

<https://doi.org/10.51574/kognitif.v6i2.5083>

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How to cite: Maulana, A., Sucipto, L., & Arvy, B. R. (2026). Effect of Using Geogebra-Based Interactive Media on Junior High School Students' Understanding of Geometry Concepts. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 6(2), 704–718. <https://doi.org/10.51574/kognitif.v6i2.5083>

To link to this article: <https://doi.org/10.51574/kognitif.v6i2.5083>



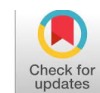
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Effect of Using Geogebra-Based Interactive Media on Junior High School Students' Understanding of Geometry Concepts

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Article Info

Article history:

Received May 15, 2026

Accepted Jun 02, 2026

Published Online Jun 05, 2026

Keywords:

Conceptual Understanding

Interactive Media

Geogebra

Geometry

ABSTRACT

Inovative and engaging learning media are needed to improve students' participation and conceptual understanding, particularly using GeoGebra-based interactive media. This research aimed to investigate the effect of GeoGebra-based interactive media on students' understanding of spatial geometry concepts. The study employed a quantitative method using a quasi-experimental approach with a pretest-posttest control group design. The population consisted of all eighth-grade students of SMPIT Jihadul Muslimin Batu Pengilik, East Lombok, in the 2025/2026 academic year. Samples were selected using a cluster random sampling technique, with class VIII A assigned as the experimental group and class VIII B as the control group, each consisting of 20 students. The experimental group received instruction through GeoGebra-based interactive media, while the control group used PowerPoint media. The research instrument was a validated test of students' understanding of spatial geometry concepts. Data analysis was conducted using descriptive statistics, the Shapiro-Wilk normality test, Levene's Test for homogeneity and the Independent Sample t-test with the assistance of SPSS 25. The findings revealed that the experimental group achieved an average posttest score of 83.70, while the control group obtained 75.90. Hypothesis testing produced a significant value of $0.001 < 0.05$, indicating that GeoGebra-based interactive media significantly affected students' conceptual understanding. In addition, the pretest analysis showed no significant difference between the two groups ($\text{Sig.} = 0.128 > 0.05$), indicating relatively equivalent prior abilities. Effect size analysis using Cohen's d showed a moderate effect on the pretest (0.50) and a strong effect on the posttest (1.17). These results demonstrate that GeoGebra-based interactive media effectively improves students' understanding of spatial geometry concepts through interactive and meaningful learning experiences.



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Introduction

Mathematics is one of the core subjects taught at various levels of education. However, many students still view mathematics as a complex and uninteresting subject. This is influenced by the abstract nature of mathematical concepts (Retta & Fitriyani, 2022), which often makes it difficult for students to understand concepts and apply them in everyday life. The low conceptual understanding of Indonesian students is also evident in the result of the 2022 Programme for International Student Assessment, where Indonesia scored 366 points, still below the OECD average of 472 points (OECD 2022). These data indicate that Indonesian students' mathematical abilities, particularly in conceptual understanding, still need improvement.

One of the mathematics topics often considered difficult by students is geometry, particularly the topic of geometric shapes. This material requires spatial visualization skills because it deals with three-dimensional shapes. Based on survey results (Kemdikbudristek (2021)), many junior high school students experience difficulty understanding geometric shapes due to the abstract nature of the material and the limited use of visual media in the learning process. Poor understanding of mathematical concepts is also influenced by the suboptimal use of learning media that can help students transform abstract concepts into more concrete ones. Furthermore, the learning process, which still focuses on conventional methods, such as lectures and the use of two-dimensional media, makes students less actively involved and makes it difficult to understand concepts more deeply (Susanto, 2021).

Observation results show that learning about geometric shapes is still carried out conventionally, where teachers explain the material through lectures and two-dimensional drawings on the board. Students tend to only note and imagine the shape of the geometric shapes abstractly, so they have difficulty in understanding concepts such as shape, volume, surface area, and the relationship between the elements of the geometric shapes. This has an impact on low student learning outcomes, which is indicated by the majority of students not reaching the minimum completion criteria where out of 40 students only 20 percent of students achieved the KKM score, the remaining 80 percent were still below the KKM.

In this study, understanding of spatial geometry concepts refers to students' ability to reinterpret mathematical ideas, recognize the components of three-dimensional figures such as faces, edges, and vertices, categorize objects according to their characteristics, utilize both visual and mathematical representations, apply formulas related to volume and surface area, and associate these concepts with real-life contextual situations. Therefore, conceptual understanding is not merely focused on memorizing formulas, but also involves students' capacity to explain, interpret, and apply mathematical concepts meaningfully across various contexts and problem-solving situations (Kilpatrick, et al. 2001)

To address these issues, innovations in the mathematics learning process are needed through the use of more interactive media that can present concepts more realistically (Mawardi, et al. 2019). Advances in digital technology have opened up opportunities for the use of technology-based learning media as an appropriate alternative in teaching and learning activities (Rahmatudin & Serlina, 2024). Interactive learning media not only helps students absorb the material but also provides opportunities for direct interaction with the concepts being studied, thereby increasing student engagement and understanding (Yasifati Hia & Nainggolan, 2023). Furthermore, Daryanto (2021) states that interactive learning media is able to create a more interesting learning process, so that students become more active and more easily understand the material being taught.

One media that can be used is GeoGebra, a dynamic mathematical software capable of presenting interactive visualizations of geometric objects (Tatar, 2013). GeoGebra not only

functions as a visualization tool, but also as an exploratory learning medium that enables students to connect visual, symbolic, and conceptual representations in mathematics learning. Through GeoGebra, students can directly manipulate objects, observe changes in shapes, explore relationships among geometric elements, and independently construct mathematical concepts. GeoGebra allows students to directly observe, manipulate, and explore geometric shapes, making abstract concepts easier to understand (Nasrulloh & Sugandi, 2023). GeoGebra media allows users to draw, manipulate objects, and explore the relationships between various mathematical elements (Asnawi, et al 2023). The use of interactive media based on GeoGebra can be used as an alternative effective, innovative, and engaging mathematics learning media, especially for the material of prisms and pyramids. GeoGebra can help students visualize abstract concepts more concretely, thereby improving junior high school students' understanding of mathematical concepts (Huda, et al. 2023). GeoGebra media is highly interactive. Users can manipulate objects such as points, lines, and graphs directly, with changes immediately reflected in numerical and visual representations. This feature makes it easy for users to experiment and visualize various concepts (Suhafii, et al. 2023). The use of GeoGebra can also increase student activity and strengthen conceptual understanding through the visualizations and interactions provided (Salim, 2022).

Various previous studies have shown that the use of GeoGebra in mathematics learning has a positive impact on conceptual understanding and student learning outcomes (Putri, et al. 2023). Nevertheless, earlier studies have generally concentrated on broad geometry topics, coordinate systems, or mathematical thinking abilities across different educational levels. In addition, many of these studies implemented instructional designs without specifically comparing the effectiveness of GeoGebra with other instructional media through the use of a control group. Furthermore, the use of GeoGebra is also considered capable of increasing student learning motivation and conceptual understanding compared to learning with conventional methods (Anggraeni, et al. 2023). Research conducted by Lubis (2024) also shows that GeoGebra is effective in improving students' understanding of mathematical concepts in geometry. However, studies on the application of GeoGebra to spatial geometry, especially prisms and pyramids at the junior high school level, are still limited. Therefore, this study focuses on analyzing the effect of GeoGebra-based interactive media on junior high school students' understanding of spatial geometry concepts. Based on this description, this study was conducted to analyze the effect of using interactive GeoGebra-based media on junior high school students' understanding of spatial concepts. This research is expected to contribute to the development of more innovative, effective, and engaging mathematics learning, as well as support the improvement of the quality of geometry learning in various schools in Indonesia.

Method

Settings

This study applied a quasi-experimental approach employing a non-equivalent control group design. The design was chosen because individual random assignment of students into experimental and control groups was not feasible, as the classes had already been officially organized by the school prior to the implementation of the research. Consequently, the study utilized intact existing classes as the research groups, consisting of an experimental group and a control group. Therefore, the use of this design was deemed appropriate because it could demonstrate the effect of using GeoGebra-based interactive media on students' understanding of spatial concepts through differences in learning outcomes in the two classes.

Population and Sample

The population of this research included all eighth-grade students of SMPIT Jihadul Muslimin Batu Pengilik, East Lombok, during the 2025/2026 academic year. The eighth grade consisted of four classes, namely VIII A, VIII B, VIII C, and VIII D, with 20 students in class VIII A, 20 students in class VIII B, 20 students in class VIII C, and 19 students in class VIII D, resulting in a total population of 79 students. The sample was selected through a cluster random sampling technique because the population had already been organized into intact classroom groups with relatively similar academic characteristics. The sampling procedure was conducted by randomly drawing the existing classes to determine the experimental and control groups. Based on the result of the class lottery, class VIII A was chosen as the experimental group receiving instruction through GeoGebra-based interactive media, while class VIII B was assigned as the control group taught using PowerPoint media. Each sample class consisted of 20 students. The type of research used was a quasi-experiment design with a pretest–posttest control group design (Sugiyono, 2019). This research was conducted in two classes: an experiment class that was given treatment using interactive GeoGebra-based media and a control class that used PowerPoint media in conventional learning. This study uses a pretest and posttest to determine students' initial and final abilities after being given the treatment. The research design can be seen in Table 1.

Table 1. Quasi-Experimental Research Design

Group	Pre-test	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Note:

O_1 : Pre-test of the experimental group

O_2 : Posttest of the experimental group

O_3 : Pretest control group

O_4 : Posttest control group

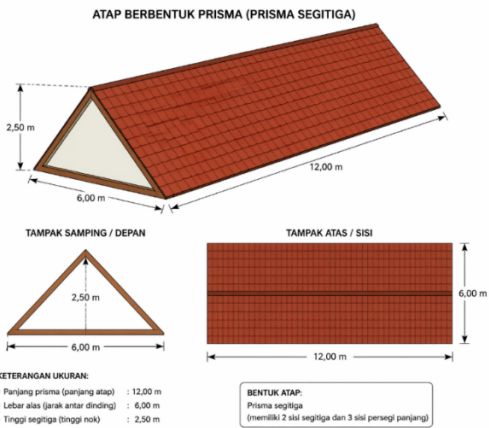
X_1 : Treatment using the help of interactive media GeoGebra

X_2 : Treatment using PowerPoint media assistance

Test Questions

The test instrument in this study was in the form of descriptive questions used to measure junior high school students' ability to understand the concept of spatial geometry. The questions were designed to measure students' ability to understand, re-explain, classify, and apply mathematical concepts to solve contextual problems related to prisms and pyramids. The questions were designed based on Kilpatrick's conceptual understanding indicators, namely restating concepts, classifying objects based on certain properties, providing examples and non-examples, applying concepts in problem solving, and presenting concepts in various mathematical representations. The test results were analyzed to determine the increase in students' conceptual understanding after the application of GeoGebra-based interactive media in learning spatial geometry. In this study, the test consisted of two descriptive questions focusing on the material of prisms and pyramids as shown in Table 2.

Table 2. Test Instrument

Task	Task Characteristics
<p>Task #1. An architect is designing a monument in the shape of a square pyramid as an icon in a city. The monument has a square base with a side length of 8 meters and a pyramid height of 6 meters. The entire surface of the upright side of the monument will be coated with a special material to protect it from the weather, while the interior will be filled with concrete material. Students are asked to: a) describe the shape of the pyramid and its dimensions, b) determine the volume of the pyramid, and c) determine the surface area of the pyramid.</p>	<p>Students must understand the concept of the rectangular pyramid through pictorial representation, determine the elements of the geometric shape, and apply the formulas for the volume and surface area of the pyramid in the context of everyday life. This task requires students to: (1) restate the concept of the rectangular pyramid; (2) identify the elements of the pyramid such as sides, edges, and height; (3) connect the concept of the Pythagorean theorem to determine the hypotenuse; (4) apply the formulas for the volume and surface area of the pyramid; and (5) present the solution in the form of mathematical representation and pictures.</p>
<p>Task #. Look at the picture of a house roof in the shape of a triangular prism.</p>  <p>The diagram shows a 3D perspective of a triangular prism roof with a red tiled surface. The length of the prism is 12.00 m, the base width is 6.00 m, and the height from the base to the peak is 2.50 m. Below the 3D view are two 2D views: 'TAMPAK SAMPING / DEPAN' (side view) showing a triangle with base 6.00 m and height 2.50 m, and 'TAMPAK ATAS / SISI' (top view) showing a rectangle with length 12.00 m and width 6.00 m. A legend box contains the following information:</p> <p>KETERANGAN UKURAN:</p> <ul style="list-style-type: none"> • Panjang prisma (panjang atap) : 12,00 m • Lebar atas (jarak antar dinding) : 6,00 m • Tinggi segitiga (tinggi nok) : 2,50 m <p>BENTUK ATAP: Prisma segitiga (memiliki 2 sisi segitiga dan 3 sisi persegi panjang)</p> <p>Students are asked to: a) explain the meaning of a prism and its properties, b) provide examples and non-examples of prisms in everyday life along with the reasons, and c) determine the volume and surface area of the roof of the prism.</p>	<p>Students must think about the concept of prism based on the characteristics of spatial shapes and relate them to real objects in everyday life. This task requires students to: (1) restate the concept of prism and its properties; (2) classify objects based on the characteristics of prisms; (3) provide examples and non-examples of prisms; (4) apply the concept of volume and surface area of prisms in solving contextual problems; and (5) present the concept of prisms in the form of verbal representations, pictures, and mathematical calculations .</p>

Before being used in the research, the test instrumen was first validated by two validators, namely a Mathematics Education lecturer and a junior high school mathematics teacher who has competence in the field of mathematics learning evaluation. Validation was carried out to assess three main components, namely the suitability of the material content, the quality of the question construction, and the clarity of the language used in the instrument. The assessment was given using a four-category scale, then analyzed to determine the level of feasibility of the research instrument. The validation result showed that the test instrument had met the criteria for validity and was suitable for use in research. The validators assessed that the questions were in accordance with the indicators of understanding the concept of spatial shapes, had a clear construction, and used language that was easily understood by junior high school students. Thus, the test instrument can be used to measure students' conceptual understanding of prisms and pyramids material after the application of interactiv media based on GeoGebra.

Learning Implementation Observation Sheet

Learning Implementation Observation Sheet used to observe and assess how effectively a learning process (teacher and student) has been implemented according to plan, including preliminary, core and closing activities, observation sheets are used to assess the extent to which the learning process is implemented according to the scenario designed in the lesson plan.

Lesson Implementation Plan (LIP)

Used as a guide for teachers, it contains procedures and learning organization to achieve one or more Core Competencies, which are outlined in more detail from the syllabus into concrete steps, objectives, materials, methods, learning resources, and assessments for each meeting or more. The LIP serves as a guide for teachers so that learning is structured, effective, and achieves curriculum goals. LIPP is used to differentiate the treatment between the experimental class (using GeoGebra) and the control class (conventional learning).

Data Collection

The data collection technique used in this study were test and observation. A conceptual understanding test was administered before the treatment (pretest) to determine students' initial ability to understand the concept of spatial shapes, and after the treatment (posttest) to determine the improvement in students conceptual understanding after the application of GeoGebra-based interactive media. In addition to the test, observations were conducted during the learning process to observe students' activities and engagement in learning using GeoGebra-based interactive media in the experimental class and conventional learning in the control class. The result of the pretest and posttest were then analyzed to determine the effect of using GeoGebra-based interactive media on junior high school students understanding of the concept of spatial shapes.

Data analysis

The prerequisite analysis in this study includes a normality tests and a data homogeneity test. The normality test become conducted the use of the Shapiro–Wilk approach because the range of samples in every organization was less than 50 college students. This check pursuits to determine whether or not the facts is usually allotted. moreover, a homogeneity check turned into conducted using Levene's test to peer the similarity of variance between the experimental elegance and the control magnificence. Next, a pretest equivalence analysis was conducted using an Independent Sample t-test to examine whether the experimental and control groups possessed comparable initial abilities prior to the treatment. When the pretest results indicated no statistically significant difference between the two group, the hypothesis testing proceeded through an Independent Sample t-test on the posttest scores. Conversely, if significant differences had been identified in the pretest results, ANCOVA would have been applied to control for the influence of students' prior abilities. In the final stage, Cohen's d was calculated to measure the magnitude of the effect produced by the implementation of GeoGebra-based interactive media on students understanding of spatial geometry concept.

Research Findings

Experimental Class

Analysis of the pretest and posttest results was intended to identify students' initial conceptual understanding. The descriptive statistics used included the mean, highest score, lowest score, and standard deviation. A summary of the result of the descriptive statistics calculations for students' conceptual understanding in the experimental class is outlined in Table 3.

Table 3. Pretest and Posttest Results Data for the Experimental Class

Pretest	Posttest	Information
10	67	Max
45	95	Min
24.35	83.70	Mean
10.78	7.44	Standard deviation

Based on the findings of the conducted research at SMPIT Jihadul Muslimin Batu Pengilik, East Lombok in the 2025/2026 academic year, experimental class data was obtained from 20 students of class VIII.A. After the learning process using GeoGebra media was implemented, students were then given a final test (posttest). The posttest results showed that the lowest score obtained by students was 67, while the highest score reached 95. In addition, the average posttest score was 83.70 with a standard deviation of 7.44. A more detailed description of the experimental class data can be seen in Table 3.

In the experimental group, the learning activities on prisms and pyramids were conducted using interactive learning media developed with GeoGebra. The software was utilized to display three-dimensional geometric models that students could observe from multiple viewpoints through rotation and zooming features. By interacting with these models, students were able to recognize the components of solid figures, including faces, edges, vertices, bases, and heights more clearly than through conventional two-dimensional illustrations.



Figure 1. Implementation of GeoGebra-Based Interactive Media in Learning Prism and Pyramid

Control Class

Pretest and posttest data obtained from the control class in this study are described based on the statistical calculations shown in Table 4.

Table 4. Pretest and Posttest Results Data for the Control Class

Pretest	Posttest	Information
10	64	Max
30	85	Min
20.25	75.90	Mean
4.72	05.85	Standard deviation

Based on research conducted at SMPIT Jihadul Muslimin Batu Pengilik, East Lombok in the 2025/2026 academic year, control class data was obtained from 20 students in class VIII.B. After the learning activities took place, students were given a final test (posttest) to determine the learning outcomes achieved. From the posttest result , it was known that the lowes student score was 64 and the highes score reached 85. Meanwhile, the average posttest score obtained by students was 75.90 with a standard deviation of 5.85. A more detailed explanation of the control class data can be seen in Table 4. Comparison of the results between the experimental class and the control class after administering the treatment is presented in [Figure 2](#) below:

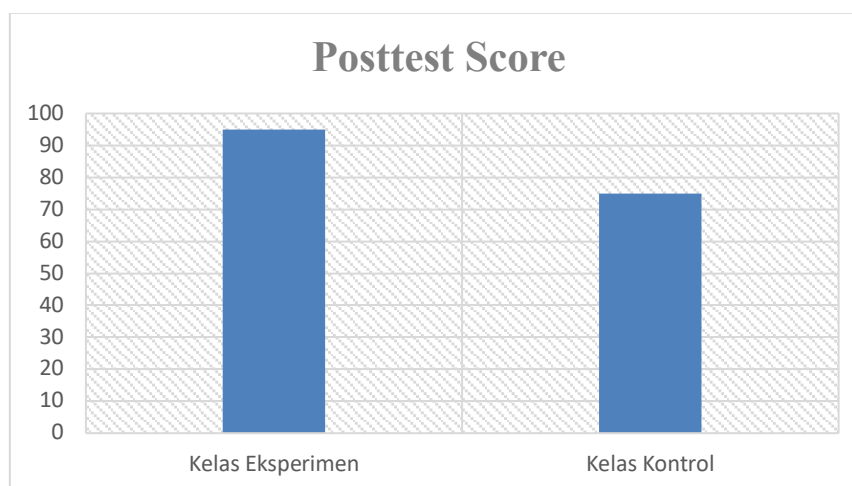


Figure 2. Pretest and Posttest Data for Experimentalland ControllClasses

Based on [Figure 2](#), the average posttest score in the experimental class was 83.70 while the control class obtained an average of 75.90. These results indicate that students' understanding of the concept of spatial shapes in the experimental class increased after learning using GeoGebra media . The average difference between the two classes of 7.08 also indicates that the use of GeoGebra is more effective than conventional learning.

Prerequisite Test

NormalityTest

With the aid of SPSS version 25, the Shapiro-Wilk method was used to perform the data normalcy test in this investigation. [Table 5](#) displays the test results.

	Pretest		Posttest	
	E	C	E	C
Sig	0,268	0,076	0,157	0,141
Shapiro-Wilk test	$\geq 0,05 H_0(\text{acc epted})$	$\geq 0,05 H_0(\text{acc epted})$	$\geq 0,05 H_0(\text{acc epted})$	$\geq 0,05 H_0(\text{acc epted})$
Decision	Normal	Normal	Normal	Normal

The results of the normality test showed that the pretest and posttest data on understanding the concept of spatial shapes in the experiment and control class were normally distributed because the significance value obtained was greater than 0.05. This indicates that the distribution of data in each group did not experience significant deviations from the normal distribution, so the data is able to describe the condition of the population well.

Homogeneity Test

The homogeneity test in this analysis uses SPSS 25 software with Levene's test. The results of the homogeneity test are described in Table 6.

Table 6. Results of Homogeneity Test

	Pretest	Posttest
Sig	0,001	0,857
Levene's test	< 0,05 H_0 (rejected)	\geq 0,05 H_0 (accepted)
Decision	Non-Homogeneous	Homogeneous Data

Based on the results of Levene's test, the pretest significance value of 0.001 (> 0.05) indicates that the pretest data is not homogeneous so that H_0 is rejected. In the posttest data, the significance value of 0.857 (< 0.05) indicates that the data is homogeneous and H_0 is accepted. Thus, only the posttest data meets the homogeneity assumption, while the pretest data does not meet this assumption. Although the pretest data were not homogeneous, hypothesis testing could still proceed because the assumption of normality was met. Therefore, an analysis of differences in students' understanding of spatial concepts was conducted using an Independent Samples t-test.

Hypothesis Testing

Independent Sample t-test

The results of the prerequisite tests indicate that the research data is normally distributed, allowing the analysis to proceed using parametric testing in the form of an Independent Samples t-test. The results of the hypothesis test are presented in Table 7.

Table 7. Pretest Result of Independent Sample t-test

Data	Experiment	Control
<i>n</i>	20	20
Average	24.35	20.25
Sig. (2-tailed)	0.128	
Conclusion	H_0 accepted and H_1 rejected	

The results of the hypothesis test on the pretest data showed a significant value of 0.128, which is greater than 0.05. Thus, H_0 is accepted and H_1 is rejected. These results indicate that the initial abilities of students in the experimental and control classes did not differ significantly before the treatment was given.

Table 8. Posttest Results of Independent Samples t-test

Data	Experiment	Control
<i>n</i>	20	20
Average	83.70	75.90
Sig. (2-tailed)	0.001	
Conclusion	H_0 rejected and H_1 accepted	

The results of the hypothesis test on the posttest data obtained a significant value of 0.001 which is smaller or equal to 0.05. Therefore, H_0 is rejected and H_1 is accepted. These findings indicate that the use of interactive media based on GeoGebra has a significant influence on the understanding of the concept of spatial shapes of junior high school students.

Effect Size Test

To strengthen these findings, a further analysis was conducted by calculating the effect size using Cohen's *d* index. This measurement was intended to determine the magnitude of the influence of GeoGebra media on students' understanding of geometric concepts. Therefore, the results of the study not only demonstrated statistically significant differences, but also provided a clearer description of the strength and practical relevance of GeoGebra media in improving students' conceptual understanding. The result of the effect size calculation are presented in Table 9.

Table 9. Results of Effect Size

Effect Size Cohens'd		
	Pretest	Posttest
Point Estimate	0,50	1,17
Category	Currently	Strong

Based on the results of the effect size calculation using Cohen's *d*, the effect size value obtained for the pretest was 0.50, which was categorized as a medium effect. Meanwhile, the posttest produced an effect size value of 1.17, which fell into the strong effect category. These findings indicate that the treatment provided a moderate influence during the pretest stage and a strong influence on students' conceptual understanding in the posttest stage.

Discussion

Based on the results of the pretest analysis using the Independent Samples t-test, the average value of the experimental class was 24.35 and the control class was 20.25 with a significance value (2-tailed) of 0.128. Because the significance value is greater than 0.05, H_0 is accepted and H_1 is rejected. These effects imply that there is no full-size distinction in preliminary abilities among college students inside the experimental class and the manipulate magnificence before the remedy is given. Thus, both classes can be said to have relatively equal initial abilities in the material of spatial figures. Therefore, the difference in learning outcomes after treatment is thought to be influenced by the differences in learning media used, namely interactive media based on GeoGebra in the experimental class and PowerPoint media in the control class.

The result of the Independent Samples t-test analysis on the posttest data showed a significant value of 0.001, which is smaller than 0.05, so the null hypothesis is rejected. This finding indicates that the use of GeoGebra-based interactive media has a significant influence on junior high school students' understanding of spatial concept. The result of this study also support the research of Julita, et al. (2022) which stated that GeoGebra is effective in improving students' understanding of mathematical concept in three-dimensional material.

Based on the research results, the use of interactive media based on GeoGebra has been proven to have a significant influence on junior high school students' understanding of spatial concepts. This can be seen from the average posttest score of the experimental class of 83.70, which is higher than the control class of 75.90. The average difference of 7.08 indicates that learning using GeoGebra is more effective than conventional learning with the help of PowerPoint. In line with that, Nasrulloh & Sugandi (2023) stated that GeoGebra is able to help students understand mathematical concepts through clearer and more interactive visualizations.

The improvement in learning outcomes in the experimental class occurred because GeoGebra was able to help students visualize the concept of geometric shapes in a more concrete and interactive way (Putri & Pasaribu, 2025). In geometry learning, particularly geometric shapes, students often experience difficulties because the objects studied are abstract and require spatial visualization skills (Oktoviani et al., 2022). By using GeoGebra, students can see geometric shapes in three dimensions, rotate objects, observe geometric elements, and understand the relationships between geometric parts directly (Kultuca, 2013). This condition makes it easier for students to understand the concept of volume, surface area, edges, vertices, and sides of geometric shapes. This statement is supported by research Salim (2022) which states that GeoGebra can improve students' mathematical visualization skills through dynamic object displays.

In addition to influencing learning outcomes, the use of interactive GeoGebra-based media also increased student participation during learning. In the experimental class, students appeared more active in observing and exploring the material compared to the control class, which used conventional learning (Bicer et al., 2014). Direct student engagement with learning media helped them construct conceptual understanding independently, making the learning process more meaningful (Hohenwarter & Preiner, 2007). This finding aligns with constructivism theory, which emphasizes that knowledge is more easily understood when students are actively involved in learning activities. This opinion is also supported by Yasifati Hia & Nainggolan (2023) which states that interactive learning media can increase student activity while strengthening the understanding of mathematical concepts.

The increase in students' conceptual understanding was influenced by the interactive and exploratory nature of GeoGebra as a learning medium. First, GeoGebra assisted students in visualizing three-dimensional objects, enabling abstract spatial concepts to be observed in a more concrete and dynamic manner (Arbain & Shukor, 2015). Second, the software provided opportunities for learners to manipulate and investigate geometric objects directly, such as rotating figures, modifying dimensions, and examining relationships among geometric components in greater depth. These learning activities encouraged students to participate more actively in constructing their own mathematical understanding. Third, GeoGebra supported the integration of visual, symbolic, and conceptual representations within mathematics learning. Students were not only able to interpret geometric models visually, but also connect them with mathematical symbols, formulas, and problem-solving procedures simultaneously. The integration of these multiple representations contributed to a deeper and more meaningful understanding of prism and pyramid concepts (Zengin et al., 2012).

The result of this study is also supported by the result of the hypothesis test using the Independent Samples t-test with a significant value of 0,001 or less than 0,05. Therefore, H_0 is rejected and H_1 accepted. This means that there is a significant influence of the use of interactive media based on GeoGebra which has been proven to have an impact on the understanding of the concept of spatial figures in junior high school students. This result is supported by research Julita, et al (2022) showed that GeoGebra is effective in improving student understanding of mathematical concept in three-dimensional material. Furthermore,

Sugiyono (2019) states that a significance value of less than 0.05 indicates a significant difference between the groups being compared.

The pretest and posttest data in both the experimental and control classes showed a normal distribution because the significance value obtained was greater than 0.05. Furthermore, the result of the homogeneity test showed that the posttest data had a homogeneous variance with a significance value of 0.857. Although the pretest data was not homogeneous, hypothesis testing could still be carried out because the normality requirements had been met and the Independent Samples t-test could still be used to analyze differences in learning outcomes between the two groups. This opinion is in line with Sugiyono (2019) which states that parametric tests can still be applied if the data meets the assumption of normality.

The results of this study support previous research findings that GeoGebra can improve students' understanding of mathematical concepts through dynamic and interactive geometric visualizations. The use of GeoGebra not only helps students understand abstract concepts but can also increase motivation and interest in learning mathematics. Research Putri, et al. (2023) showed that the use of GeoGebra had a positive impact on students' mathematics learning outcomes. Furthermore, research Fitriani & Kurniawan (2022) also stated that GeoGebra-assisted learning can significantly improve students' understanding of geometric concepts. Thus, interactive media based on GeoGebra can be used as an effective learning alternative in mathematics, particularly in spatial geometry. Using GeoGebra can create a more innovative, engaging, and interactive learning process, thereby helping to improve junior high school students' understanding of mathematical concepts.

Conclusion

Based on the findings of this study, it can be concluded that the implementation of GeoGebra-based interactive media supports students' understanding of spatial geometry concepts. Students who learned through GeoGebra-based interactive media demonstrated better conceptual understanding compared to those who learned using PowerPoint media. The hypothesis testing results also revealed a significant difference between the experimental and control groups after the treatment was administered. In addition, the pretest analysis indicated that both groups possessed relatively equivalent prior abilities before the learning intervention was conducted. The effect size analysis using Cohen's *d* demonstrated a moderate effect on the pretest and a strong effect on the posttest, indicating that GeoGebra-based interactive media contributed substantially to improving students' conceptual understanding. Therefore, GeoGebra can be utilized as an interactive learning medium that assists students in visualizing, exploring, and understanding spatial geometry concepts in a more meaningful way within mathematics learning.

Acknowledgments

The author would like to express his private gratitude to all parties who've supplied guidance and contributions within the implementation and training of this research. The author also expresses his gratitude to the institution that provided academic support during the research process. He also expresses his gratitude to the research site that provided permission, facilities, and support so that this research could be carried out successfully. The author also expresses his gratitude to the principal, mathematics teachers, and all students who have actively participated and cooperated throughout the research process. The author also expresses his respect and gratitude to the supervisor who provided direction, guidance, and constructive input from the planning stage to the preparation of this research report. Furthermore, the author also expresses his

gratitude to various parties, colleagues, and all parties who have provided moral support, motivation, and assistance, both directly and indirectly, so that this research can be completed successfully. May all assistance and contributions be rewarded with the best.

Conflict of Interest

The researcher states that there is no conflict of interest in this research.

Auhor Contributions

A.M. contributed to the research concept development, data collection, data analysis, research implementation, and article writing. L.S. contributed to providing research methodology guidance, instrument validation, and manuscript revision. B.R.A. contributed to research supervision, research results analysis, and refinement of the article's content and language. All authors have read and approved the final version of the article for publication. The distribution of contributions to the conceptualization, writing, and revision of this study is as follows: A.M.: 60%, L.S.: 20%, and B.R.A.: 20%.

Data Availability Statement

The author declares that data supporting the findings of this study can be obtained through the corresponding author, [A.M], upon reasonable request.

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