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Physics Learning Using Guided Inquiry Models Based on Virtual Laboratories and Real Laboratories to Improve Learning

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ABSTRAK

Minimnya kreativitas guru dalam menguji berbagai model dan metode pembelajaran memberikan kontribusi yang signifikan terhadap stigma kebosanan dan kebosanan dalam belajar fisika. Model pembelajaran yang tepat sangat diperlukan sehingga dapat membantu siswa meningkatkan hasil belajar khususnya pembelajaran fisika. Tujuan penelitian ini adalah untuk menganalisis pengaruh metode eksperimen yang dipadukan dengan model pembelajaran inkuiri terbimbing berbasis eksperimen virtual dan nyata terhadap hasil belajar fisika. Sampel penelitian adalah kelas XI IPA 1 (32 orang) untuk kelompok eksperimen dan kelas XI IPA 2 (32 orang) untuk kelompok kontrol. Dalam penelitian ini teknik cluster sampling yang digunakan adalah random sampling. Teknik pengumpulan data dalam penelitian berupa instrumen tes hasil belajar di awal (pretest) dan di akhir pembelajaran (posttest). Teknik analisis data yang digunakan adalah uji normalitas dan independent sample t-test. Untuk menguji hipotesis penelitian digunakan dua uji kesamaan rata-rata dengan menggunakan uji t yaitu independent sample t-test atau one way analysis of variance (ANOVA) dengan menggunakan program SPSS versi 21. Hasil penelitian menunjukkan bahwa model pembelajaran inkuiri terbimbing menggunakan laboratorium virtual dan laboratorium nyata berpengaruh terhadap hasil belajar siswa (0,000 < 0,05). Berdasarkan hasil penelitian dapat disimpulkan bahwa eksperimen virtual dan eksperimen nyata dapat meningkatkan hasil belajar fisika siswa yang dibuktikan dengan adanya perbedaan skor rata-rata hasil belajar siswa pada kelas eksperimen (87,47) dibandingkan dengan kelas kontrol (69.72).

ABSTRACT

The lack of teacher creativity in testing various learning models and methods makes a significant contribution to the stigma of boredom and boredom in studying physics. The right learning model is needed so that it can help students improve learning outcomes, especially learning physics. The purpose of this study was to analyze the influence the experimental method combined with the virtual and real experiment-based guided inquiry learning model had on the physics learning outcomes. The research samples were class XI IPA 1 (32 people) for the experimental group and class XI IPA 2 (32 people) for the control group. In this study, the cluster sampling technique used was random sampling. Data collection techniques in research are in the form of learning outcomes test instruments at the beginning (pretest) and at the end of learning (posttest). The data analysis technique used is the normality test and the independent sample t-test. To test the research hypothesis, two similarity tests were used on average using the t test, namely the independent sample t-test or one-way analysis of variance (ANOVA) using the SPSS version 21 program. The result show that the guided inquiry learning model uses virtual laboratories and real laboratories to influence student learning outcomes (0.000 < 0.05). Based on the research results, it can be concluded that virtual and real experiments can improve students' physics learning outcomes, as evidenced by the difference in the average score of students' learning outcomes in the experimental class (87.47) compared to the control class (69.72).

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1. INTRODUCTION

Science and technology have an inseparable relationship. Science is the basis for seeking understanding and knowledge. While technology is application of science and it is developed to produce tools, techniques, machines and equipment. Technology is found when people find tools and process a job to be easier and better. There have been many efforts made by the community and government to improve the quality of physics learning in schools including; developing national and local curricula, increasing teacher competence through training, procuring books and tools, teaching, procuring and repairing educational facilities and infrastructure and improving the quality of school management (Maharani et al., 2019; Pamungkas, 2020; Rosmawarni., 2023). Education is the activity of educators in exploring the abilities that exist in students with the teaching and learning process. Education has a major role in the life of the nation and state because it plays a role as a determinant of the quality of national education (Afandi et al., 2019; Rohmantika & Pratiwi, 2022). Education is not something static but dynamic so that it requires students to make continuous efforts to improve learning. Students must also have the ability to do something using processes and scientific principles that have been mastered, and learning to know and learning to do must be achieved in teaching and learning activities (Nuayi, 2020; Violadini & Mustika, 2021). Education in principle is a process to assist humans in developing themselves so that they are able to face all the changes and problems of life with an open, creative and responsible attitude to achieve real success in life. 21st century learning requires students to master the 4C skills (Anindayati & Wahyudi, 2020; Zubaidah, 2018).

Physics is one of the fields of Natural Sciences (IPA) that studies events and symptoms that occur in the universe so that physics can be said to be a technological foundation that is reasonable enough to be given to students as a provision for facing life in the future. Physics also provides enormous input to the development of science and technology (Nailufar & S., 2022; Rosmawarni., 2023). In general, physics learning is often teacher-oriented, not student-oriented. The ability to work scientifically is important to develop so that it can develop and use high-order thinking patterns through alternative problem solving and develop critical thinking that is embedded in various processes of scientific performance (Simbolon & Sahyar, 2015; Susilo et al., 2018). As a physics teacher has the task of creating interesting, fun learning conditions, namely democratic learning conditions, can arouse students to dare to express opinions and be able to connect the subject matter with everyday life. The lack of teacher creativity in testing various learning models and methods makes a significant contribution to the stigma of boredom and boredom in studying physics. Teachers prefer status as learning centers rather than as learning facilitators who place students as objects not subjects in the learning process. As a result, students experience prolonged boredom and boredom in studying physics so that it has an impact on decreasing achievement and motivation to study physics.

The selection of innovative, contextual, and student-centered learning models when compiling tools must be adapted to the characteristics and needs of students who meet the 2013 curriculum guidelines in order to achieve learning objectives. Learning in the 2013 curriculum prioritizes a scientific approach. One learning model that applies a scientific approach is guided inquiry (Labouta et al., 2018; Listiani et al., 2022). The guided inquiry learning model (Guided Inquiry Approach) is a learning model in which the teacher provides broad guidance/instructions for students. The guided inquiry learning model is a teaching and learning model that makes students solve problems with certain procedures directed by the teacher so that it can lead to the growth and development of a number of skills in students so they can process information or new things that are useful in the form of facts, concepts, principles, laws, scientific theories as well as the development of attitudes and values. In guided inquiry learning, some of the planning is made by the teacher, students do not formulate problems. Teachers must provide guidance to students in carrying out activities so that students who have low intelligence are still able to participate in the activities that are being carried out (Rachman et al., 2022; Sulistyani et al., 2022). Several previous studies have shown that guided inquiry-based learning is able to facilitate students' active participation in exploring and finding solutions to problems in a systematic, critical, logical, and analytical manner (Puspitasari, 2019; Triyuni et al., 2019). Teachers are able to overcome the limitations of space and time, make it easier for students to learn independently according to their abilities, and allow students to measure and evaluate the learning outcomes of their own products and processes.

In addition to the right learning model during the learning process, the selection of methods and media used must also be considered. One of the learning methods that is able to facilitate the achievement of students' mastery of concepts and activities as well as students' problem-solving abilities is the experimental method. The experimental method is a learning method that can provide direct experience to students to introduce, familiarize, and train students to carry out scientific steps and procedural knowledge (Hanik et al., 2018; Simbolon & Sahyar, 2015). One of the learning media that supports student activity in class is computer-based learning media. Computer-based media will be more effective in learning physics than using conventional methods (Huertas-Abril, 2021; Rezaei & Katz, 2022). One of them is interactive learning media, namely PhET (Physics Education Technology) simulation. PhET is a service provided by the University of Colorado for learning. Based on the official PhET creating this interactive simulation software is to help students visually comprehend concepts, ensure educational effectiveness and usability.

Even though PhET services were available several years before the pandemic, teachers preferred practicums in physics laboratories over computers. This software contains abstract physics simulations that cannot be seen even by the eye. For quantitative exploration, this software has measuring instruments in the form of a ruler, stopwatch and voltmeter. PhET is a site that provides free-to-use physics learning simulations that can be used individually or in class (Abdjul & E, 2019; Zaki, 2021). In PhET there are theoretical and experimental simulations that actively involve users. Users can manipulate activities related to experiments. So that besides being able to build concepts, PhET can also be used to bring up science process skills. In previous research, it was stated that the discovery learning model and PhET simulation had an effect on student learning outcomes (Adlina et al., 2019). In addition, learning using PhET simulations can significantly improve student physics learning outcomes in learning that applies guided inquiry models based on real experiments with virtual laboratories compared to direct learning (Ekawati et al., 2015; Simbolon & Sahyar, 2015). The results of the study showed an increase in students' physics learning outcomes by learning using PhET simulations (Ekawati et al., 2015). In research previous research obtained a significant increase in physics learning outcomes in guided inquiry learning based on real experiments with virtual laboratories compared to direct learning (Simbolon & Sahyar, 2015).

Based on this explanation, the Guided Inquiry learning model is used, because besides this model it is suitable to be combined with practicum or experimental media, this model is also suitable for students, so that it can improve their physics learning outcomes. The aims of this study is to analyze the influence the experimental method combined with the virtual and real experiment-based guided inquiry learning model had on the physics learning outcomes.

2. METHOD

This research is a Quasi-Experimental study using a simple factorial design, namely 2 x 2 in order to determine the effect caused by the 2 independent variables on the dependent variable. The populations in this study were all students of class XI SMAS Methodist 1 Medan. The sample of this research was class XI IPA 1 (32 people) for the experimental group and class XI IPA 2 (32 people) for the control group. In this study, the cluster sampling technique used was random sampling. The research design is show in Table 1.

Table 1. Research Design

Group	Pre test	Treatment	Posttest
Experimental Class	X_1	P_1	X_2
Control Class	Y_1	P_2	Y_2

Data collection techniques in this research are in the form of learning achievement test instruments at the beginning (pretest) and at the end of learning (post-test). The data analysis technique used is the normality test and the independent sample t-test. The normality test was applied to find out whether the data obtained was normally distributed or not. The t-test was used to test the effect of the guided inquiry learning model with virtual laboratories and real laboratories on students' physics learning outcomes.

3. RESULTS AND DISCUSSION

Results

Data who described in this study include data on physics learning outcomes of class XI IPA SMA Methodist-1 Medan. Student physics learning outcomes are the value of student learning outcomes taught using guided inquiry learning models based on real experiments and virtual laboratories and student groups taught using direct instruction using real experiments. The research data obtained in the form of pretest scores on student physics learning outcomes for the experimental class and control class are presented in Table 2.

Table 2. Pretest Score of Experimental Class and Control Class

Pretest Experimental Class			Pretest Control Class		
Score	Frequency	Average	Score	Frequency	Average
23.00	2	35.38	23.00	1	38.25
24.00	1		25.00	1	
26.00	1		28.00	2	
28.00	2		30.00	1	
30.00	3		32.00	2	
31.00	4		34.00	2	
32.00	2		35.00	3	
34.00	3		36.00	3	
35.00	1		37.00	2	
36.00	3		38.00	2	
38.00	1		40.00	2	
39.00	1		42.00	2	
42.00	2		44.00	2	
44.00	1		45.00	1	
46.00	1		47.00	1	
48.00	1		48.00	2	
50.00	1		50.00	2	
53.00	1		55.00	1	
55.00	1				

Table 2 shows the average pretest result for the experimental class was 35.38 and that for the control class was 38.25. Then the post test score is show in Table 3.

Tabel 3. Posttest Score of Experimental Class and Control Class

Posttest Experimental Class			Posttest Control Class		
Score	Frequency	Average	Score	Frequency	Average
72.00	1	87.47	55.00	1	69.72
74.00	1		56.00	1	
76.00	1		60.00	3	
78.00	2		62.00	4	
81.00	4		64.00	2	
83.00	3		66.00	5	
85.00	3		68.00	2	
88.00	3		70.00	3	
91.00	4		73.00	2	
94.00	3		77.00	2	
95.00	1		80.00	3	
97.00	2		85.00	3	
98.00	2		93.00	1	
99.00	2				

Table 3 shows the average posttest result for the experimental class was 87.47 and that for the control class was 69.72. In summary, the average value of student physics learning outcomes is presented in Table 4 and Figure 1.

Table 4. The Average Value of Physics Learning Outcomes for Experiment Class and Control Class Students

Group	Pretest	Posttest
Experimental Class	35.38	87.47
Control Class	38.25	69.72

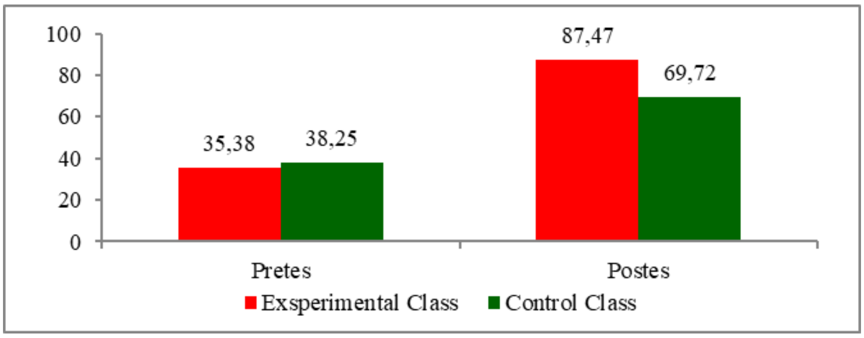

Figure 1. Graph of the Average Score of Student Physics Learning Outcomes

Based on Table 4 and Figure 1, it can be concluded that the average pretest score of students' physics learning outcomes was higher in the control class (38.35) compared to the experimental control class (35.38). However, the average post-test scores for physics learning outcomes in the experimental class were higher (87.47) compared to the control class (69.72). The calculation of the normality test is show in Table 5.

Table 5. Normality of Physics Learning Outcomes Data for Experiment Class and Control Class Students

Model	Group	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Exsp. Class	Pretest	0.158	32	0.041	0.937	32	0.063
Cont. Class		0.153	32	0.054	0.942	32	0.085
Exsp. Class	Posttest	0.112	32	0.200*	0.955	32	0.196
Cont. Class		0.107	32	0.200*	0.983	32	0.888

From the results of the calculation of the normality test in Table 5, it can be concluded that the data on student physics learning outcomes are normally distributed (Sig. α > 0.05). This is evidenced by the significance value of the test results using the SPSS version 21 program using the Kolmogorov-Smirnov test with Lilliefors Significance Correctional at a significance level of α = 0.05. The result of homogeneity test is show in Table 6.

Table 6. Homogeneity of Student Physics Learning Outcomes in Experiment Class and Control Class

Group	Levene Statistic	df1	df2	Sig.
Pretest	0.147	1	62	0.703
Post test	0.714	1	62	0.401

Based on Table 6, pre-test and post-test data on physics learning outcomes using the Lavene test at a significance level of α = 0.05. It can also be concluded that the group of students comes from a homogeneous population (Sig. α > 0.05). Hypothesis test of student physics learning outcomes is show in Table 7.

Table 7. Hypothesis Test of Student Physics Learning Outcomes

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5041.000	1	5041.000	67.410	0.000
Within Groups	4636.438	62	74.781		
Total	**9677.438**	**63**			

Hypothesis testing in this study used a two-way similarity test using the t-test, namely the independent sample t-test or one-way analysis of variance (ANOVA) using the SPSS version 21 program at a significance level of α = 0.05. Based on the results of the t-test and ANOVA analysis, a Sig (2-tailed) value of 0.000 is obtained, which means it is smaller than the significant level value of 0.05. It can be concluded that the guided inquiry learning model uses virtual laboratories and real laboratories to influence student physics learning outcomes (0.000 < 0.05). Graph of Differences in the Learning Outcomes is show in Figure 2.

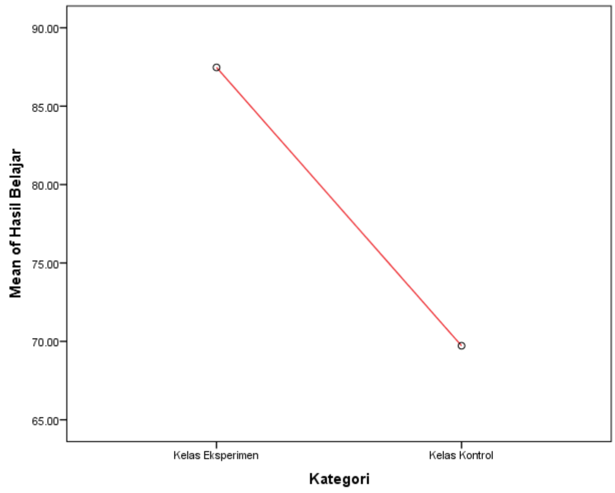

Figure 2. Graph of Differences in the Learning Outcomes of the Experimental Class and the Control Class

Discussion

This study discusses the use of the Guided Inquiry (GI) learning model based on Virtual Laboratories and Real Laboratories in improving student physics learning outcomes. In this study, researchers made a comparison between the physics learning outcomes of students using the GI model based on the Virtual Laboratory and the Real Laboratory. The results showed that the two learning models were effective in improving students' physics learning outcomes. However, the learning outcomes of students using the Real Laboratory-based GI model were higher compared to the Virtual Laboratory-based GI model.

Virtual laboratory-assisted inquiry learning has an effect on students' mastery of physics concepts so that it can be used as a teacher as an alternative learning that can be applied when teaching physics. Besides that, through practicum activities it can be more effective in helping students construct knowledge, develop logical abilities and the ability to solve problems and collaborate well (Ristina & W., 2020; Rusliati & R., 2019; Tyas, 2018). The influence of the guided inquiry learning model based on virtual and real experiments is in line with the research that found that the inquiry learning model can make it easier for students to discover science concepts independently because when learning students are positioned as thinkers (Maryam et al., 2020). Scientists and problem servers who are active in carrying out scientific processes so that they support in helping children's cognitive development (Karuru, et al. 2023). In addition, through the application of the guided inquiry learning model, it requires students to be directly involved in the learning process (active students) because learning is student-centered while the teacher only acts as a motivator and facilitator (Amijaya et al., 2018; Karlina et al., 2019; Nurmayani et al., 2018). Therefore, it can be said that the application of guided inquiry learning models based on virtual and real experiments can improve students' physics learning outcomes.

The implication of this study is that the use of GI models based on Virtual Laboratories and Real Laboratories can improve students' physics learning outcomes. Virtual Laboratory based GI models can be used as an alternative when Real Laboratories are unavailable or limited. However, the use of the Real Laboratory is still recommended because it can provide a more realistic and interactive learning experience for students. The limitation of this research is that this research was only conducted in one school and in one subject only. Therefore, the results of this study cannot be generalized to schools or other subjects. In addition, this study also did not consider other factors that could affect student learning outcomes such as motivational factors and students' initial abilities.

This study can also be used as a reference for further research by revealing aspects that have not been presented and develop. As a suggestion to other researchers, in teaching physics, teachers can present learning through experiments using the guided inquiry learning model. So to increase students' knowledge competence before conducting the lesson, the teacher or researcher must first analyze the learning device to suit its use, especially in terms of time allocation, supporting facilities and student characteristics.

4. CONCLUSION

Based on the research results, it can be concluded that learning physics using guided inquiry learning models based on virtual and real experiments using can improve student physics learning outcomes, as evidenced by the difference in the acquisition of the average value of student learning outcomes in higher experimental classes compared to the control class. The application of guided inquiry learning models based on virtual and real experiments can improve students' physics learning outcomes.

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