

## THE EFFECTIVENESS OF THE AMAZING GEOMETRY AR APPLICATION FOR SOLID GEOMETRY LEARNING

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**ABSTRACT** Learning mathematics, particularly in the area of solid geometry, is often perceived as difficult by elementary school students, which highlights the need for appropriate learning media to support their understanding. This study aims to examine the effectiveness of learning media based on the Amazing Geometry Augmented Reality application in introducing solid geometry concepts to students. The research employed a pre-experimental design using a one-group pre-test and post-test. The population and sample consisted of all fifth-grade students at SDN Margodadi, totaling 11 students, selected through saturated sampling. Data were collected using essay tests that had undergone content and empirical validation, as well as reliability testing. Data analysis involved descriptive statistics, a normality test, and a paired sample t-test using IBM SPSS 26. The results showed that the average post-test score was higher than the pre-test score. The paired sample t-test indicated a t-count value of 15.486, which was greater than the t-table value of 1.812, with a significance level (2-tailed) of less than 0.05. These findings demonstrate that the use of the Amazing Geometry Augmented Reality application has a significant positive impact on students' understanding of solid geometry. Overall, this study suggests that integrating augmented reality into mathematics instruction can enhance the learning process, particularly in the introduction of spatial concepts, and offers valuable implications for the broader use of technology in elementary mathematics education.

**Keywords:** augmented reality, solid geometry, mathematics learning, experimental design

**ABSTRAK** Pembelajaran matematika, khususnya pada materi bangun ruang, sering dianggap sulit oleh siswa sekolah dasar sehingga diperlukan media pembelajaran yang tepat untuk mendukung pemahaman mereka. Penelitian ini bertujuan untuk menguji efektivitas media pembelajaran berbasis *Amazing Geometry Augmented Reality* dalam memperkenalkan konsep bangun ruang kepada siswa. Penelitian ini menggunakan desain pra-eksperimen dengan model *one-group pre-test and post-test*. Populasi sekaligus sampel penelitian ini adalah seluruh siswa kelas V SDN Margodadi yang berjumlah 11 siswa, dipilih dengan teknik *saturated sampling*. Data dikumpulkan melalui tes uraian yang telah melalui uji validitas isi, validitas empiris, dan reliabilitas. Analisis data dilakukan dengan uji statistik deskriptif, uji normalitas, serta uji *paired sample t-test* menggunakan IBM SPSS 26. Hasil penelitian

menunjukkan bahwa skor rata-rata post-test lebih tinggi dibandingkan skor pre-test. Uji *paired sample t-test* memperoleh nilai *t*-hitung 15,486 lebih besar dari *t*-tabel 1,812 dengan nilai signifikansi (2-tailed) kurang dari 0,05. Temuan ini membuktikan bahwa penggunaan aplikasi *Amazing Geometry Augmented Reality* memberikan pengaruh positif yang signifikan terhadap pemahaman siswa mengenai bangun ruang. Secara keseluruhan, penelitian ini menyarankan bahwa integrasi augmented reality dalam pembelajaran matematika dapat meningkatkan efektivitas proses belajar, khususnya dalam memperkenalkan konsep spasial, serta memberikan implikasi penting bagi pemanfaatan teknologi dalam pendidikan matematika sekolah dasar.

**Kata-kata kunci:** augmented reality, bangun ruang, pembelajaran matematika, desain eksperimen

## INTRODUCTION

In every educational environment, including mathematics education, mathematics is a subject that must be studied because it is closely related to other sciences. Afsari et al. (2021) revealed that in world science, mathematics is often referred to as the Mother of Science or Queen of Science. Through mathematics learning at the educational level, students are expected to think critically, develop computational skills, implement fundamental ideas in mathematics, and apply them in daily life (Afsari et al., 2021). Kholisah, Anggraini, and Kartini (2020) emphasized that mathematics has a vital role in everyday life and plays a key role in technological innovation. This importance is also stated in the Law of the Republic of Indonesia on the National Education System, Article 37 No. 20 of 2003, which affirms mathematics as a compulsory subject in both primary and secondary schools (Government Regulation of Republic Indonesia, 2003).

The objectives of mathematics learning include developing students' abilities to understand mathematical concepts and apply them effectively (Wulandari, Hidajat, & Exacta, 2024). However, in practice, students often face difficulties in mastering mathematics. Many students show low interest in mathematics, as reported by Amallia and Unaenah (2018). Similarly, Wijayanti and Yanto (2023) noted that students tend to struggle with calculations and often perceive mathematics as monotonous, which creates a sense of fear and aversion. Karisma et al. (2023) further observed that during mathematics lessons, students often display signs of disengagement such as fatigue, drowsiness, or lack of focus. This disengagement is reflected in Indonesia's relatively low performance in mathematics at the international level, as shown by the Program for International Student Assessment (PISA) 2022 results, where Indonesian students scored an average of 365 and ranked 69th out of 80 participating countries.

The PISA results confirm that Indonesian students' mastery of mathematics remains suboptimal. This is especially evident in topics such as solid geometry, which many students consider difficult. Teachers often rely on conventional and monotonous teaching methods, which do not involve innovative learning media (Karisma et al.,

2023). Rusminati and Styanada (2020) found that most students struggled to answer solid geometry problems, while Maulin and Chotimah (2024) reported that the difficulties often lay in applying formulas for calculation. Similarly, Sahara and Nurfauziah (2021) pointed out that students struggled with understanding the basic concepts and properties of solid geometry.

Evidence from observations at SDN Margodadi, Belitang Madang Raya, also supports this finding. Reports showed that although students' general numeracy scores were in the moderate category (78.57%), their competence in geometry was only 48.05%, which is considered low. Teachers at this school tend to dominate the learning process, using static media such as pictures or textbooks. Rozi et al. (2021) noted that in geometry lessons, teachers often rely solely on textbooks that present two-dimensional images, making the learning process less effective. This issue highlights the need for more effective learning media that can support students' conceptual understanding and foster active participation. As Sugiantara et al. (2024) emphasized, the use of appropriate media can make learning content easier to understand and ensure learning objectives are achieved.

One potential solution is the use of Augmented Reality (AR). Maritsa et al. (2021) explained that technology continues to evolve and provide new opportunities in education, while Mursyidah (2022) described AR as a digital tool that blends virtual objects with real environments, creating a sense of reality. AR technology has been shown to create interactive and engaging learning experiences (Syahputra et al., 2024). According to Meilindawati et al. (2023), AR learning media integrates three-dimensional objects into real-time environments, making abstract concepts more accessible to students. Several studies have demonstrated the effectiveness of AR in mathematics learning. For example, Syahputra et al. (2024) found that AR applications based on Unity and Vuforia significantly improved students' understanding of solid geometry. Similarly, Widiadnyana et al. (2021) reported that using AR in combination with the REACT learning strategy positively influenced student learning outcomes compared to conventional methods.

Other studies have also supported the use of AR in mathematics learning. Meilindawati et al. (2023), through a literature review, concluded that AR media was effectively implemented to enhance student learning. Alternative approaches to teaching geometry, such as video media (Mashuri, 2020) or puppet-based media (Kristiawan et al., 2020), have also been explored, but AR offers a more immersive experience. The application used in this study, *Amazing Geometry AR*, is a mathematics learning tool designed to teach solid geometry through interactive elements that make learning more engaging. The word "Amazing" highlights its captivating design, while AR technology enables students to interact with three-dimensional representations of geometric objects.

Although prior research on AR in mathematics has yielded positive results, there remains a gap in empirical quantitative analysis of its effectiveness in solid geometry

learning. Much of the existing research has focused on development studies or literature reviews, rather than direct application in classroom practice. This study aims to fill that gap by conducting an empirical quantitative analysis of the *Amazing Geometry AR* application to examine its effectiveness in improving students' understanding of solid geometry.

## METHODS

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This study applied a quantitative approach with an experimental method using a One Group Pre-test Post-test pre-experimental design. As explained by Fauziyah and Anugraheni (2020), this design involves only one group without a comparison group. The tests in this study were considered equivalent because the same group of students participated in both the pre-test and post-test. Although the instruments used were not identical in structure, they were equivalent in terms of question types. This approach was intended to minimize the possibility of students simply recalling and reproducing their previous answers.

The population of this study consisted of all fifth-grade students at SDN Margodadi. The sampling technique employed saturated sampling, in which the entire population was included as research subjects, amounting to 11 students. Data were collected through essay tests designed to measure students' ability to recognize solid geometry. The pre-test consisted of 7 questions, while the post-test consisted of 5 questions. Although the number of items differed, both tests covered the same type of problems and were scored according to predetermined criteria.

Two types of validation were conducted to ensure the accuracy of the instruments: content validation and empirical validation. Content validity focused on the appropriateness of the test items for measuring the intended objectives. Expert validators were asked to review the test items to confirm their relevance and alignment with research objectives. Meanwhile, empirical validation involved reliability and validity testing, carried out by administering the pre-test and post-test questions to a sixth-grade class that was not part of the research sample. This procedure ensured that the test items could measure students' understanding accurately.

After the instruments were validated, the pre-test was administered to the fifth-grade students to measure their initial understanding of solid geometry. The treatment was then carried out over three meetings using Augmented Reality (AR)-based learning media for teaching solid geometry. At the end of the intervention, students were given a post-test to measure their understanding after exposure to the learning media.

The data analysis process began with descriptive statistical analysis to calculate the mean scores of the pre-test and post-test. Next, the Shapiro–Wilk test was conducted to examine data normality as a prerequisite for hypothesis testing. Since the data were normally distributed, a paired-sample t-test was performed to

determine whether there was a significant difference between students' pre-test and post-test scores.

## FINDING AND DISCUSSION

The hypothesis in this study is "there is an influence of learning media based on the Amazing Geometry Augmented Reality application on the introduction of solid geometry material for fifth grade". This hypothesis test is to see how big the influence of the introduction of solid geometry is for fifth grade students before being given a treatment and after being given a treatment. In statistical testing, SPSS software version 26 was used as support. After the process of providing treatment with learning media and post-test activities has been carried out, the following descriptive data results can be presented:

**Table 1.** Descriptive Statistics Test

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Result	11	11.00	33.00	20.0000	8.44985
Post-test Result	11	58.00	95.00	77.1818	13.61483
Valid N (listwise)	11				

As presented in the table above, it is evident that the minimum value, maximum value, and average value of the post-test results are superior to the pre-test value. So, descriptively, it can be said that there has been a change in what has been obtained or the results of the introduction of solid geometry after being given treatment with the help of learning media with the Amazing Geometry Augmented Reality application. The difference in results shows that students in fifth grade understand the material on introduction to solid geometry better after being treated with the form of learning media. After the data was obtained from the results of the spatial recognition test, the first data analysis was carried out, namely the normality test on the data using Shapiro-Wilk. The results of the normality test are summarized in Table 2.

**Table 2.** Tests of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre-test Result	.212	11	.180	.906	11	.221
Post-test Result	.175	11	.200*	.893	11	.152

\*. This is a lower bound of the true significance.

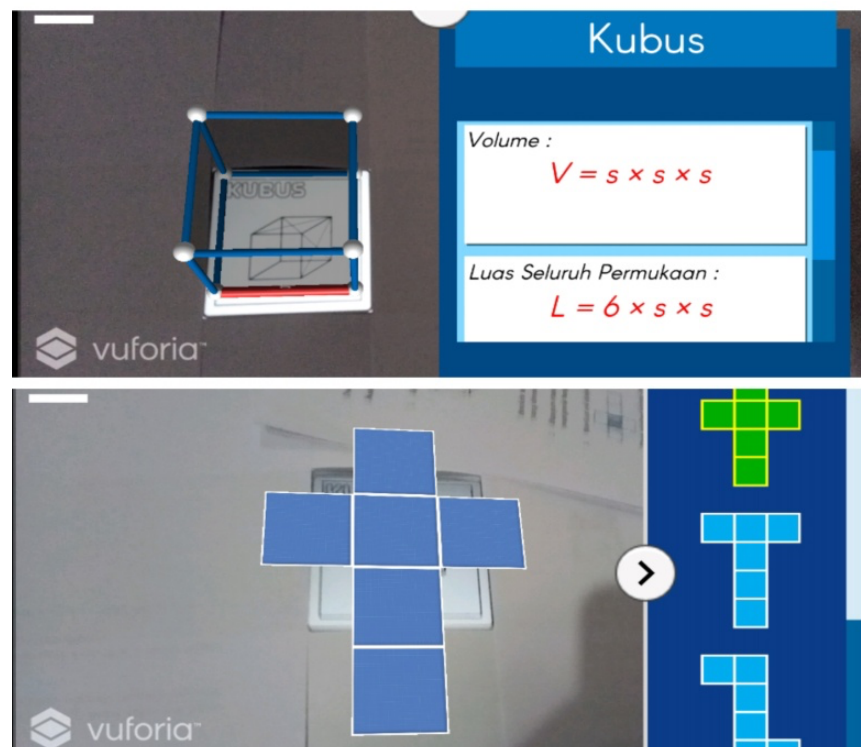
a. Lilliefors Significance Correction

As presented in the table above, it is evident that the significance level of the pretest and posttest values is greater than 0.05. Thus, it can be inferred that the data in this study follows a normal distribution. After that, the paired sample T-test is used to test the hypothesis in the study. The results of this hypothesis as illustrated in table 3 below:

**Table 3.** Paired Sample T-Test

		Paired Differences				T	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	Pre-test								
	Post-test	-56.37	12.085	3.644	-64.483	-48.245	-15.468	10	.000

The tcount value in the SPSS output produces 15,486 while the t-table value at a significance level of 5 percent and dk with a magnitude of N-1, namely 11-1 = 10, then the ttable is 1,812, thus indicating the tcount value of 15,486 > ttable 1,812 and at a significance value (2-tailed) = 0.000, this means that it is less than 0.05, so Ho is rejected and H1 is accepted. Based on the interpretation of these values, it may be inferred that learning media based on the Amazing Geometry Augmented Reality application has an influence on the introduction of solid geometry in fifth grade. These findings cannot be separated from the following implementation characteristics:



**Figure 1.** Interface Features on Amazing Geometry Augmented Reality Application

The implementation of learning media based on Amazing Geometry Augmented Reality application was carried out after the pre-test as a comparison material for the post-test results. In this learning process, there are two groups of students who are selected randomly, to make the use of Android more effective during the learning process.

Data findings from the pretest and posttest are used for testing descriptive statistics and prerequisite tests, namely data normality tests, which aim to obtain information on whether the data is normal or not. Based on table 2, the SPSS output shows that the data used in this study is normally distributed, so it can proceed to the hypothesis testing stage in the Paired Sample T-Test. In the descriptive statistics table, it shows that the average value in fifth grade which consists of 11 students, experienced an increase in the output results. From the statement above, there is a difference in value between mathematics learning after using the Amazing Geometry Augmented Reality application-based learning media and before the media was applied at all.

Furthermore, in Table 3, there are differences in the significant results between the two tests that have been given, and data is obtained that there is an influence of learning media based on the Amazing Geometry Augmented Reality application on the material for introducing solid geometry in fifth grade. Based on the data above, it is in line with research from Syahputra et al., (2024) which reveals that through the use of Augmented Reality media, students can easily visualize abstract objects in a real environment, thus proving to be effective and interactive. Not only that, there is other research by Widiadnyana et al., (2021) shows that student learning outcomes are better when REACT strategy learning is applied with the help of Augmented Reality on solid geometry material compared to using conventional learning. Mursyidah (2022) also added the same thing in his research results that implementing a learning process with the Augmented Reality application has been proven to facilitate students learning mathematics related to understanding the concept of solid geometry. This research supports some of the results of the research above providing the same results that show that Augmented Reality media can be used effectively in learning to solid geometry.

In the pre-test the results are low, it is possible because of the lack of understanding of the concept of solid geometry. While in the post-test the results obtained by students showed a better change than before (pre-test), this is because before the post-test students have been given an intervention using learning media based on Amazing geometry augmented reality application as an interactive learning media. In accordance with the name and content, this application is devoted to elementary school geometry material, so that the material presented has a suitability for that level. By applying this AR media, students are easier to remember the information of solid geometry material because students themselves use this media directly. The feature in this AR media that contributes to students understanding lies in the display of the properties of solid geometry. This feature displays an example of a

solid geometry while listing the location of its corners, sides, and ribs so that students can distinguish each element of the geometry. The feature on the nets also contributes to students understanding, because it displays boxes that can move and form perfect shapes.

The implementation of learning solid geometry using the Amazing Geometry Augmented Reality application has provided an improvement, this is because the Augmented Reality application contains various features that make to help the students better comprehend the material of solid geometry such as features on the properties of solid geometry presented through images that seem real, and features on formulas or nets that can move when touched. The features in the Amazing Geometry Augmented Reality application contain materials that are in solid geometry, so that the material information can be conveyed as a whole. In addition to students finding it easier to understand the material with this media, students are also happy when learning with technology, this observation can be seen during the research, the enthusiasm of students in competing to answer questions given by researchers is very high because they already understand the material well. The understanding of the material is evidenced by the research data. Rachim et al., (2024) revealed that Augmented Reality or AR, apart from being more practical and fun for students, is also able to increase students' enthusiasm for learning. Augmented Reality (AR) is a sophisticated technology that overlays virtual objects in real time and blends them with a real three-dimensional environment (Purnamasari et al., (2023). Through this sophistication, it will encourage educators in the teaching and learning process for students, as expressed by Zapata et al., (2024) in education, AR has advantages as a digital tool in visualizing structured concepts.

In learning solid geometry, especially for elementary school students, it is difficult to get a good picture or visualization of solid geometry. Therefore, the use of learning media based on the Amazing Geometry Augmented Reality application is needed, so that students will get a real picture of how the solid geometry looks, because so far students have only seen solid geometry from pictures in books. Through the visualization of learning media, students will be able to understand abstract concepts that were previously difficult for them to understand, thereby increasing students' interest and motivation to learn. In this research, Augmented Reality used in learning is supported by the theory of constructivism, which will be able to facilitate the knowledge construction process of grade V students to build their own interactions and knowledge about space. Students can visualize spatial shapes such as cubes, blocks, tubes and others into three-dimensional form on the application screen, so as to strengthen geometry concepts in depth and gain a better understanding of the properties, nets and implementation of spatial shapes in the mathematics subject itself. This is in line with Mursyidah (2022) who said in her research that the learning process in solid geometry material using Augmented Reality media is related to the implementation of the constructivist learning theory

perspective, where when the process of teaching and learning occurs, students will build their understanding from their experiences and interactions with the Augmented Reality media. Mukhaiyar (2023) reveals that constructivist learning theory emphasizes that knowledge is not only about transferring information given by teachers to students, but students must actively build their knowledge process. Suhaiza & Hanid., (2024) explains that through a constructivist theory, knowledge will be actively developed through the use of Augmented Reality to create new knowledge. Similar to constructivism theory, this research also emphasizes multimedia learning theory, because the application used presents information in a more interesting and interactive form through the elements and features generated from this technology. Sugilar (2019) says multimedia technology can be of particular interest, because in this case multimedia applies interactive tools for users to interact directly with the display on the software. Software in math applications can simplify and explain material in learning (Sugilar, 2019). In this amazing geometry augmented reality application integrates multimedia technology such as images generated from application scans, text on the display of the properties of space buildings and 3-dimensional movements on their nets and examples of space building elements in the formula section. Therefore, with the learning media based on Amazing Geometry Augmented Reality application, students will be more active in their learning, because with this technology media, students will feel curious about the material presented by the teacher. But even so, this study has limitations in the context that lies in the sample size, which is 11 students, this small number needs to be interpreted with caution.

## **CONCLUSIONS AND RECOMMENDATIONS**

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The results of this study indicate that the *Amazing Geometry Augmented Reality* application has a significant positive effect on students' understanding of solid geometry concepts. The integration of AR-based learning media provides an interactive and visual experience that makes abstract geometry more concrete, thereby helping students recognize spatial shapes more effectively. Through its interactive features, the application creates a more engaging learning atmosphere and increases students' motivation to actively participate in the learning process. This finding confirms that technology-assisted learning media can be an effective alternative to overcome students' difficulties in mastering geometry material.

Furthermore, the study shows that AR-based media not only improves students' conceptual understanding but also supports the development of their spatial reasoning. By presenting three-dimensional objects in real-time, the application allows students to observe, manipulate, and explore geometric shapes directly, something that is difficult to achieve through traditional two-dimensional textbooks. This interactive approach helps students to better connect mathematical concepts with real-world applications, which is in line with current educational demands that emphasize meaningful and student-centered learning.

However, this study also has limitations. The research was conducted with a small sample of only 11 students, which limits the generalizability of the findings. Therefore, future research should be carried out with larger and more diverse samples, involving students from different schools and grade levels, to strengthen the validity and reliability of the results. Despite these limitations, this study highlights the potential of AR applications as innovative learning tools that can improve students' motivation, engagement, and understanding in mathematics, particularly in solid geometry. Thus, integrating the *Amazing Geometry Augmented Reality* application into classroom practice is recommended as an effective alternative to support the improvement of learning quality in mathematics education.

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