DEVELOPMENT OF AUGMENTED REALITY LEARNING MEDIA TO IMPROVE MATHEMATIC SPATIAL ABILITY

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Abstract

This study aims to develop Augmented Reality (AR) learning media to improve the mathematical spatial ability of junior high school students on geometry material. The method used is research and development (R&D). The learning media developed in this research is Augmented Reality, called Virtual Geometry. The research instrument consisted of a validation sheet, an observation sheet, and a spatial ability test. Data collection techniques used are unstructured interviews and observations. Data analysis techniques in this study include validity, practicality, and effectiveness. The results showed that Augmented Reality-based Virtual Geometry learning media met the valid and practical aspects. The media is effective in increasing spatial ability.

Keywords: *Augmented Reality, Virtual Geometry, Spasial Thinking Ability*

INTRODUCTION

Learning media developed with the help of computers have various types, one of which is an Android-based application that can be used on smartphones as teaching media. *Learning media* is a tool used in the student learning process to stimulate learning (Adam, 2015; Miftah, 2013; Rohmat, 2010). *Augmented Reality* is a learning application that combines 2D or 3D virtual shapes into a natural environment and projects these virtual shapes in real time (Huda N & Fitri P, 2017). Augmented Reality works with several technologies, including display systems that are useful for combining the natural and virtual worlds, sensing and registration functions for rendering graphics in the proper perspective, and interaction techniques for object manipulation using control interfaces (Olwal, 2010; Afissunani, 2014). The use of Augmented Reality in learning mathematics is in the material of building space. In studying the spatial structure of students, it is not easy to visualize the shape, so the teacher needs to provide suitable media to help the learning process. According to Dienes (in Jannah, 2013), every mathematical concept can be understood perfectly if presented in a concrete form, so learning media is needed to present the concept concretely. Using Augmented Reality technology and Android smartphones, geometric objects can be seen as accurate through 3D virtual modeling similar to the real object virtually right on the image on paper. Augmented reality-based learning media is closely related to spatial abilities.

According to Ningsih (2019) and Lee & Bednarz (2011), indicators of spatial ability include; (1) Spatial perception (spatial perception) is the ability that requires the position of the object being observed horizontally or vertically; (2) Visualization (visualization), namely the ability to show the rules of change or displacement of the constituents of a building, either three-dimensional to two-dimensional or preferably; (3) Mental rotation, namely the ability to rotate two-dimensional and three-dimensional objects precisely and accurately; (4) Spatial relations, namely the ability to understand the composition of an object and its

parts and their relationship to one another; and (5) Spatial orientation, namely the ability to observe and identify the shape or position of a geometric object viewed from various points of view.

The geometry of flat-sided shapes at the junior high school level is a learning material that discusses elements such as planes, corner points, edges, diagonals, diagonals of space, diagonal planes, and formulas, namely circumference, surface area, and volume. Building a flat side and curved side space will be difficult to understand if it only relies on imagination. The low level of student mastery of concepts is possible because students studying a spatial shape's visual characteristics are still weak. The cause is that the learning process provided by the teacher has not reached the required quality and abilities. Must be owned by students in learning geometry.

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Several studies have been conducted previously, including Carrera & Asensio (2016), who researched augmented reality-based learning media that can improve spatial orientation. Wahyudi & Arwansyah (2019) explained that augmented reality-assisted learning media could improve visual-spatial abilities. Pangestu et al. (2019) explain that augmented reality-assisted learning media can improve spatial abilities. Research by Arifin et al. (2020) explains that augmented reality-based learning media fulfills valid, practical, and effective aspects.

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Based on the results of interviews with mathematics teachers, many students still have difficulty learning the geometry material of flat-sided and curved-sided shapes. This is due to the lack of visualization of spatial shapes and the limited learning media to describe the characteristics of a shape that is still lacking. Not all students have the same learning experience. Based on the explanation above, it encourages researchers to conduct research with the title "Development of Augmented Reality (AR) Learning Media to Improve Mathematical Spatial Ability in Geometry Materials in Junior High Schools."

METHOD

This research uses research and development methods, with research and development design, to develop new products following level 3 development steps. In this study, the product developed is Augmented Reality learning media. Figure 1 below illustrates the research flow.

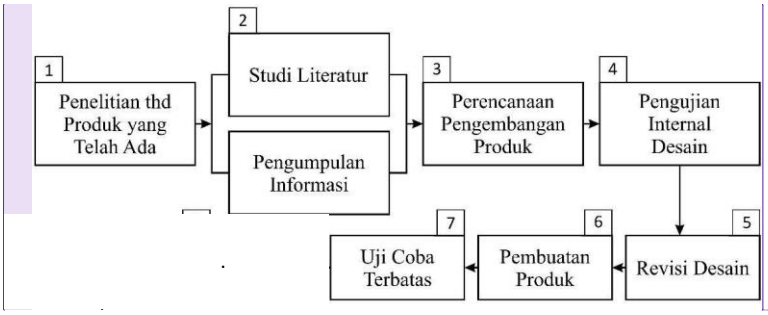

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Figure 1. Level 3 R&D research stage chart

The subjects of this study were students of SMP N 2 Pamarican researchers using pre-test and post-

test data. Data collection techniques are unstructured interviews, questionnaires, and tests with information sources from mathematics education lecturers, two junior high school teachers as material validators, and informatics engineering lecturers as media validators. The data analysis technique in this study used descriptive qualitative analysis.

RESULTS AND DISCUSSION

The following is a discussion of the research results on class VIII students at SMP Negeri 2 Pamarican. Figure 2 and Figure 3 show a geometric virtual cloud view. Figure 4 and Figure 5 show the toolbar on the menu.

Figure 2. *Third splash screen*

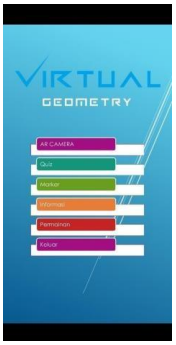

Figure 3. *Main menu*

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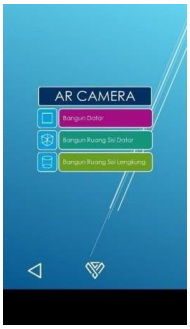

Figure 4. AR camera sub menu

Figure 5. AR camera button information

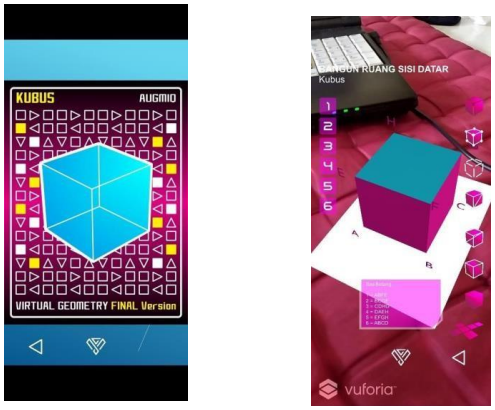

Figure 6. Examples of cube space objects

Figure 6 shows the exciting side of a flat-sided shape of the cube type. Meanwhile, Figure 7 provides information on media and creators.

Figure 7. Media and developer information

3D Modeling Using Blender Software

In this section, we explain the visual 3D shape of the surface of a cube (shown in Figure 8) and the edges of a cube (Figure 9).

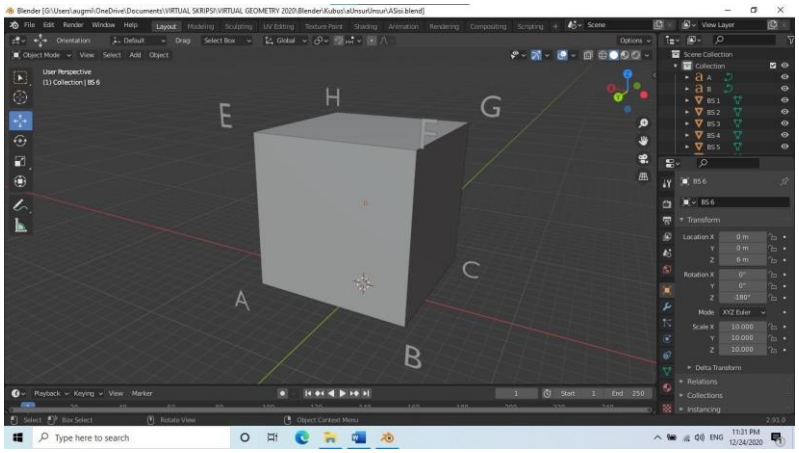

Figure 8. Cube surface 3D model

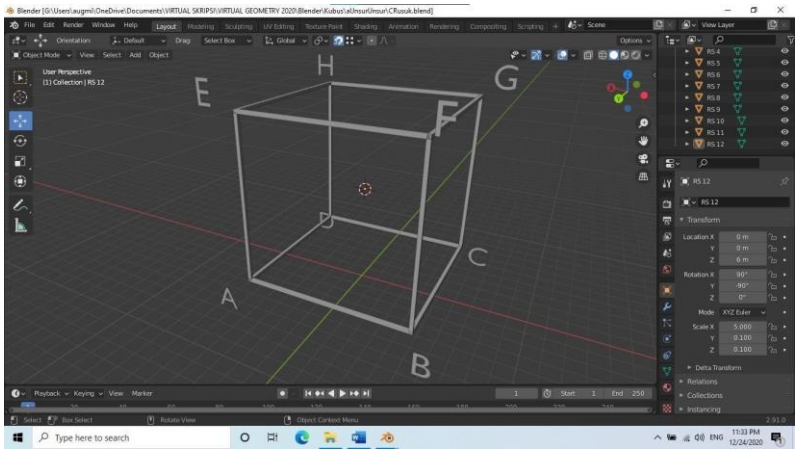

Figure 9. Cube edge 3D model

Practical Results of Virtual Geometry Learning Media

Researchers tested virtual geometry media in a small class of 15 students of SMP Negeri 2 Pamarican. The product was tested once on November 19, 2020, and students were given a user response questionnaire. Based on the test, it was found that the average score was 12.48, which was converted to 83.2%, so it was categorized as "Very Practical," or in this context, students responded well. According to the students, this virtual geometry learning media was practical and got exciting comments from students because it was new to using Augmented Reality.

The data on the student's mathematical visual-spatial ability results were obtained from the pre-test and post-test scores in the form of mathematical visual-spatial ability questions for 15 students of SMP Negeri 2 Pamarican. The results obtained from the average pre-test were 16, the lowest score was eight, and the highest score was 22. For more details, it can be seen in table 1 below:

Table 1. Virtual Geometry Pre-Test Results

No	Name	Score				Amount
		1	2	3	4	
1	Susilawati	0	4	2	2	8
2	Winda	0	4	4	3	11
3	Fitri	5	3	3	1	12
4	Yudha	5	6	2	0	13
5	Tiara	0	4	5	4	13
6	Sinta	0	4	6	4	14
7	Inez	0	5	5	6	16
8	Gendis	5	5	3	4	17
9	Indri	5	6	5	2	18
10	Deni	0	5	5	8	18
11	Rizki	5	6	6	2	19
12	Yasmin	5	5	6	3	19
13	Mediana	5	4	5	6	20
14	Salsa	5	5	6	4	20
15	Laela	5	4	5	8	22
		Amount				240
		Average				16

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Table 2 below shows that the number of interval classes is 5, with each class interval being 3. The most obtained values are in the interval 17-19, which is 33.30% (5 out of 15 students).

Tabel 2. Virtual Geoemetry Pre-Test Frequency

No	Value	Frequency (f)	xi (middle value)	f.xi	Percentage
1	8-10	1	9	9	6,66%

2	11-13	4	12	48	26,66%
3	14-16	2	15	30	13,33%
4	17-19	5	18	90	33,33%
5	20-22	3	21	63	20,00%
	Amount	15	-	240	-
	Average		fxi/n = 16		

The results obtained from the post-test average were 18.8, the lowest score was 12, and the highest score was 25. For more details, it can be seen in table 3 below:

Table 3. Post-Test Results

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No	Name	Score				Amount
		1	2	3	4	
1	Susilawati	5	3	2	2	12
2	Sinta	0	4	6	3	13
3	Winda	0	4	4	6	14
4	Fitri	5	6	2	3	16
5	Tiara	0	4	4	8	16
6	Yudha	5	5	4	4	18
7	Deni	0	5	5	8	18
8	Yasmin	5	5	6	2	18
9	Indri	5	6	5	4	20

10	Rizki	5	6	4	5	20
11	Inez	5	4	5	8	22
12	Gendis	5	6	3	8	22
13	Mediana	5	6	6	6	23
14	Salsa	5	6	6	8	25
15	Laela	5	6	6	8	25
			Amount			282
			Average			18.8

Table 4 below shows that the number of interval classes is 5, with each class interval being 3. The most values obtained are in the interval 16-18, which is 40% (4 out of 10 students).

Table 4. Frequency Post-Test Virtual Geometry

No	Value	Frequency (f)	xi (middle value)	f.xi	Percentage
1	12-14	3	13	39	20,00%
2	15-17	2	16	32	13,33%
3	18-20	5	19	95	33,33%
4	21-23	3	22	66	20,00%
5	24-26	2	25	50	13,33%
	Amount	15	-	282	-
	Average		fxi/n = 18,8		

Below are descriptive statistics from the results of the pre-test and post-test, as well as the increase in mathematical spatial ability consisting of the highest score, lowest score, and average can be seen in table 5 below:

Tabel 5. *Pre-Test* and *Post-Tes* Virtual Geometry

Type	N	Xmin	Xmax	Average	Information
Pre test	1	8	22	16	Before using virtual media geometry
Post test	1	12	25	18,8	After using virtual media geometry

Post-test mean score – Pre-test mean value = Increase score .18,8 – 16 = 2,8

Table 5 above shows that the average increase obtained from the pre-test and post-test scores after using virtual geometry media increased by 2.8%. More details can be seen in Figure 9 below:

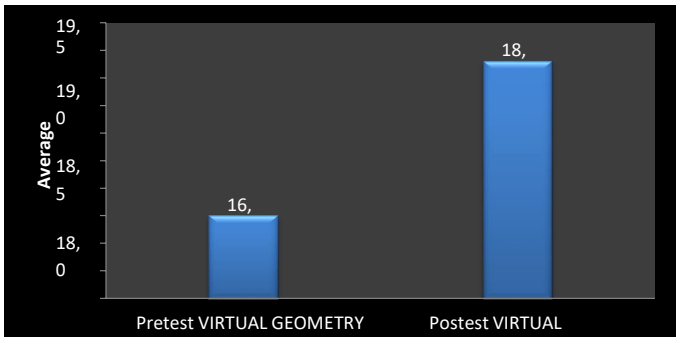

Figure 9. ***Average pre-test and post-test scores***

Based on these findings, it was identified that learning geometry material for junior high school using virtual geometry media influenced students' mathematical spatial abilities. In other words, virtual geometry media can improve the mathematical spatial ability of SMP Negeri 2 Pamarican students. In line with the research of Arifin et al. (2020) that, augmented reality-based learning media fulfills the effective aspect of increasing spatial abilities. Research by Carrera & Asensio (2016) and Wahyudi & Arwansyah (2019) explains the same thing that augmented reality-based learning media can improve spatially.

CONCLUSION

Based on the results of research on the development of Augmented Reality (AR) learning media to improve mathematical spatial abilities in geometry material in junior high schools, the conclusions are:

1. Student responses in learning to use virtual geometry media obtained from the results of the student response questionnaire were 83.2%, which means that students responded very well and virtual geometry was practically used.
2. Based on the study's results, it was identified that learning geometry material using virtual geometry media improves students' mathematical spatial abilities. Using virtual geometry media makes the middle school geometry learning experience more meaningful for students because it can explore geometric objects more real.

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