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The Influence of Geogebra Media on the Ability to Understand Class XI Concepts in Three-Dimensional Materials

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Abstract

This study examines the effect of GeoGebra learning media on 11th-grade students' understanding of three-dimensional mathematical concepts, specifically cubes. A Pre-Experimental One-Group Pretest-Posttest design was conducted at SMA Negeri 2 Medan. Data collected through pretest and posttest were analyzed using the Wilcoxon Signed Rank Test. The results showed a significant improvement in students' average scores (from 44.38 to 84.10, $p < 0.001$). Therefore, it can be concluded that GeoGebra's visual and interactive features significantly enhance students' understanding of abstract geometric concepts.

Keywords: GeoGebra, Concept Understanding, Three Dimensions, Learning Media.

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INTRODUCTION

Mathematics is one of the fields of science that plays an important role in the development of science and technology. In daily life, mathematics is used to solve various problems, both simple and complex. According to Saputra (2022), mathematics plays a crucial role in efforts to master science and technology, both in its application and in its understanding. In addition, mathematics is also a means to develop skills in solving practical problems through a combination of intuition, logic, construction, and analysis (Simanjuntak et al. in Alfianiawati, Desyandri, & Nasrul, 2019). Therefore, mathematics learning does not only focus on mastering the material, but also aims to cultivate high-level thinking skills that are indispensable in daily life. One of these thinking abilities is the understanding of mathematical concepts which is the basis for learning the next material.

Understanding mathematical concepts is an important aspect in mathematics learning. Fajar et al. (2019) stated that understanding of mathematical concepts is an essential aspect during the mathematics learning process. This is also strengthened by the national education policy contained in the Regulation of the Minister of Education and Culture Number 34 of 2018, which states that one of the competencies of graduates is to have mathematical thinking skills and to be able to use factual, conceptual, and procedural knowledge of mathematics in solving problems. Thus, understanding concepts not only helps students understand the material studied, but also supports their ability to solve problems logically and systematically.

However, the reality on the ground shows that the ability to understand mathematical concepts of students in Indonesia is still relatively low. This is evidenced by the results of the 2023 Trends in International Mathematics and Science Study (TIMSS), which places Indonesia at 67th out of 203 countries (IEA, 2023). In addition, the results of the Programme for International Student Assessment (PISA) in 2022 show that the mathematics scores of Indonesian students only reach 366, which is still far below the international average of 489 (Nasution, 2021). This low score indicates that students still have difficulty solving problems that require understanding of concepts and reasoning skills. This finding is in line with the research of Yulaistin and Roesdiana (in Panuntun, 2020) which states that the understanding of mathematical concepts of Indonesian students is still relatively low.

Students' low understanding of mathematical concepts is also caused by misconceptions in mathematics learning. Misconception is a misunderstanding of a concept that should be understood correctly. Novak and Gowin (in Johar et al., 2017) state that misconception is an interpretation of concepts in a statement that is unacceptable. This often happens because mathematics learning tends to be directed at the use and memorization of formulas without providing a deep understanding of the underlying concept. As a result, students have difficulty understanding the relationship between concepts and applying them in different situations.

One of the branches of mathematics that requires a good understanding of concepts is geometry, especially in the material of building a cube space. According to Purba (in Fajar, 2019), geometry is a field of mathematics that focuses on measurement, shape, relative position, and building space. Building space is a three-dimensional object that has volume and height, so it requires good spatial visualization skills in understanding it. At the high school level, especially in grade XI, three-dimensional materials such as cubes require students to understand the relationship between the elements of building space conceptually. Therefore, understanding mathematical concepts is a basic skill that students must have in learning the material (Nurdiana, 2021).

In the learning process, indicators of understanding mathematical concepts include the ability to restate concepts that have been learned, classify objects based on their properties, understand the operating characteristics of a concept, and present concepts in various forms of representation such as tables, graphs, sketches, and diagrams (Permendikbud Number 58 of 2014). By understanding concepts in depth, students not only know the formula, but are also able to apply the concept in a variety of different situations (Rosnawati, 2018). Therefore, innovations are needed in learning that can help students understand concepts more concretely and visually.

One alternative that can be used to improve students' understanding of mathematical concepts is the use of technology-based learning media, such as the GeoGebra application. Nur (2017) stated that GeoGebra is an excellent tool for teachers in building a mathematics learning process. Through GeoGebra, students can visualize mathematical concepts dynamically so as to help them understand abstract concepts. In addition, the use of GeoGebra can also improve students' ability to understand mathematical concepts by reducing learning difficulties caused by abstraction of mathematical objects (Jamaluddin et al., 2020). With

interactive visualization, space-building materials such as cubes can be learned more easily and interestingly.

Based on this description, the researcher will examine more deeply the influence of the use of GeoGebra media on students' understanding of mathematical concepts in three-dimensional materials, especially cubes at the high school level in grade XI. This study aims to find out whether the use of the GeoGebra application can improve students' ability to understand mathematical concepts so that it is expected to be one of the solutions in improving the quality of mathematics learning in schools.

METHODS

This type of research is qualitative research using the Pre-Experimental approach, the research design used is One Group Pretest-Posttest Design. One Group Pretest-Posttest Design is a research method that does not have a control group or comparator, so it only has research that focuses on testing one group, namely the experimental group (Muhandis & Riyadi, 2023). Here is the description of the research design:

Pretest	Treatment	Posttest
X1	Y	X2

Description:

X1 = Pretest score before being given treatment

X2 = Posttest value after treatment

This research was conducted at SMA Negeri 2 Medan, the subjects in this study are high school XI grade students who were selected using purposive sampling techniques. Abubakar (2021) stated that the purposive sampling technique is a technique for determining samples from a number of populations based on certain characteristics or traits of the population, the determination of this sample is based on the purpose of the research. The research sample consists of one class, namely class XI-B which is used as an experimental class. Students in grades XI-B were chosen because at this level the mathematics material studied, such as geometry or three-dimensionality, strongly supports the use of interactive visual media such as GeoGebra in understanding concepts.

The data collection technique is carried out through the administration of tests. The test is carried out twice, namely a pretest to find out the student's initial ability and ended with a posttest to find out the student's final ability after being given treatment in the form of learning using GeoGebra media.

The data analysis technique is carried out using statistical analysis. Before hypothesis testing, a prerequisite test is carried out in the form of a normality test to find out whether the data is normally distributed. Furthermore, a homogeneity test is carried out to see whether the variance of the populations is the same or not. After conducting the prerequisite test, then hypothesis testing is carried out using the paired sample t-test to find out whether there is a significant difference between the results of the pretest and posttest. The hypotheses proposed in this study are:

1. H_0: There is no effect of the use of GeoGebra media on students' understanding of concepts.

2. H_1: There is an influence on the use of GeoGebra media on students' understanding of concepts.

The decision-making criterion is that if the significance (p-value) < 0.05, then H_0 is rejected and H_1 is accepted, which means that there is an influence on the use of GeoGebra media on students' conceptual understanding.

RESULTS & DISCUSSION

Results

Students	Pretest	Posttest	Difference	Classification
Abie D	50	100	50	Improved
Aisyah P	38	75	37	Improved
Alya	38	100	62	Improved
Annisa F	25	75	50	Improved
Annisa Sy	38	100	62	Improved
Azkia	63	63	0	Remained the same
Fakhirah A	38	63	25	Improved
Gemintang	63	100	37	Improved
Jilan	38	100	62	Improved
Josephine	50	50	0	Remained the same
Kalila	38	88	50	Improved
katherine	38	100	62	Improved
Marsya	38	100	62	Improved
Nabila	50	88	38	Improved
Nafisah	50	88	38	Improved
regina	38	50	12	Improved
Risa	38	100	62	Improved
Shafa	63	100	37	Improved
Shafiyya	50	63	13	Improved
Shaila	38	88	50	Improved
Syifa	50	75	25	Improved
Total	932	1766	834	Improved
Mean	44,38	84,10	39,71	Improved
Maximum value	63	100	62	Improved
Minimum value	25	50	0	Improved

Based on the results of data analysis using Microsoft Excel, it was found that there was an improvement in students' learning outcomes after being given treatment using the GeoGebra learning media. This can be seen from the comparison of pretest and posttest scores.

The average pretest score of the students was 44.38, while the average posttest score was 84.10. Thus, there was an average increase of 39.72, which indicates a positive change in students' conceptual understanding after the treatment was administered.

In addition, the highest score in the pretest was 63 and increased to 100 in the posttest. Meanwhile, the lowest score in the pretest of 25 increased to 50 in the posttest. This shows that the improvement occurred not only in students with high ability but also in those with low ability.

When viewed from individual improvement, most students experienced an increase in learning outcomes. A total of 19 students showed improvement, 2 students remained the same, and no students experienced a decrease in scores. This data reinforces that the treatment provided had a positive impact overall.

Furthermore, based on the results of hypothesis testing using the paired sample t-test calculated through Microsoft Excel, the significance value (p-value) obtained was less than 0.05. Therefore, H_0 was rejected and H_1 was accepted, which means that there is an effect of the use of GeoGebra learning media on students' conceptual understanding.

The results of this study indicate that the use of GeoGebra as a learning medium is able to help students understand concepts better. This is likely due to the interactive and visual nature of GeoGebra, which makes it easier for students to learn abstract concepts.

However, this study used a One Group Pretest-Posttest Design without a control group, so the improvement in learning outcomes cannot be entirely attributed solely to the treatment, as there may be other factors influencing the results outside the study.

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Nilai_pretest	21	100.0%	0	0.0%	21	100.0%
Nilai_posttest	21	100.0%	0	0.0%	21	100.0%

Descriptives

			Statistic	Std. Error
Nilai_pretest	Mean		44.38	2.211
	95% Confidence Interval for Mean	Lower Bound	39.77	
		Upper Bound	48.99	
	5% Trimmed Mean		44.39	
	Median		38.00	
	Variance		102.648	
	Std. Deviation		10.132	
	Minimum		25	
	Maximum		63	
	Range		38	
	Interquartile Range		12	
	Skewness		.547	.501
	Kurtosis		-.138	.972
Nilai_posttest	Mean		84.10	3.856
	95% Confidence Interval for Mean	Lower Bound	76.05	
		Upper Bound	92.14	
	5% Trimmed Mean		85.11	
	Median		88.00	
	Variance		312.290	
	Std. Deviation		17.672	
	Minimum		50	
	Maximum		100	
	Range		50	
	Interquartile Range		31	
	Skewness		-.733	.501
	Kurtosis		-.812	.972

Test of Normality

Tests of Normality

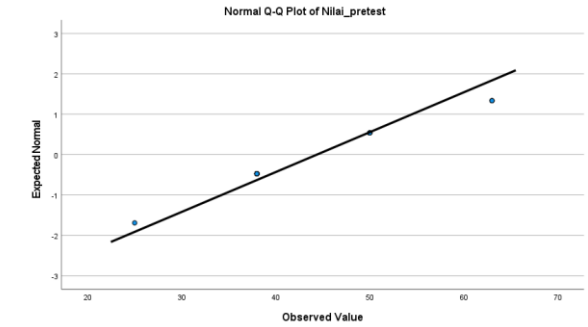
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Nilai_pretest	.307	21	<.001	.829	21	.002
Nilai_posttest	.245	21	.002	.824	21	.002

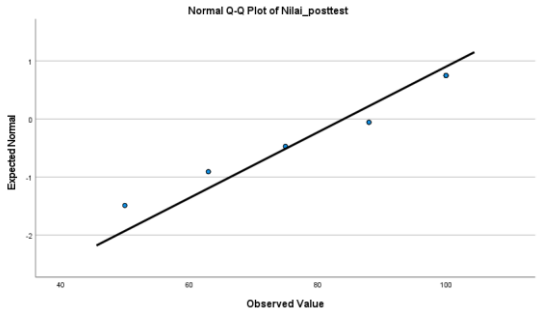
a. Lilliefors Significance Correction

Description:

If the significance value (Sig.) > 0.05, the data are normally distributed, whereas if the significance value (Sig.) < 0.05, the data are not normally distributed.

Based on the results of the normality test, the significance value obtained is 0.002 < 0.05, indicating that the data are not normally distributed. This result is also supported by the Q–Q Plot, as shown in the figure below.





Since the data are not normally distributed, the analysis was continued using a non-parametric approach, specifically the Wilcoxon Signed Rank Test, to examine the difference between pretest and posttest scores.

Ranks

		N	Mean Rank	Sum of Ranks
Nilai_posttest - Nilai_pretest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	19[b]	10.00	190.00
	Ties	2[c]		
	Total	21		

a. Nilai_posttest < Nilai_pretest

b. Nilai_posttest > Nilai_pretest

c. Nilai_posttest = Nilai_pretest

Test Statistics[a]

	Nilai_posttest - Nilai_pretest
Z	-3.843[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Description:

If the significance value (Sig.) < 0.05, there is a significant effect, whereas if the significance value (Sig.) > 0.05, there is no significant effect.

Based on the results of the Wilcoxon Signed Rank Test, the Asymp. Sig. (2-tailed) value is < 0.001, which is less than 0.05. This indicates that there is a significant difference between the pretest and posttest scores.

Thus, it can be concluded that the treatment given has a significant effect on students' learning outcomes.

In addition, the average score of students increased from the pretest to the posttest, indicating an improvement in students' understanding of mathematical concepts. This shows that the use of GeoGebra not only provides a significant statistical effect but also improves students' learning outcomes in a meaningful way.

Discussion

The Wilcoxon Signed Rank Test was employed in this study to conduct a rigorous comparison of the learning outcomes between the pre-test and post-test. This non-parametric test was selected as the prerequisite normality test yielded a significance value of 0.002 ($p < 0.05$), indicating that the data were not normally distributed. The statistical analysis revealed an *Asymp. Sig. (2-tailed)* value of < 0.001. Since the p-value is significantly lower than the 0.05 threshold, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. This empirically confirms a statistically significant difference between students' conceptual understanding before and after the intervention. Furthermore, the Z-value remained consistently negative, which serves as a statistical indicator of a clear upward trend in learning achievement, proving that the improvement observed was systematic rather than coincidental.

The descriptive statistics further illuminate the transformative impact of the treatment. The average student score underwent a substantial leap from 44.38 during the pre-test to 84.10 in the post-test, marking an average gain of 39.72 points. This improvement was inclusive, positively affecting students across the entire performance spectrum. For instance, the minimum score rose from 25 to 50, while the maximum score increased from 63 to a perfect 100. On an individual level, out of 21 subjects, 19 students demonstrated a significant increase in their scores, while 2 students remained stable, and notably, no students experienced a decline. This data suggests that the use of GeoGebra effectively bridges the gap for students who initially struggle with the material, allowing them to reach the same competency levels as their higher-achieving peers (Karo Sekali & Boentolo, 2025).

The effectiveness of this intervention is rooted in GeoGebra's capability to provide dynamic and interactive visualizations of 3D geometric objects. By utilizing these features, students are able to move beyond rote memorization of formulas and instead develop a relational understanding by observing how geometric components interact in a digital space (Sinaga et al., 2022). This pedagogical shift is supported by the Technological Pedagogical Content Knowledge (TPACK) framework, which posits that the strategic integration of technology can simplify complex and abstract concepts into concrete, manageable visual data (Yuliani et al., 2021). GeoGebra acts as a cognitive tool that reduces the

mental burden of spatial visualization, which is often a major hurdle in geometry (Karo Sekali & Boentolo, 2025).

Furthermore, the results indicate that the interactive nature of the software fosters higher student engagement and enthusiasm, which are critical precursors to successful knowledge internalization (Sinaga et al., 2022). Although the study demonstrates a clear positive impact, the findings suggest that the results could be even more robust if students were granted greater autonomy to operate the software individually or in small groups. Providing students with direct "hands-on" experience with GeoGebra allows them to construct their own logical frameworks and explore mathematical properties through trial and error, ultimately leading to a more profound mastery of the subject matter (Karo Sekali & Boentolo, 2025; Sinaga et al., 2022).

CONCLUSION

Based on the research findings and hypothesis testing presented above, it can be concluded that the use of the Geogebra learning tool has been proven to improve students' understanding of mathematical concepts in 3D geometry in 11th-grade high school. This is evident from the improvement in student learning outcomes between pretest and posttest scores, with an initial average score of 44.38 and a post-intervention score of 84.10. Statistical analysis using the Wilcoxon Signed-Rank Test also showed a significance level of <0.05, indicating a significant difference between learning outcomes before and after the intervention. Thus, the GeoGebra learning medium can be an effective alternative to support the mathematics learning process, particularly in improving students' understanding of mathematical concepts in three-dimensional topics.

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