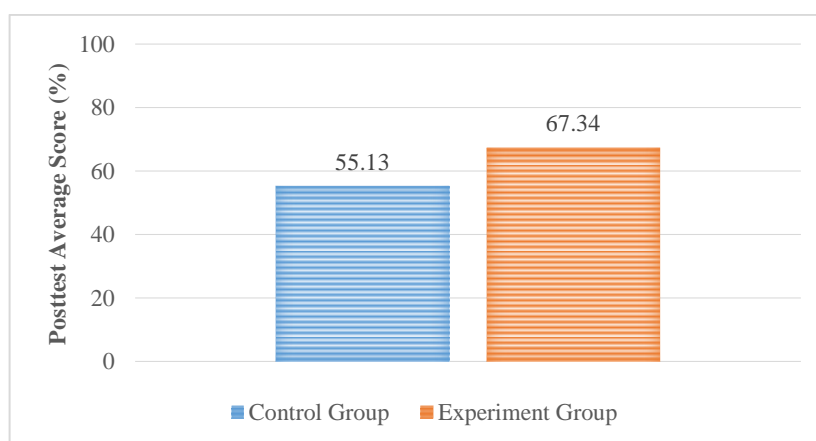


Fig 2. Graph of the average percentage of student learning outcomes

The average post-test score of the experimental class that applies the guided inquiry learning model accompanied by a virtual laboratory on static fluid material is greater than that of the control class. The control class obtained an average percentage of 55.13% and the experimental class 67.34%. From these results, it can be seen that the average post-test score in the experimental class is greater than the control class.

The data obtained were then analyzed using the independent sample t-test technique using the help of IBM SPSS 23 software. The aim was to examine the effect of applying the guided inquiry learning model accompanied by a virtual laboratory on students' physics learning outcomes in a static fluid material. The first step before carrying out the independent sample t-test is the normality test. The normality test is a requirement for conducting an independent sample t-test. The normality test is carried out to ensure that the data to be tested is normally distributed. The normality test of student physics learning outcomes data using the Kolmogorov-Smirnov test technique can be seen in Table 3 below.

Table 3. Test the normality of student physics learning outcomes data

	Control Group	Experiment Group
N	31	32
Mean	55.12	67.34
Std. Deviation	17.67	15.49
Asymp. Sig. (2-tailed)	0.20	0.09

Based on Table 3 regarding the normality test of the two samples in the control class, the value of Sig. (2-tailed) of 0.200 and the experimental class of 0.091. In accordance with the basis for decision making if the value of Sig. (2-tailed) > 0.05 it can be concluded that the data is normally distributed. The normality test results obtained showed that the data were normally distributed because $0.200 > 0.05$ and $0.091 > 0.05$. Data on student physics learning outcomes that were normally distributed were then analyzed by independent sample t-test using IBM SPSS 23 software. The output of the independent t-test test results on student physics learning outcomes can be seen in Table 4 below.

Table 4. Independent sample t-test data on students' physics learning outcomes

		df	Sig. (2-tailed)
Physics Learning Outcomes	Equal variances assumed	61	0.005
	Equal variances not assumed	59.04	0.005

Based on the output of Table 4 it can be seen that the value of Sig. on Levene's Test for Equality of Variances of 0.673 or greater than 0.05 ($0.673 \geq 0.05$), which means that the data on student physics learning outcomes is homogeneous. Hypothesis testing using the independent sample t-test technique obtained the value of Sig. (2-tailed) of $0.005 \leq 0.05$ so that H_0 is rejected and H_a is accepted. Based on these results, it can be concluded that there is an effect of applying the guided inquiry learning model accompanied by a virtual laboratory on the physics learning outcomes of high school students in a static fluid material.

The guided inquiry learning model accompanied by a virtual laboratory can support learning activities and has the advantage of strengthening students' mastery of physics concepts. The guided inquiry model accompanied by a virtual laboratory can be an option for teachers when determining appropriate learning models and media to improve the quality of learning. A virtual laboratory is an alternative for teachers when the practicum tools provided in schools are limited. Today's students who are familiar with technology will be interested in learning to use a virtual laboratory. This is proven during the learning process students can easily operate a virtual laboratory so that the concepts of physics material being taught can be easily accepted by students. Working on post-test questions will be easier if students understand the concepts of physics. This is evidenced by the average post-test results of the experimental class being better than the control class, so it can be concluded that the

application of the guided inquiry learning model accompanied by a virtual laboratory has an effect on students' physics learning outcomes. The results of this study are in accordance with the results of research conducted by Fatimah et al [25]; and Kusdiastuti et al [26] which revealed that the guided inquiry learning model accompanied by a virtual laboratory could improve students' physics learning outcomes.

The data that will be analyzed next is data on students' physics learning motivation obtained from the distributed questionnaires. The data recapitulation of students' motivation to learn physics can be seen in Table 5 below.

Table 5. Recapitulation of students' physics learning motivation data

Group	Aspect	Statement	P (%)	Category	
Control	Attention	I really pay attention teacher's explanation during the process of material physics learning static fluid	78,80%	Good	
		during the learning process of static fluid physics of matter, I tried to find literature that supports an understanding theory	69,60%		
	Relevance	I can relate static fluid concepts in daily life	63.80%	Good	
		Very static fluid material useful in daily life	69.00%		
	Confidence	I often convey current opinions and feedback on material physics learning static fluid	44.60%	Sufficient	
		I was able to finish static fluid physics matter independently without cheat	54.80%		
	Satisfaction	I always try to be active during the learning process of static fluid physics of matter	58.80%	Sufficient	
		I do my homework and post-test questions thoroughly without cheating	50.40%		
	Experiment	Attention	I really pay attention teacher's explanation during the process of material physics learning static fluid	91.20%	Very Good
			during the learning process of static fluid physics of matter, I tried to find literature that supports an understanding theory	70.60%	
Relevance		I can relate static fluid concepts in daily life	67.60%	Good	
		Very static fluid material useful in daily life	72.00%		
Confidence		I often convey current opinions and feedback on material physics learning static fluid	64.40%	Good	
		I was able to finish static fluid physics matter independently without cheat	64.40%		
Satisfaction		I always try to be active during the learning process of static fluid physics of matter	73.20%	Good	
		I do my homework and post-test questions thoroughly without cheating	55.60%		

Based on Table 5 regarding the recapitulation of students' physics learning motivation data, a graph with the percentage of each indicator is obtained which can be seen in Figure 3 below.

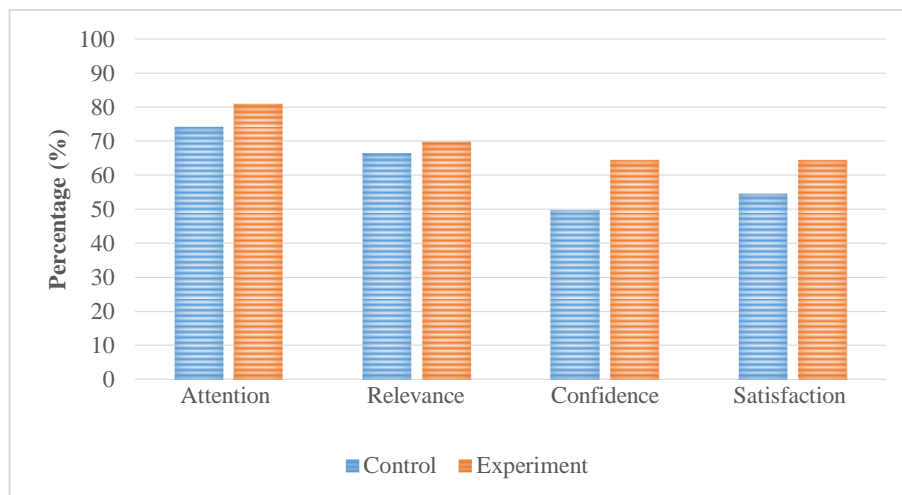


Fig 3. Graph of the average percentage of student learning outcomes

Figure 3 shows that in the control class, the attention aspect obtained a percentage of 74.20% in the good category, relevance of 66.40% in the good category, confidence of 49.70% in the sufficient category, and satisfaction of 54.60% in the sufficient category. If each aspect is combined, the control class obtains an average P of 61.23 which is in the good category. In the experimental class, the attention aspect obtained a percentage of 80.90% in the very good category, relevance of 69.80% in the good category, confidence of 64.40% in the good category, and satisfaction of 64.40% in the good category. If each aspect is combined, the experimental class obtains an average P of 69.86 which is in the good category.

Data on students' motivation to study physics were then tested using an independent sample t-test. The purpose is to examine the effect of applying the guided inquiry learning model accompanied by a virtual laboratory on students' motivation to learn physics in a static fluid material. The first step before carrying out the independent sample t-test is the normality test. The normality test is a requirement for conducting an independent sample t-test. The normality test is carried out to ensure that the data to be tested is normally distributed. The normality test for students' physics learning motivation using the Kolmogorov-Smirnov test technique can be seen in Table 6 below.

Table 6. Test the normality of students' physics learning motivation data

	Control Group	Experiment Group
N	31	32
Mean	3.06	3.49
Std. Deviation	0.50	0.54
Asymp. Sig. (2-tailed)	0.20	0.20

Based on Table 6 regarding the normality test of the two samples in the control class, the value of Sig. (2-tailed) of 0.200 and the experimental class of 0.200. In accordance with the basis for decision making if the value of Sig. (2-tailed) > 0.05 it can be concluded that the data is normally distributed. The normality test results obtained show that the data is normally distributed because 0.200 > 0.05. Data on students' physics learning motivation which were normally distributed were then analyzed by independent sample t-test using IBM SPSS 23 software. The output of the independent t-test results on students' physics learning motivation data can be seen in Table 7 below

Table 7. Independent sample t-test data on students' motivation to learn physics

		df	Sig. (2-tailed)
Student' Motivation to Learn Physics	Equal variances assumed	61	0.002
	Equal variances not assumed	60.93	0.002

Based on the output of Table 7 it can be seen that the value of Sig. on Levene's Test for Equality of Variances of 0.753 or greater than 0.05 ($0.753 \geq 0.05$), which means that the data on students' motivation to study physics is homogeneous. Hypothesis testing using the independent sample t-test technique obtained the value of Sig. (2-tailed) of $0.002 \leq 0.05$ so that H_0 is rejected and H_a is accepted. Based on these results it can be concluded that there is an effect of applying the guided inquiry learning model accompanied by a virtual laboratory on high school students' physics learning motivation in static fluid material.

The application of the guided inquiry learning model accompanied by virtual laboratory has an effect on students' motivation to learn physics. During the learning process, students in the experimental class are more active when working on the worksheet assignments given, are interested when receiving material explanations, are confident in answering questions, and are enthusiastic in following the inquiry learning flow. guided along with a virtual laboratory. This is an indication that students' motivation to learn physics in the experimental class is better than the control class. These results are in accordance with the results of research by Silfi and Umatin [27] which state that by applying the guided inquiry learning model, students become motivated to learn and increase their understanding of the material that has been taught. Motivation also includes several aspects, including interest and attention during the learning process, enthusiasm and student participation in doing assignments, and students' sense of responsibility in solving problems.

During the research process, there were several obstacles experienced. The first obstacle that occurred during the research process included the effectiveness of the time allotted for research. The solution is to create a conducive classroom atmosphere when applying treatment to class so that time can be put to good use. The next obstacle is that students who do not bring smartphones or laptops to carry out virtual group practicum experiments are disturbed by the division of tasks. The solution is to take turns using smartphones with group members.

CONCLUSION AND SUGGESTION

Based on the results of the study it can be concluded that: (1) there is an effect of applying the guided inquiry learning model accompanied by a virtual laboratory on students' physics learning outcomes; (2) there is an effect of applying the guided inquiry learning model accompanied by a virtual laboratory on students' motivation to learn physics. The average post-test results for the experimental class were higher than the control class. The post-test results for the experimental class obtained an average of 67.34 and that of the control class was 55.13. While the average percentage of student's motivation to learn physics in the control class was 61.23% and in the experimental class was 69.86%.

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