APPLICATION OF AUGMENTED REALITY TECHNOLOGY AS A LEARNING MEDIA

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Abstract

Augmented Reality (AR) is a concept of combining virtual reality with world reality. The benefits of technology at this time have greatly influenced human life, with the creation of sophisticated machines or tools that humans use to achieve human needs. Augmented Reality is an environment that incorporates virtual 3D objects into a real environment. Augmented Reality is growing very rapidly so that it supports the development of this application in various fields including learning media. Elementary school students find it difficult to understand the material of geometry, because without teaching aids students are only able to imagine or imagine the object of the geometry. Because this requires a learning application for geometry by applying Android-based Augmented Reality technology that can display 3d space shapes along with elements and formulas that apply to the material. Seeing these objectives, the researcher took the type of Research and Development Method or what in English is called R&D (Research and Development), which is a method used to produce a certain product and test the effectiveness of the product (Sugiyono, 2009: 297). The calculation method uses the one-way ANOVA method. The trial was carried out at SD Islam Pasuruan. It was tested on students in grades VI A and B and 18 participants were taken randomly and divided into 3 groups consisting of 6 students in each group. The results obtained from the calculation analysis using one-way Anova with F_count = 4.68 greater than F table = 3.68 with a significant level of 5% (0.05). Furthermore, the Scheffe test was performed to compare the values between groups. With the results, the first group (5.30) has a greater value than the second (2.65) and third (2.652) groups. This application can be installed and running on all types of android used in testing, and the recommended best distance between mobile devices to detect markers is 40 cm - 90 cm for all marker sizes, namely 10 cm, 15 cm and 20 cm in size.

Keywords: *Augmented Reality, Geometry, Android, Unity, Anova*

1. Introduction

The benefits of technology at this time have greatly influenced human life, with the creation of sophisticated machines or tools that humans use to meet human needs. In line with these developments, augmented reality technology emerged, or so-called Augmented Reality (AR).

The Augmented Reality is an interaction technology that can combine 2-dimensional or 3-dimensional virtual objects which will be added to the real environment and combine the two so as to create Mixed Reality and project it into real time [1] In AR technology, users can see the real world around them by adding virtual objects generated by computers [2].

Learning media that uses Augmented Reality technology can easily improve student understanding because 3D objects, text, images, videos, audio can be displayed to students in real time. Students can be involved interactively, which causes Augmented Reality to become a learning medium that can provide feedback to students so that students get comfortable using the media [3].

For example [4] "create AR applications to teach basic concepts of electromagnetic science. In this application, students can explore the effects of magnetic fields. In order to achieve this goal, the components used in the experiment such as cables, magnets, batteries, etc., can be identified using mobile camera devices such as tablets. Researchers in the field of education have recognized AR as a technology with great potential to influence effective and cognitive learning outcomes [5].

Students find it difficult to understand the material of geometry, because without teaching aids the student is only able to imagine or imagine the object of the geometry. By looking at this condition, a study was carried out with the aim

of designing, analyzing and testing the effectiveness of the AR-based learning media application that can be used by students to make it easier to understand and increase interest in learning about the material for introducing space. So the research was taken with the title "THE APPLICATION OF AUGMENTED REALITY TECHNOLOGY AS A LEARNING MEDIA".

2. *Methods*

A. Research Methods

This chapter describes the purpose of research, namely to design and build a mathematics learning media application in geometry material which is applied in a book called AR-Book by using Augmented Reality technology which is useful for supporting student learning. Seeing these objectives, the researcher took the type of Research and Development Method or what in English is called R&D (Research and Development), which is a method used to produce a certain product and test the effectiveness of the product [6]. This research was conducted in seven stages consisting of (1) literature study, (2) implementation design, (3) testing, and (4) test results (5) analysis of test results (6) reports and activity schedules.

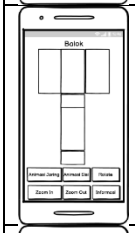
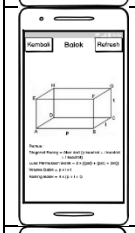
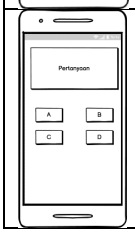
a) Study Of Literature

The stages in this process include conceptualizing the application that will be made by conducting literature studies based on the research topics taken. From the literature above, it can be a basis for researchers to design, analyze and determine application concepts that are attractive and effective for users in Geometry learning applications.

b) Implementation Design

At this stage using a storyboard to describe a description of each scene, by explaining all multimedia objects and the scene links that are displayed.

Table 1. Storyboard And Description

Storyboard	***Description***
	*Main Menu Display* *There are several buttons like Ar Camera, Guide, Quiz, Exit.*
	*Ar Camera view* *There are several buttons such as Net Animation, Side Animation, Rotate, Zoom In, Zoom Out, Information.*
	*Camera Ar Information Display* *There is information about the material and a back and refresh button.*
	*Quiz View* *There are several questions and buttons to answer these questions.*

c) Testing

1) The variables to be used

The independent variable or independent variable is the variable that affects the change [7]. So that the independent variable in this study is AR Learning Media.

The dependent variable or dependent variable is the variable that is observed or measured to determine whether there is an effect on the independent variable [8]. So that the dependent variable in this study is the effectiveness of learning applications to improve learning abilities and interest.

2) *Test Place*
   Game trials were conducted at the SD Islam Pasuruan, East Java Province. Site permits and research samples have been approved by the principal of the Islamic Elementary School in Pasuruan City, in this case, Mrs. Evi Nurhidayah, S.Pd.I.
3) *Trial Time*
   The application trial was carried out on the same day on July 18, 2020, due to this pandemic, the school's policy for teaching and learning activities was divided into several days, for example Monday for grade 1, Tuesday for grade 2 and so on up to grade 6 The game was tried out on class VI students who had received the geometry material. Of all the students in grades VI A and B, 18 students were taken randomly and divided into 3 groups. From each group there are 6 students to become participants in the trial.
4) *Population*
   The population in this study were 18 participants who came from class VI A and VI B in SD Islam Pasuruan city. The 18 participants were divided into 3 groups into 6 trial participants in each group. Participants are students who have received material about geometry.
5) *Sample*
   The total number of participants who were tested was 18 students. Students are divided into three groups so that one group consists of 6 people.

d) *Data Collection Technique*

There are 2 ways in which to collect sample data in this study. Among them are: (1) The content of the geometry is adjusted to the abilities of the participants. So that it takes mathematics book literature for class V with the 2013 learning curriculum. (2) Test questions are given to participants so that researchers know the participant's initial level of ability (pretest) and the final level of participant ability (posttest) after conducting the AR application experiment.

e) *Data Processing Technique*

After the participants conducted the trials in the form of tests and treatments (AR Application Geometry), then the difference in the value of the total participant scores was calculated where: X1 (pretest value) - Y1 (postest value). After the test results are obtained, the next step is to perform a test analysis using the one-way ANOVA method and using a significance level of 5% (0.05). The hypothesis that will be made is:

H0 = AR learning media geometry is not effective for students to increase interest in learning about geometry.
H1 = AR learning media for geometry is very effective for students to increase interest in learning about geometry.

The difference between the participant's tests was analyzed using the one-way ANOVA method with the aim of knowing whether there was a difference in the average between the sample groups (Koyan, 2012).

B. *System Planning.*

a) *Flowchart System / Main Menu*
   The algorithm of the wake-up learning application system to be built is as shown in Figure 1:
   1) *When opening the application, the user will enter the main menu with 3 options namely Ar geometry, Guide and Exit.*
   2) *If the user selects Ar Bangun Ruang, the user will be directed to the Ar Bangun Ruang menu / page.*
   3) *If the User selects Guide, then the user will be directed to the menu / page of the Guide.*
   4) *If the User selects Exit, the user will exit the application.*

b) *AR Flowchart Geometry*
   The algorithm of the Ar Menu will be built as shown in Figure 2:
   1) *When the user enters the Ar Geometry Menu, the first display appears is a guide, then point the smartphone at the marker, then the marker rendering process occurs which will display a 3d shape display.*
   2) *There are several buttons in the menu including, Net Animation, Side Animation, Rotate, Zoom In, Zoom Out, Information, Flash and Back, where these buttons have their respective functions.*
   3) *If the user presses the Grid Animation button, the geometry 3D Space will display the Grid Animation / Change the Geometry to a nets Geometry.*
   4) *If the user presses the Side Animation button, the Geometry 3D Space will display the Side Animation.*
   5) *If the user presses the rotate button, the Geometry 3D Space will have a rotate / rotation effect / function.*
   6) *If the user presses the Zoom In / Zoom Out button, the Geometry 3D Space will have an effect / function to enlarge / reduce the object.*
   7) *If the user presses the Information button, a display of material from the Geometry will appear, such as formulas and elements, then there is a game quiz button below, if pressing the button will switch to the game quiz page.*
   8) *If the user presses the Flash button, the smartphone camera flash will turn on which functions to illuminate the marker when it is dark / lack of light, to simplify the process of rendering the marker into 3D.*

c) *Flowchart Guide*

The algorithm of the Guide Menu to be built is as shown in Figure 3:

1) *When the user enters the Guide menu, a manual display will appear in using the application.*
2) *The first download marker Ar Geometry.*
3) *Point the Camera at the marker.*
4) *Try to have adequate lighting so that when scanning the marker is not difficult.*
5) *3D model will appear when the marker is detected by the camera.*

d) *Quiz Flowchart*

The algorithm of the Quiz Game that will be built is as shown in Figure 4:

1) *When the user enters the Game Quiz page, a quiz display will appear, in the quiz there are 5 multiple choice questions with different material according to the Geometry in the scene.*
2) *After the user completes the 5 questions, the final score will appear.*
3) *Then there are Repeat and Back buttons, if you press the repeat button, the user will repeat the quiz, if you press the back button, the user will return to the Camera AR Menu.*

3. Results and Discussion

A. Making Applications

The application is designed using the Unity application, Blender and the database using Vuforia. This application will later be tested on the Android 9.0 (Pie) platform. The following is an explanation of the application made.

Fig.5. Main menu display

Description:

This is the main menu view of the application, in that view there are several menus / buttons, the first is the AR menu Geometry, Guide, Exit.

Fig.6. Guide display when activating AR

Fig.7. AR game display

Description:

This is the display of the ar room wake up menu, in the ar menu of the geometry, the first one there is a guide view in using the application, if you click the first guide, it will be directed to Google Drive to download the marker, then after the marker scan is done, the display will appear automatically. 3d, then there is a net animation button to see the animation of the net (a flat shape becomes a space), then there is a side animation button (to find out the side of the shape), then there is a rotate button, if the button is pressed, the 3d shape will be rotate / rotate clockwise, then there is a zoom in, zoom out button, which aims to enlarge / reduce the 3d object, then there is an Information button, if the button is pressed, information (material) about the 3d shape will appear, information about the explanation , the formula and the characteristics of the 3d shapes then there is a game quiz button which will be directed to quiz page, then there is a home button in the upper right corner, which functions to return to the main menu, then there is a light button, which functions to turn on the flash of the cellphone so that you can read the marker at night / in a low light room.

B. Application Testing

Application testing is carried out to determine the level of application effectiveness in learning to build a space. The learning outcomes in this study were taken based on the pre-test and post-test scores. The questions in the form of entries are 10 items which are counted on a scale of 100 so that the value of one item is 10. In the initial stage, participants are

given pre-test questions. Furthermore, participants are given treatment including 3D Arbuild Space views, materials and game quizzes with one chance to play, then players are given a post-test with similar questions to know the level of development. The data were taken from the pre-test and post-test. Following are the results of the participants' pre-test and post-test which are shown in Tables 2, 3 and 4.

Table 2. First Group Test Results

Participants	***Early (Pre-test)***	***And (Post-test)***	***Difference***
1	*30*	*80*	*50*
2	*50*	*90*	*40*
3	*50*	*90*	*40*
4	*30*	*80*	*50*
5	*40*	*80*	*40*
6	*30*	*90*	*60*
Average			*46,66*

Table 3. Second Group Test Results

Participants	***Early (Pre-test)***	***And (Post-test)***	***Difference***
1	*50*	*80*	*30*
2	*50*	*90*	*40*
3	*80*	*90*	*10*
4	*40*	*90*	*50*
5	*70*	*90*	*20*
6	*30*	*90*	*60*
Average			*35*

Table 4. Third Group Test Results

Participants	***Early (Pre-test)***	***And (Post-test)***	***Difference***
1	*30*	*70*	*40*
2	*60*	*80*	*20*
3	*70*	*80*	*10*
4	*60*	*80*	*20*
5	*60*	*90*	*30*
6	*60*	*80*	*20*
Average			*23,33*

From the results of the three tests, the difference in value is assumed to be the change in the value of the trial participants. As shown in table V below.

Table 5. Result Of Difference Between Groups

Participants	***Difference in value between pre-test and post-test***			
	Kel A	***Kel B***	***Kel C***	***Total***
1	*50*	*30*	*40*	
2	*40*	*40*	*20*	
3	*40*	*10*	*10*	
4	*50*	*50*	*20*	
5	*40*	*20*	*30*	
6	*60*	*60*	*20*	
	$N_1 = 6$	$N_2 = 6$	$N_3 = 6$	$N_3 = 18$
	$\sum X1 = 280$	$\sum X2 = 210$	$\sum X3 = 140$	$\sum Xtot = 630$
	$\sum x_1^2 = 13400$	$\sum x_2^2 = 9100$	$\sum x_3^2 = 3800$	$\sum x_{tot^2} = 26300$

After obtaining the result data from the pre-test and post-test, the data normality test was then carried out. The data normality test aims to see whether the data is normally distributed or not before performing the Anova statistical test. The data normality test here uses the Shapiro Wilk method because the data sample is small, which is less than 50 with a significance level of 0.05. The results of the data normality test of the three data are shown in Figure 13 below.

Tests of Normality

		Shapiro-Wilk		
	Kuis Game	Statistic	df	Sig.
Penerapan Teknologi Augmented Reality Sebagai Media Pembelajaran	Kelompok 1	.822	6	.091
	Kelompok 2	.982	6	.961
	Kelompok 3	.915	6	.473

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

a. Lilliefors Significance Correction

Fig.13. Normal Distribution Data Test

From the results of the data normality test above, the significance value for Group 1 is 0.091. Group 2 amounted to 0.961 and Group 3 amounted to 0.473. The results show that the significance value (sig.) Of the three groups is greater than the tolerance value 0.05. So it can be concluded that the data can be normally distributed. Furthermore, the Anova calculation is carried out as follows.

Anova calculation:

1) *Calculate the Total Sum of Squares* JK_{tot}
   $= 26300 - \frac{630^2}{18}$ *(1)*
   $= 4250$
2) *Calculating the number of squares between groups* JK_{antar}
   $= \frac{280^2}{6} + \frac{210^2}{6} + \frac{140^2}{6} - \frac{630^2}{18}$ *(2)*
   $= 1633.33$
3) *Calculating the Number of Squares in the Group* JK_{dalam}
   $= 4250 - 1633.33 = 2616.66$ *(3)*
4) *Calculating the Mean Squared (Average Number of Squares or RJK) between groups*
   $= a\text{-}1 = 3\text{-}1 = 2$ *(4)*
   $= 1633.33 : 2 = 816.66$
5) *Calculating the Mean Squared (Average number of Squares or RJK) in the Group*
   $= N\text{-}a = 18\text{ -}3 = 15$ *(5)*
   $= 2616.66 : 15 = 174.44$
6) *Calculate the price* F_{hitung}
   $\frac{RJK_{antar}}{RJK_{dalam}} = \frac{816.66}{174.44} = 4.68$ *(6)*
7) *Consult F table with the db (degrees of freedom) numerator (a-1) and db (degrees of freedom) denominator (N-a)*
   Pembilang (a-1) $= 3\text{-}1 = 2$
   Penyebut (N-a) $= 18\text{-}3 = 15$
   F_{tabel} *(2.15) dengan taraf 0.05* $= 3.68$ *(7)*
   $F_{hitung} = 4.68$
8) *Decision rule: if* F_{hitung} *is greater than* F_{tabel} *at a certain significant level, for example: ts 5% or 1% then* H_1 *is accepted and* H_0 *is rejected.*
   $\boldsymbol{H_1}$*= "AR learning media for geometry is very effective for students to increase their interest and ability to learn to Geometry ".*

Sumber Variasi	JK(SS)	db(df)	RJK(MS)	Fh	Ft	Keputusan
Antar A	1633,333333	2	816,6666667	4,681528662	3,68	Signifikan
Antar D	2616,666667	15	174,4444444	-	-	
Total	4250	17	-	-	-	

Fig.14. Anova calculation summary

Because H_0*is rejected, the next step is to make comparisons between groups with the t value test. Where in this study the t test used was the Scheffe test.*

Critical values of the Scheffe test:

$t_s = \sqrt{(3-1)F_{(0.05):(2.15)}} = \sqrt{2(3.68)} = \sqrt{7.36} = 2.71$

$t1-3 : t = \frac{46.66-23.33}{\frac{\sqrt{2(174.44)}}{18}} = \frac{23.33}{\frac{\sqrt{348.88}}{18}} = \frac{23.33}{\sqrt{19.38}} = \frac{23.33}{4.40} = 5.30$ *(1)*

$t1-2 : t = \frac{46.66-35}{\frac{\sqrt{2(174.44)}}{18}} = \frac{11.66}{\frac{\sqrt{348.88}}{18}} = \frac{11.66}{\sqrt{19.38}} = \frac{11.66}{4.40} = 2.65$ *(2)*

$t2-3 : t = \frac{35-23.33}{\frac{\sqrt{2(174.44)}}{18}} = \frac{11.67}{\frac{\sqrt{348.88}}{18}} = \frac{11.67}{\sqrt{19.38}} = \frac{11.67}{4.40} = 2.652$ *(3)*

By comparing the t value with the critical value of the Scheffe test (ts), it can be concluded that the t1-3 value (group 1 vs group 3) is greater than the critical value of 2.71. This means that the first group has a greater value on the learning outcomes of participants than the second group and the third group.

From the results of the analysis above, it is concluded that the learning media using AR technology is very effective for improving the learning outcomes of Geometry Learning participants (students).

C. Mobile Device Testing

In this test, experiments were carried out on several android mobile devices that have different specifications and versions of Android. The results can be seen in Table 4.5 with the information that "installed" means the application is installed on

the android mobile device, and "running" means that the application can run smoothly and can be implemented on the android mobile device.

Table 6. Android Mobile Device Testing Results Table

No	***Types of Android Mobile***	***Specification***	***Information***
1	*Xiaomi Redmi Note 2*	*Ram : 2 Gb* *Kamera : 13 Mp* *Android : Android 5.0 (Lollipop)* *Processor : Octa-core 2.0 GHz Cortex-A53*	*Applications Installed and Running with clear 3D object results*
2	*Sony Xperia Z2*	*Ram : 3 Gb* *Kamera : 20,7 Mp* *Android : 6.0 (Marshmallow)* *Processor : Quad-core 2.3 GHz Krait 400*	*Applications Installed and Running with clear 3D object results*
3	*Oppo F5*	*Ram : 4 Gb* *Kamera : 16 Mp* *Android : 7.1 (Nougat)* *Processor : Octa-core 2.3 GHz Cortex A53*	*Applications Installed and Running with clear 3D object results*
4	*Samsung Galaxy J7 Prime*	*Ram : 3 Gb* *Kamera : 13 Mp* *Android : 8.1 (Oreo)* *Processor : Octa-core 1.6 GHz Cortex-A53*	*Applications Installed and Running with clear 3D object results*
5	*Asus Zenfone Max M2*	*Ram : 4 Gb* *Kamera : 13 Mp* *Android : 9.0 (Pie)* *Processor : Octa Core 1.8 GHz Kryo 385*	*Applications Installed and Running with clear 3D object results*
6	*Realme 3 Pro*	*Ram : 4 Gb* *Kamera : 16 Mp* *Android : 10.0 (Q)* *Processor : Octa-core (2x2.2 GHz Kryo 360 Gold & 6x1.7 GHz Kryo 360 Silver)*	*Applications Installed and Running with clear 3D object results*

Table 6 explains that all types of androids used in this test can be paired and run with the results of 3D objects clear.

D. Marker Testing

This marker testing is done by testing based on the distance between the android mobile device and a marker on a scale of 10 cm - 100 cm and 3 kinds of marker sizes including 10 cm, 15 cm and 20 cm. The results can be seen in Table VII where the checklist sign (√) explains that the marker is detected, that is, the android mobile device can display 3D objects well, while the cross (×) explains that the marker is not detected, that is, the 3D object does not appear.

Table 7. Marker Testing Results Table

		Marker

No	*Distance (cm)*	*Marker 10 cm*	*Marker 15 cm*	*Marker 20 cm*
1	*100*	*x*	√	√
2	*90*	√	√	√
3	*80*	√	√	√
4	*70*	√	√	√
5	*60*	√	√	√
6	*50*	√	√	√
7	*40*	√	√	√
8	*30*	√	√	*x*
9	*20*	√	*x*	*x*
10	*10*	*x*	*x*	*x*

Table 7 explains that the smaller the marker size, the closer the mobile camera device is to detect the marker, and the larger the marker used, the farther the mobile camera device is in detecting the marker. The best distance between mobile devices to detect markers is 40 cm - 90 cm for all marker sizes, namely 10 cm, 15 cm and 20 cm.

4. CONCLUSIONS AND SUGGESTIONS

From the results of the research that has been done at SD Islam Pasuruan, several conclusions can be drawn as follows.

1) *Geometry Learning Application using Android-based Augmented Reality technology as an effective learning medium to increase interest and improve student learning outcomes. The material and questions presented in the application are based on the Mathematical Formulas book and the 5th Grade Elementary School Mathematics book which are in accordance with the 2013 curriculum and approved by the Mathematics Teacher.*

2) *The trial was carried out at the SD Islam Pasuruan. Students in the test were students of class VI A and B and were taken randomly with a total of 18 participants. Students are divided into 3 groups consisting of 6 participants in each group. The testing phase is to provide a test (pre-test) in the form of questions, treatment play the game quiz. And then the test (Post-test) by giving the same questions. Then perform the data normality test, because the sample is less than 50 using the Shapiro Wilk test. The results show that the significance value (sig.) Of the three groups is greater than the tolerance value 0.05. Then perform one-way ANOVA calculations. The results obtained from the calculation analysis using one-way ANOVA with F_count = 4.68 greater than F table = 3.68 with a significant level of 5% (0.05) then H_1 is accepted with the hypothesis "AR learning media is very effective for students to increase their interest and learning ability geometry". Because H_0 was rejected, a Scheffe test was performed to compare the values between groups. The result is that the first group (5.30) has a greater value on the learning outcomes of participants with a critical score (t_s) of 2.71 compared to the second (2.65) and third (2.652) groups.*

3) *The test results of the android mobile device explain that the application can be installed and run well on all types of android used in testing, and in marker testing, the best distance between mobile devices in detecting markers is 40 cm - 90 cm for all marker sizes. namely the size of 10 cm, 15 cm and 20 cm. Size of AR Geometry Application is 34.2 mb.*

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