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Transformation of Trigonometry Learning: Optimizing Mathematical Reasoning through Geogebra-Assisted Discovery Learning

Jihan Zahra Permana[1] *, Arie Purwa Kusuma[2] , Rusdi Hamdany Nuary[3]
Mathematics Education Study Program, STKIP Kusuma Negara, Jakarta, Indonesia
*jihanzahra@stkipkusumanegara.ac.id

Abstract

In the context of mathematics learning, mathematical reasoning is an important skill that students must possess through appropriate learning models and media. The purpose of this study was to determine whether the Geogebra-assisted Discovery Learning model was effective in improving students' mathematical reasoning skills when compared to the conventional learning model, namely the lecture method. This study used a quantitative approach with a quasi-experimental research design. Students in grade XI at SMK Adi Luhur Jakarta were the population in this study. Grade XI TKJ 2 was the sample for the experimental class, and grade XI-TKJ 1 was the control class. In conducting the research, seven test questions were used to assess mathematical reasoning ability as a technique for collecting data. The data was then analyzed using Microsoft Excel to calculate normality tests, homogeneity tests, and difference tests (T-tests). The findings show that the Discovery Learning model assisted by Geogebra is more effective than the conventional learning model in teaching mathematics on trigonometric functions.

Keywords: Geogebra, Learning Model, Mathematical Reasoning Ability

1 INTRODUCTION

Education is a necessity and one of the most important things for a person. Basically, education is aimed at developing a person's personality and broadening their perspective. Broadly speaking, education can be defined as the learning, knowledge, and skills of a person that are passed on to others. One of the subjects that has a significant impact on education is mathematics because it teaches students how to solve everyday problems using logic, critical thinking, and systematic thinking (Kusumawati et al., 2024). Mathematics is one of the basic sciences that every human being must master, especially school students (Retno, A. D., Alghadari, F., & Nuary, R. H., 2024). Meanwhile, in learning mathematics, there are several skills that students need to understand, including communication, reasoning, conceptual understanding, problem solving, and mathematical literacy (Kusumawati, et al., 2024). Among these skills, one of the most essential is reasoning. The reasoning skills used in the mathematics learning process are called mathematical reasoning skills. Mathematical reasoning skills play an important role in mathematics learning. After studying mathematics, students are expected to not only be proficient in arithmetic but also able to think rationally, creatively, analytically, and systematically in solving problems to achieve the objectives of mathematics learning (Faradila, Z. P., 2024). Another opinion , states that mathematical reasoning skills are needed to understand and master mathematical material and concepts, so mathematical reasoning skills are used as one of the goals in mathematics learning (Suryani, S., Kusuma, A. P., & Arihati, D. B., 2022). However, the reality in the field shows that students' mathematical reasoning skills are still relatively low.

The lack of diversity in mathematics learning models and media is one of the reasons why students have low reasoning skills (Haryanti, 2023). The use of innovative learning models such as project-based learning or problem solving and interactive learning materials can increase students' motivation and interest in mathematics. The Discovery Learning model is one paradigm that can support student reasoning by encouraging them to reason rationally and think critically and systematically with the ultimate goal of finding answers (Hidayah et al., 2024). In addition to learning models, the use of media is also necessary to facilitate learning activities, especially in mathematics lessons. Therefore, methods or innovations in mathematics learning are needed to help students understand concepts better. One way to improve the effectiveness of student learning in mathematics is to use learning media that can be utilized, namely computers as media based on information and communication technology. Computers can be used as tools in preparing teaching materials and in the learning process to make it more effective and efficient (Kusuma, A. P., Rahmawati, N. K., & Ayuningrum, L., 2022). One example is the *Geogebra* application.

Geogebra was created by Markus Hohenwarter and offers teachers an effective opportunity to create an interactive online learning environment that encourages students to discover and experiment in class (Pamungkas, D., & Sudihartinih, E., 2021). Geogebra can be used both to solve mathematical problems and to create virtual learning media or draw geometric shapes and function graphs (Huda et al., 2023). One example is trigonometric function material involving graphs. Trigonometry is a subject in mathematics that has many formulas, which must be memorized and requires a high level of understanding in its application (Ariati, C., & Juandi, D., 2022). Therefore, it is important to explore how the Discovery Learning model supported by the Geogebra application can help students develop their mathematical reasoning and overcome problems in learning trigonometric functions. This is also expected to support active learning so that students can more easily understand mathematical concepts and apply them to real-world situations.

Based on the background described above, the author designed a study to determine the differences between learning models and the use of Geogebra on students' mathematical reasoning abilities. Therefore, the author conducted a study entitled "Transformation of Trigonometry Learning: Optimizing Mathematical Reasoning through Geogebra-Assisted Discovery Learning."

2 RESEARCH METHODS

The design of this study is a quantitative method, namely quasi-experimental research. The quantitative approach also uses traditional, positive, and experimental or empirical paradigms (Paramita, R. W. D., 2021). Quasi-experimental designs differ from true experimental designs. Quasi means pseudo. Thus, sampling is based on existing class groups rather than individuals. In this study, the object targeted for generalization of the research results is the population. The population is the entire object of the study (Sutiyono, S., et al., 2020). The population targeted in this study is all 11th grade students. To determine one experimental class and one control class, the researcher simply took two classes from the four classes at random. For example, class XI-1 was selected as the experimental class using the Discovery Learning model and the Geogebra application as support, and class XI-2 was selected as the control class using the conventional model (lecture). In detail, the flow of this research can be seen in Table 1, which presents the experimental research design used. The following is Table 1 of the experimental research design.

Table 1. Experimental Research Design

Group	**Treatment**	***Post-test***
Experimental Class	X	P
Control Class	-	P

Where X is the Discovery Learning model treatment assisted by Geogebra and P is the *post-test* given to the experimental class and control class. The learning will be given to the experimental class and control class using *cluster random* sampling. *Cluster random sampling* is a sampling technique in which the population is divided into several groups or *clusters* (Prihastuty, D. R., 2023). Sampling is done randomly without regard to population levels or groups. This method will be used if the population is homogeneous or relatively homogeneous.

The data analysis techniques used in this study are normality tests, homogeneity tests as prerequisite tests, and hypothesis tests (T-tests). Normality tests are the first step in data analysis to determine whether the data is normally distributed or not (Nurhaswind et al., 2025). The next step after the normality test, if the data is normally distributed, is to conduct a homogeneity test to determine whether the samples taken from the population are homogeneous or not. The sample homogeneity test uses the F-test (*Fisher)*. Finally, the hypothesis test (T-test) is used to determine the significance of variable X on Y and to accept or reject the proposed hypothesis. This is to ensure and assess the effectiveness of learning that applies the Discovery Learning model assisted by Geogebra simultaneously on students' mathematical reasoning abilities.

3 RESULTS AND DISCUSSION

3.1 Sub-results

The post-test was administered after the treatment was carried out in both classes (experimental class and control class). The results showed that the post-test scores in the experimental class ranged from a high of 81 to a low of 57, with a mean of 70, a median of 69, and a standard deviation of 6. Meanwhile, the post-test results in the control class showed the highest score of 52, the lowest score of 35, an average of 46, a median of 45, and a standard deviation of 3. The following table shows the frequency distribution and histogram graph for the control class. The following table shows the frequency distribution and histogram graph for the experimental class and the control class.

Table 2. Frequency Distribution

No.	Interval Class	f_i	f_k	x_i	Interval Limit
Experimental Class					
1	57 - 61	1	1	59	56.5 - 61.5
2	62 - 66	4	5	64	61.5 - 66.5
3	67 - 71	9	14	69	66.5 - 71.5
4	72 - 76	4	18	74	71.5 - 76.5
5	77 - 81	2	20	79	76.5 - 81.5
	total	20		345	
Control Class					
1	35 - 38	2	2	46.5	34.5 - 38.5
2	39 - 42	2	4	40.5	38.5 - 42.5
3	43 - 46	8	12	44.5	42.5 - 46.5
4	47 - 50	7	19	48.5	46.5 - 50.5
5	51 - 54	1	20	52.5	50.5 - 54.5

total	20	232.5

The following are histogram and polygon graphs for the experimental class and control class.

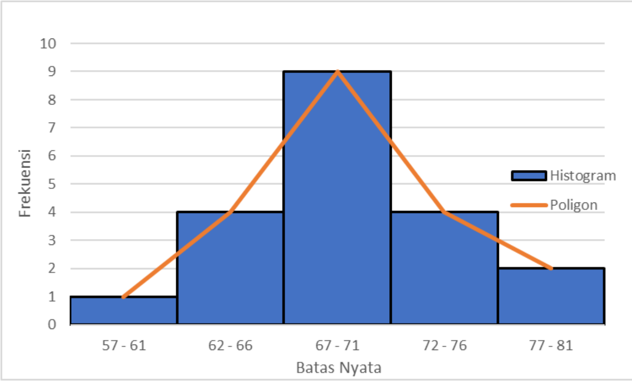

Figure 1. Histogram and Polygon Graphs for the Experimental Class

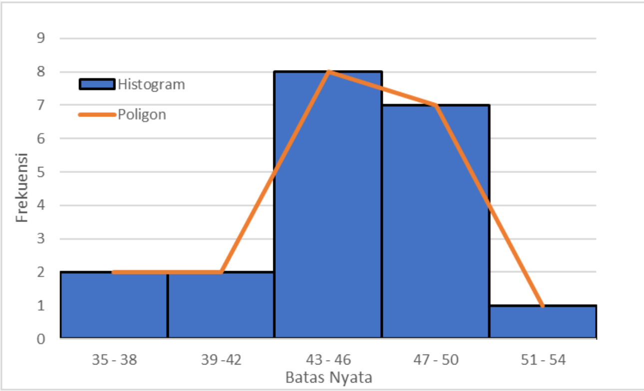

Figure 2. Histogram and Polygon Graphs for the Control Class

3.1.1 *Normality and Homogeneity Tests*

A normality test was conducted to determine whether the *post-test* data for the experimental and control classes were normally distributed. The normality test used the *Liliefors* method for the mathematical reasoning test. Thus, the normality test was a crucial first step to ensure the quality and accuracy of data analysis in the study. The results of the normality test are shown in Table 3 below:

Table 3. Normality Test

No.	Value	N	Test Statistics			Distributed
			α	L_{hitung}	L_{tabel}	
1.	Experimental Class	20	0.05	0.145	0.190	Normal
2.	Control Class	20	0.05	0.183	0.190	Normal

Based on the normality test table, it can be seen that the post-test scores for mathematical reasoning ability of students in the experimental class and control class come from a population that is normally distributed. The experimental class has$L_{hitung} = 0{,}145$ and$L_{tabel} = 0{,}190$ while the control class has $L_{hitung} = 0{,}183$ and $L_{tabel} = 0{,}190$. Because the value of$L_{hitung} < L_{tabel}$ thenH_0 is accepted. Next, a homogeneity test (*Fisher's test*) will be conducted to determine whether the population has a homogeneous variance. The results *of the Fisher's test* are presented in Table 4.

Table 4. Homogeneity Test (*Fisher's Test*)

No.	Class	N	df	Test Statistics		F_{hitung}	F_{tabel}	Conclusion
				α	Variance			
1.	Experiment	20	19	0.05	45.00	2.198	4.10	Homogeneous
2	Control	20	19	0.05	20.47			Homogeneous

Table 4 shows that the value of $F_{hitung} < F_{tabel}$, so H_0 is accepted. With the variance of the experimental class at 45.00 and the variance of the control class at 20.47, the result is $F_{hitung} = 2{,}198$, which is smaller than $F_{tabel} = 4{,}10$. It can be concluded that the *post-test* data results for students' mathematical reasoning abilities in the experimental and control classes have homogeneous variance. Next, a T-test will be conducted to determine the significance of the effectiveness of the Geogebra-assisted Discovery Learning model on mathematical reasoning skills in trigonometric functions, as presented in Table 5.

Table 5. T-test Results

Class	Mean	N	Variance	t_{hitung}	t_{tabel}	Conclusion
Experiment	69.5	20	45.00	14.1	2.02	Significant effect
Control	43.95	20	20.47			

The results of data calculation using the T-test yielded values of $t_{hitung} = 14{,}1$ and $t_{tabel} = 2{,}02$ at a significance level of $\alpha = 5\%$ and$dk = (20 + 20) - 2 = 38$, resulting in a value of $t_{tabel} = 2{,}02$. The results of $t_{hitung} = 14{,}12$ and $t_{tabel} = 2{,}02$ show that $t_{hitung} > t_{tabel}$, so that H_0 is rejected and H_1 is accepted. Based on the T-test results, it can be concluded that mathematical reasoning ability using the Discovery Learning model assisted by the Geogebra application is more effective than the conventional learning model.

3.2 Sub-Discussion

The research conducted by the researcher was an experimental study with two research groups, namely the experimental group of class XI-TKJ 2 and the control group of class XI-TKJ 1. The purpose of the study was to determine the effectiveness of the Discovery Learning model assisted by the Geogebra application on the mathematical reasoning abilities of students in class XI at SMK Adi Luhur Jakarta on the subject of trigonometric functions.

In this study, the researcher first created a test instrument in the form of 10 essay questions. These questions were then tested to meet the requirements of a good test and were subsequently used as research questions. The requirements for a good test question pass several stages, namely validity, reliability, difficulty level, and discrimination. After conducting the test questions to determine which questions were sufficient, the results of the four tests showed that there were seven questions that could be used as questions for collecting research data. From the results of the instrument analysis, 7 questions were found to be valid and 3 questions were invalid. Therefore, the researcher used 7 valid questions for the research after the treatment was given. After the treatment in the control and experimental classes was completed, both classes were given a post-test consisting of seven questions that had been validated. The results of this post-test were then analyzed, including normality tests, homogeneity tests, and T-tests of mathematical reasoning ability.

The normality test of the *post-test* scores in the experimental class yielded $L_{hitung} = 0{,}145$, and $L_{tabel} = 0{,}19$, with a significance level of $\alpha = 5\%$, indicating that $L_{hitung} < L_{tabel}$, thus the data in the experimental class is normally distributed. Meanwhile, the scores in the control class yielded $L_{hitung} = 0{,}183$, and $L_{tabel} = 0{,}19$, with a significance level of $\alpha = 5\%$, indicating that $L_{hitung} < L_{tabel}$, thus it can be concluded that the data in the control class is also normally distributed. Next, a homogeneity test was conducted using the F-test (*Fisher)* to determine whether the data from the experimental class and the control class were homogeneous or not. The results of the homogeneity test calculation were obtained as follows $F_{hitung} = 2{,}19$, with a significance level of $\alpha = 5\%$, and dk numerator = 20-1=19 and dk denominator = 20-1=19, resulting in $F_{tabel} = 4{,}1$, which indicates that $F_{hitung} < F_{tabel}$. Thus, the data from both classes were homogeneous.

The next step is a T-test to determine whether the *post-test* scores between the experimental and control classes have similar or different average values. The results of data calculation using the T-test obtained a value of $t_{hitung} = 14{,}12$, and at a significance level of $\alpha = 5\%$, and dk = 20 + 20 – 2 = 38, obtained $t_{tabel} = 2{,}02$. The results obtained based on $t_{hitung} = 14{,}12$ and $t_{tabel} = 2{,}02$ show that $t_{hitung} > t_{tabel}$, so H_0 is rejected and H_1 is accepted. This means that the conclusion from the T-test results is that the Discovery Learning model assisted by Geogebra is effective for mathematical reasoning skills in trigonometric function material. This finding is in line with previous research conducted by Manah, N.K., et al (2020), which concluded that Discovery Learning assisted by flashcards is also effective in improving students' trigonometric reasoning. The similarity of these results strengthens the argument that the Discovery Learning model has great potential to improve students' mathematical reasoning skills regardless of the media used (Geogebra application or flashcards).

4 CONCLUSION

Based on the results of this study, it can be concluded that mathematical reasoning skills are more effectively developed using the Discovery Learning model assisted by Geogebra than using conventional learning models in mathematics education.

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