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THE EFFECT OF GEOGEBRA LEARNING MEDIA ON SPATIAL CAPABILITY AND UNDERSTANDING OF STUDENTS' MATHEMATICS LEARNING CONCEPTS

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ABSTRACT

The purpose of this study was to see how geogebra learning media on flat-sided geometrical material affected the spatial abilities and understanding of learning ideas in Probolinggo Private MTs class 8 pupils. The experimental research approach was given to courses VIII. The control class is VIII-B with 30 students and the experimental class is VIII-C with 25 students. Quasi experiment design in this research are used. Pre and Post-tests were used to examine the influence of geogebra on students' knowledge of learning concepts, while surveys were used to determine the effect of geogebra on students' psychological capacities. The data was analyzed using the Anova test. The findings of the study reveal that: (1) Geogebra learning media on flat-sided geometric material influence students' spatial ability. (2) Students' knowledge of learning ideas is improved when Geogebra learning media are used in class functional content compared to students who do not use Geogebra.

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1. INTRODUCTION

Mathematics is structured knowledge, where properties and theories are created deductively based on defined or undefined elements and based on axioms, properties, or theories that have been proven to be true. Geometry is a crucial component of mathematics. The study of form and space is known as geometry. It helps humans make sense of the world by comparing shapes, objects, and their relationships. Geometry objects can be observed in everyday life. Children can learn geometry or acquire knowledge by observing the world as real things. The world of geometry can generally be represented by pictures, diagrams and charts. Representation is the process of conceptualizing geometric ideas. The use of geogebra is an aid for students in solving abstract problems because the use of visualization of the problems encountered provides a real picture to make it easier to understand the problem (P. C. Sari et al., 2019).

Geometry is a field in mathematics that studies points, lines, planes, and space as well as their properties, dimensions, and their relationship to one another (Nur'aini et al., 2017). Involving the process of visualization and cognitive reasoning is a way to understand the concept of geometry (geometric thinking). Visualization is a skill that helps students identify and create new shapes or objects and find relationships between them. Meanwhile, geometric thinking refers to the creation and use of formal conceptual systems to study shapes and space. Both of these cognitive processes can be enhanced with the help of learning methods. Understanding of mathematical ideas determines the quality of final learning outcomes, which affects overall student performance in mathematics (Fauziyah et al., 2023). To improve understanding of geometric concepts, learning is needed that can create an environment that adapts to students' thought processes. Improving the effectiveness of learning geometry, such as increasing student participation, providing learning conditions that stimulate cognitive activity, and encouraging students to discuss and share is one of the things that must be done. Geometry learning is aimed at developing attitudes or ways of visualizing the relationship between the elements and the properties of geometric objects. To achieve this, students must be given sufficient opportunities and a supportive learning environment to observe, explore, and discover geometric concepts. Concrete media and interactive media can accurately distinguish the relationship between elements of spatial objects. Learners who do not have tangible tools, relying only on their imaging abilities are prone to misunderstandings.

Some of the traditional geometric tools like lines, arcs, etc. have a part in the geometry search process. These deficits include failure to reflect epistemic behavior, individual learning, reduced efficiency, lack of visualization support to form flexible and functional thinking and lack of heuristic strategy development. From this, it can be concluded that the representation of geometric objects presented traditionally in textbooks or by teachers is a static representation. Therefore, the researcher stated that one of the most important needs in learning geometry is to add dynamics to the presentation of geometric concepts so that student's understanding of geometric concepts can be simplified and more comprehensive. One solution to overcome the above problems is to integrate technical media into learning in the form of computer software. The development of digital technology is so advanced that the positive benefits bring many conveniences for us today in solving problems that arise (Suhaifi et al., 2021). Furthermore, geometry may be utilized as a medium for learning mathematics in order to show or represent mathematical concepts as well as a tool for developing mathematical concepts. The employment of technology in the form of software programs in the learning process can assist in the sketching of abstract concepts and can engage students in an active role in the learning process (J. R. R. Sari & Faradiba, 2023). Geometry Sketchpad, Cabri, and other dynamic computer tools are necessary for displaying a variety of geometric objects and abstract notions (Akhirni & Mahmudi, n.d.).

A variety of effective learning mediums will boost accomplishment Study. The GeoGebra application is one option (Abidin et al., 2023). Researchers used GeoGebra as a visualization tool to teach mathematics to students in this study. GeoGebra is a computer program designed to teach geometry and algebra. GeoGebra provides services for the construction of points, lines, triangles, circles, and other geometries in planes and spaces, as well as complete geometry computations. Abstract geometric concepts can be illustrated with GeoGebra, making it easier to learn and analyze them. Furthermore, the software performs correct computations, making geometry analysis simple and time-saving.

When studying mathematics, the GeoGebra learning environment, can offer innovations that assist students in answering abstract issues by visualizing themes (Nurfadilah & Suhendar, 2018). It is intended to help students understand and solve problems by providing a representation of the real world that has been ordered systematically by the students themselves. Students who learn based on their experiences will get a greater awareness of maths. This is the reality of meaningful learning implementation (Faradiba et al., n.d.). Geogebra is a highly beneficial medium for learning mathematics with various activities such as demonstration and visualization, as a building aid, and as a tool for the discovery process (Putri et al., 2019). Teachers can use GeoGebra to help pupils and explain how to solve issues in the form of mathematical descriptions. If school facilities and infrastructure are not used consistently, they will not work optimally. ICT-based technology is highly helpful in the learning process of mathematics as a bridge to comprehending students' concepts. The Geogebra application can help pupils grasp ideas better (Nisa & Faradiba, 2023). GeoGebra, which serves as a learning environment, attempts to assist students in solving a particular problem. GeoGebra is utilized as a tool for pupils to discover a mathematical topic in this scenario.

Understanding the notion of each topic being taught is the most important aspect of studying mathematics (Nisrina et al., 2023). The GeoGebra program can also understand the concept of geometric shapes using geometric objects (Purwanti et al., 2016). This expertise can provide a thorough knowledge of a subject that would be impossible or ineffective if taught directly by the teacher. Geogebra should be able to describe and convey issues that are relevant to "real-world" learners as a result of this. GeoGebra's visualization is visually appealing and can be moved and enlarged, making it easier for pupils to explore and observe. Mathematical concepts can become dynamic with this software. Construction and study of geometric shapes and equation diagrams can be done dynamically. Mathematics learning becomes exploratory, with students seeing the link between analytical and visual representations of an idea, as well as the relationship between mathematical concepts, directly and quickly. In mathematics lessons, spatial awareness must be addressed in addition to proper learning methodologies and media. The capacity to see the spatial environment clearly and to create changes through sight or imagination is referred to as spatial ability.

Visual-spatial intelligence will show students' ability to understand spatial and dimensional perspectives (Achdiyat & Utomo, 2018). Spatial thought processes are required to solve geometric problems. Spatial thinking skills can be improved through a systematic thinking process. The importance of studying spatial reasoning about indicators of success rates in mathematics (Bintoro & Sumaji, 2021). Defining spatial ability as having three components: spatial visualization, spatial interactions, and spatial orientation (Wulandari, 2019). The capacity to mentally alter the movement of a spatial object is referred to as spatial visualization. The capacity to visualize a spatial item from a certain point of view is referred to as spatial orientation. While spatial relations refer to the ability to form connections between spatial items. Meanwhile, defining spatial ability as the capacity to preserve, retrieve, construct, and transform well-structured visual pictures according to Lohman (1993) in (Hibatullah et al., 2020). Students who possess spatial abilities can recognize, handle, and construct three-dimensional pictures, forms, and places. As a result, a high or low level of spatial awareness allows for the comprehension of various mathematical ideas, particularly spatial (geographical) content.

Given the importance of comprehending geometry when learning and mastering Mathematics, the researcher wishes to provide GeoGebra learning material via the lens of spatial imagination. As a result, the goal of this study was to discover: (1) Is the knowledge of mathematical ideas of students studying using GeoGebra media greater than that of traditional learning participants? (2) Is there a relationship between GeoGebra media learning and pupils' spatial ability to grasp geometric concepts?

2. METHOD

This study is quantitative. This is a quasi-experiment design (a quasi-experiment with a control class and experiment class) (Creswell, 2012). Spatial ability exams are administered before therapy to measure the students spatial abilities. Students in the experimental and control groups were divided into two groups based on their spatial abilities: high and low. GeoGebra media will be used to teach the experimental group, whereas explanatory learning will be used for the control group. This study used a factorial design with stratification. The factorial design increases the number of relationships studied in experimental research. This design is essentially a variant of the posttest-only control group design or the pretest-posttest control group design, with other independent variable studies taken into consideration (Fraenkel et al., 2012). This study's independent variables include GeoGebra-assisted learning and traditional learning (demonstrations).

Another benefit of the factorial design is that it allows the researcher to investigate the interaction of the independent variable with one or more additional factors, sometimes known as the moderating variable. Treatment factors and subject variables can both be moderating variables (Fraenkel et al., 2012). Researchers employed spatial abilities as a moderating variable in this investigation. Table 1 shows the factorial design employed in this investigation, which was a 2×2 factorial design.

Table 1. 2×2 Factorial Design

GeoGebra learning		Learning Strategy (A)	
		Experiment (A_1)	Conventional (A2)
Spatial Ability (B)	High (B_1)	A_1B_1	A_2B_1
	Low (B_2)	A_1B_2	A_2B_2

In this study, 55 students are 30 students of class VIII A for experiment and 25 students of class VIII B for control class. They were from MTs Darul Lughah Wal Karomah Kraksaan Probolinggo. Students in both the experimental and control groups were further separated into two groups depending on their spatial abilities. The data gathered in this study will be utilized to better comprehend the idea of geometry. Data was gathered through testing in the form of descriptions. Starting with the presupposition tests, especially the normality and homogeneity tests, the data were analyzed using a two-way ANOVA at a significance level of 5%. The data collection technique used was a questionnaire, then processed using tables at the data analysis stage using the ANOVA test (Creswell, 2012). First, the researcher prepared pre-posttest questions and a questionnaire for student responses to Geogebra learning media. The pretest is intended to determine the level of understanding of initial concepts related to cube material and the posttest is intended to determine whether there is an increase in the understanding of the concept of cube material after learning using GeoGebra media, while the student response questionnaire is used to determine the level of effectiveness of the GeoGebra media that has been used. Secondly, the data that has been obtained is processed and analyzed using the ANOVA test

3. RESULTS AND DISCUSSION

3.1 Result

The final information for understanding the idea of geometry is derived based on the results of the post-test done for the experimental and control groups, as shown in Table 2 below:

Table 2. Post Test Results for Understanding Geometry Concepts

Group	Spatial Ability	N	Mean	Stdr. Dev
Experiment	High	15	80.166	12.117
	Low	15	72.5	10.69
	Total	30	76.333	11.403
Control	High	13	70.5	13.469
	Low	12	52.333	7.988
	Total	25	61.416	10.728

Table 2 shows that the average student comprehension of geometric ideas using GeoGebra media-assisted learning is much higher than the average student understanding of geometric concepts through traditional techniques. In terms of spatial abilities, research shows that when taught with improved GeoGebra learning media versus standard ways, students with strong spatial abilities had a greater average knowledge of geometric ideas. Students with low spatial ability produce similar findings.

The normality and homogeneity tests are used to validate the analytical criteria. In this study, the Kolmogorov-Smirnov test was utilized to determine the normality of the data. The following hypothesis was evaluated in the normalcy test.

H0: the data is drawn from a regularly distributed population.

H1: the information does not come from a regularly dispersed population.

The findings of determining the data's normality are shown in Table 3 below.

Table 3. Normality Test Results

	Kolmogorov-Smirnov[a]		
	Statistic	**df**	**Sig.**
Exp	.136	30	.167
Control	.183	25	.112

a. Lilliefors Significance Correction

The significance value (Sig.) is bigger than the significance level utilized (=0.05), as shown in the table of normality test results using the Kolmogorov-Smirnov test above. In other words, the acquired statistical statistics are not significant, hence H0 is accepted. As a result, the data is normally distributed.

In this study, Levene's test is employed to assess data homogeneity. The results of determining the data's homogeneity are shown in Table 4 below.

Table 4. Levenes Test Results

Dependent Variable: conceptual understanding of geometry			
F	df1	df2	Sig.
2.012	3	55	.123

The results of the Levene test are shown in the table above, with a F value of 2.012 and a significance (Sig.) of 0.123. When the significance level is adjusted to =0.05, the sig. is significantly higher than This implies that the F value is not important and that the cell variety is homogenous.

Furthermore, hypothesis testing was performed using a two-way analysis of variance (Anava AB). SSPS 26.0 was used to analyze the data. Table 5 summarizes the findings of the data analysis.

Table 5. Results of Hypothesis Analysis

Dependent Variable: conceptual understanding of geometry					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
GeoGebra	3337.604	1	3337.604	26.365	.000
Spatial	2502.604	1	2502.604	19.769	.000
GeoGebra * spatial	413.438	1	413.438	3.266	.076
Error	7089.167	55	126.592		
Total	297968.750	60			

Based on the results of the two-sided ANOVA calculation above, the results of the hypothesis test can be formulated as follows:

1. Test the first hypothesis
   The coefficient between learning F is 26.365 with a significance value (Sig.) of 0.000. If the significance level is set to α=0.05, then sig. much smaller, so the F value is significant. Because (sig.) < α means that the understanding of geometric concepts taught through GeoGebra media-assisted learning outperforms students' understanding of mathematical concepts taught through traditional (pointing) learning.
2. Test another hypothesis
   The coefficient F between learning ability and spatial ability is 3.266, with a significance value (Sig.) of 0.076. If the significance threshold is set to 0.05, the sig. becomes greater and the F value becomes non-significant. Because the value (sig.) > α, This suggests that there is no effect of the GeoGebra learning medium or students' spatial skills on their geometric concept understanding.

3.2 Discussion

The findings of the first hypothesis, that students' understanding of geometric concepts taught using GeoGebra learning media is better than students' understanding of mathematical concepts taught through traditional learning (exploration), agree with the findings of (Widyaningrum & Murwanintyas, 2012), who discovered that students who use GeoGebra learning media in learning quadratic function graphs outperform students who do not use GeoGebra. The incorporation of GeoGebra media in learning has characteristics and benefits, including an emphasis on in-depth understanding of the material being taught, connection to the real world, and student participation in various experiments (this learning is carried out while considering constructivism principles). The use of GeoGebra media can optimize a quality learning environment (Sunismi et al., 2023). This is marked by the superiority of GeoGebra media which presents a more realistic learning environment. It also helps learners manage lessons better. The results of the researchers' observations showed that students were more attentive when studying. This is supported by the results (Irawan &

Suryo, 2017) that the use of computers, software, or other electronic resources in teaching mathematics aims to increase attention and determine whether students have learned.

Integrating GeoGebra media into learning is an innovative and creative learning process in the information age. This combination can meet the needs of students with different interests and abilities for lifelong learning, not just absorbing knowledge. GeoGebra media supported by advanced education creates independent and independent learning conditions. The subjects are simpler to comprehend the notion of constructing space with GeoGebra, since it utilizes the subject GeoGebra can view the building in 3D (Arsita et al., 2020). Therefore, GeoGebra media-based learning is much more effective than traditional learning.

According to the findings of the second hypothesis, there is no connection between the GeoGebra learning media and students' knowledge of the geometric idea of spatial abilities (Siregar et al., 2023). This suggests that students who use GeoGebra learning material in their classes have a better knowledge of mathematical ideas than students who study traditionally, as well as students with strong and poor spatial ability. This conclusion is consistent with the findings of Goleman, Daniel, Boyatzis, and Richard Mckee (2019) showing students who are taught using a problem-based learning model with visual aids outperform those who are taught using standard learning models. Using GeoGebra has been shown to provide an optimal learning environment for learners with good and poor spatial skills. This is because GeoGebra can be used to represent geometric objects dynamically and accurately, enabling all students to help construct geometric objects in their imagination. Students may use Geogebra learning media to rapidly, precisely, and effectively illustrate and depict three-dimensional material. The usage of this program also creates a new environment in mathematics learning, making it more dynamic and entertaining (Sari Faradiba et al., 2023). One of the weaknesses of traditional learning that has been frequently used so far is that it cannot be fair to students with low spatial awareness. The main indicator behind this claim is geometry learning, which is not able to dynamically and accurately display representations of geometric objects.

The advancement of science and technology has an impact on the creation of interactive learning media. Media interactive learning is anticipated to increase students' enthusiasm to study as well as their spatial ability (Raharjo et al., 2023). Spatial students are students who can form geometric representations in their minds, both two-dimensional and three-dimensional. Of course, traditional paper and pencil learning is only suitable for learners with a high level of spatial awareness. Summarizing the geometric representation of objects, both two-dimensional and one-dimensional, is not difficult, because it is supported by high visualization capabilities. As a result of technological advancements, there is a lack of creativity in learning material that is diverse and simple to use. Simple learning material is one-way, resulting in a lack of spatial ability in pupils (Buchori & Kusumaningsih, n.d.). The presence of GeoGebra in geometry learning is an option to optimize students' understanding of geometric concepts, both for students who have good and weak spatial abilities. Integrating GeoGebra media in learning is a very important requirement in learning geometry. During the learning process, researchers found that students with poor spatial abilities were no longer fluent in understanding various geometric representations, both two-dimensional and three-dimensional.

GeoGebra media's accuracy and dynamism can raise awareness and passion for learning mathematics. GeoGebra adds dynamic to the presentation of geometric ideas, allowing students' grasp of geometric concepts to be simplified and broadened. When you analyze the formula for the volume of a cube, for example, it is derived from the cube itself. Figure 1 depicts the GeoGebra screen on LKS.

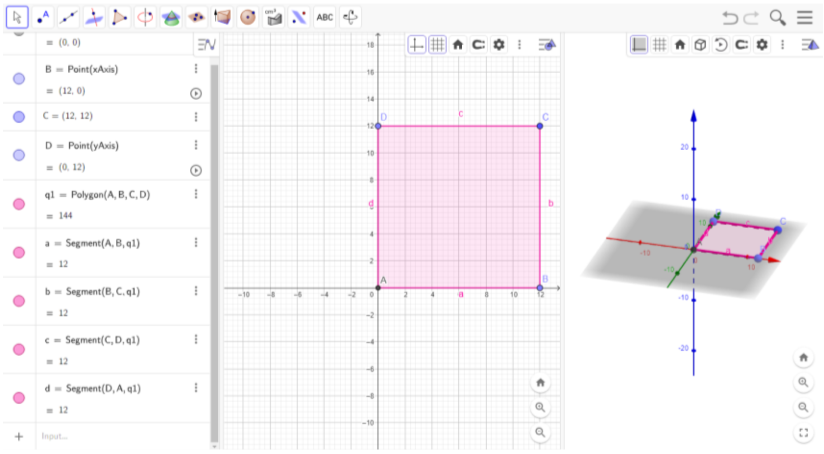

Figure 1. *GeoGebra screenshots*

Figure 1 above shows the process of making a cube starting from making a flat, square shape. Students are directed to read the instructions and then start working on it. When the cube is clicked, the volume of the cube will appear. Look at the following 2 pictures!

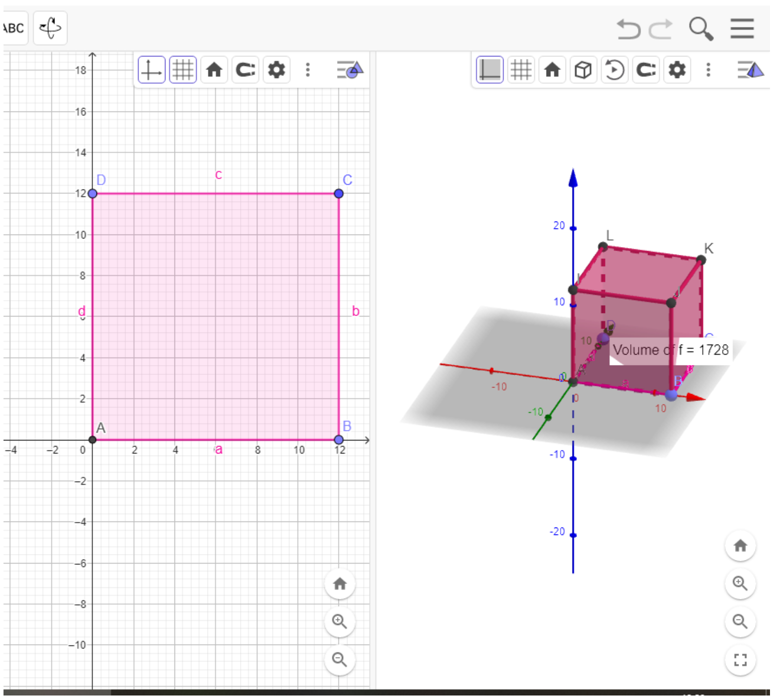

Figure 2. *GeoGebra screenshots*

In Figure 2, you can see a cube with a volume size. Students can see clearly the existence of the volume of the cube. Furthermore, the students were directed to look for the relationship between the volume of the cube and the volume of the block. In the case above, the researcher sees that the dynamics and accuracy of GeoGebra media can provide students with understanding. GeoGebra enables students with strong spatial abilities to reason more creatively, whereas GeoGebra enables students with low spatial abilities to reason more creatively. not indifferent to comprehending the depiction of diverse geometric objects so that their knowledge may be maximized. As a result, it has been demonstrated that using

GeoGebra may increase mathematical concept understanding in pupils with both strong and weak spatial skills.

The researchers' observations in the typical class revealed that certain students, particularly those with poor time competence, were puzzled, less adept, and had difficulties grasping the principles being taught. When questioned about the significance and elements of the geometric forms, many were perplexed. This is due to a lack of opportunity for them to actively form geometric things in their minds. Meanwhile, students with a high level of spatial imagination can explain and present various geometric representations in the form of images accurately and precisely. And well-equipped to understand, process, and visualize the spatial world both mentally and realistically.

4. CONCLUSION

The results demonstrated that when students were taught using GeoGebra learning media rather than conventional learning (demonstrations), their grasp of mathematical topics improved. It was also determined that there was a relationship between the GeoGebra learning medium and the student's comprehension of the geometric idea of spatial abilities. This suggests that when taught with GeoGebra media, children with both strong and weak spatial skills grasp mathematical ideas better. Students who take GeoGebra learning media classes grasp mathematical ideas better than students who study traditionally, and students with good or poor spatial ability do better than individuals who study conventionally.

Considering that GeoGebra media-assisted learning is effective in increasing students' understanding of mathematical concepts, mathematics teachers are advised to use GeoGebra media-assisted learning as a reference source for learning mathematics, especially geometry material.

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