

Mathematics Learning Media With Augmented Reality (AR) Based On Android Mobile Application

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Abstract— Augmented Reality is a new technology in the industry 4.0 era that combines the real world and in real time. The result of Augmented Reality is the visualization of a 3D object obtained from marker detection by a smartphone camera. Augmented Reality has been developed in various fields, one of which is the field of education. Augmented Reality in education can be used as a medium for learning mathematics, especially in the material of geometry in junior high schools where most students find it difficult to understand the concept of the material. With the help of Augmented Reality, students can learn directly about the concept of nets, surface area, and volume of building space in 3D. Users just need to scan the card that has a marker then in real time the user can see the object to be studied. The making of this media applies software development methods namely Waterfall and in its making using Vuforia Master Package, Unity3D, and Blender software. The ultimate goal is with AR students are expected to understand the concept of building space easily.

Keywords-component; augmented reality, learning, media, 3D object, spaced geometry, junior high school, mathematics, android

I. INTRODUCTION

Today, technology is growing rapidly. One of the factors of this technological progress is the emergence of the industry era 4.0 which emphasizes more on digital basics [1]. Thus, there are now many types of technology development. One result of the development of technology is Augmented Reality (AR) technology.

Augmented Reality (AR) has many benefits in life. For example in the fields of social, science, education, and so on. This is because Augmented Reality (AR) is a technology development that can combine real and virtual worlds in real time [2]. So, it can help the effectiveness of doing work.

The benefits of Augmented Reality (AR) in the field of education, for example, is to minimize misunderstandings that arise due to the limited ability of students to visualize concepts. Most students find it difficult to imagine what a chemical bond is, so that AR allows students to easily visualize object animation in detail. AR also has the advantage of allowing visualization of objects or macro or micro concepts that cannot be seen with the naked eye. AR displays objects and concepts in different ways or from different points of view in helping students to better understand the subject [3] in [4].

In the field of education, of course needed supporting equipment or media that can be used to help facilitate teaching and learning activities. But in today's technological era, the use of technology in learning is still very rare. Whereas according to [5], learning media is one of the things that is very important in supporting the success of activities - learning itself. Learning media can help students to more easily capture a material or concept taught by a teacher [6]. So, with learning media students are expected to be easy to understand the material or concepts given by the teacher.

Mathematics is a difficult subject for students. In fact, mathematics subjects also teach the ability to think logically, critically, systematically and analytically. Aspects in mathematics subjects are numerous, one of which is the spatial aspect. In space, it is learned about 2D and 3D objects. 3D objects in mathematics are studied in one of the mathematical fields, namely Space Geometry.

However, in the current technological era, learning media are rarely found about space geometry material. In fact, time after time the development of technology is accelerating and many new technologies are emerging. Supported from these problems, in this study will be discussed innovations related to space Geometry learning media with Augmented Reality based on Android Applications. It is expected that with this media can help students in understanding the material concept of Space Geometry.

II. THEORY

A. Learning Media

In order to provide effective services in teaching and learning the use of media education and multimedia technology is very important and the media of higher education and the delivery of multimedia technology services have had a dramatic impact on teaching and learning, especially with ready access to new technologies, education institutions are well positioned to take advantage of this rapid change. Learning media has many kinds such as print media, non-print media, electronic media, and some in the form of hardware or software. Learning media refers to communication channels that carry messages with instructional goals. They are usually used for learning and teaching purposes [7].

Learning media is like a bridge between the communicator of the material, the teacher and the student as the recipient of the material. The general meaning of the media is a tool that can be used as a channel for messages to achieve teaching objectives [8].

B. Augmented Reality

Augmented Reality (AR) is a new technology that blurs the line between what is real and what is produced by a computer by improving what we see, smell, hear, and feel. Augmented Reality (AR) is said to be one type of Virtual Reality (VR). It is said to change the way we see the world around us. Basically this adds a layer of graphics and other sensory enhancements in the natural world as they exist in real time [9]. Augmented Reality (AR) places virtual objects in a real environment in real time that we can see through different display objects and turn the environment around us into a digital interface [10]. The workings of Augmented Reality can be seen in Fig. 1.

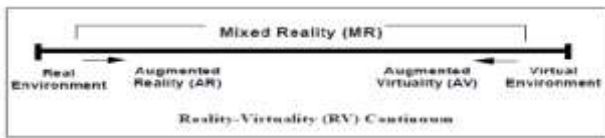


Figure 1. How to work Augmented Reality

C. Space Geometry

Geometry is one aspect of mathematics. One sub geometrical material is the geometry of space. Space geometry is the study of space in a geometric field where objects studied are spatial objects or 3D objects.

According to [11], stated that in general the geometry abilities that students must possess are: 1) Able to analyze the characters and characteristics of geometric shapes both 2D and 3D; and able to construct mathematical arguments about geometrical relations with others; 2) Able to determine the position of a point more specifically and describe spatial relationships with other systems; 3) Transformation application and use it symmetrically to analyze mathematical situations; 4) Using visualization, spatial reasoning, and geometry models to solve problems. For this purpose the purpose of geometry learning in general is so that students gain confidence about their mathematical skills, become good problem solvers, can communicate mathematically, and can reason mathematically.

D. Mobile Devices and Application

A mobile device, also known as handheld device, is a pocket-sized computing device, typically having a display screen with touch input or a miniature keyboard. Smartphones and tablets are popular amongst those who require the assistance and convenience of a conventional computer, in environments where carrying one would not be practical. These devices provide users with all features and functionalities necessary for business, study, and personal needs. Users can make phone calls, surf net, check and answer emails, set up calendar, listen to music, watch videos, prepare documents, chat with others, and play games. Typically these devices can

provide almost everything you can get from a laptop with a much higher level of portability. [12]

III. METHODS OF RESEARCH

In this study, focused on the development of Augmented Reality based on Android Applications. So, in this study the author uses the waterfall method in the development of Learning Media. The steps in the waterfall method according to [13] are as follows:

A. System Requirements Analysis

In this phase, all software product requirements are collected in this phase and documented in the software requirements specification document.

B. Design Construction

In this phase, the overall structure of the software product is designed based on the needs analysis phase.

C. Implementation (Coding)

Software development begins in this phase. This develops in small programs called units. These units are tested according to their functions and integrated in the next phase. [14] in [13]

D. Testing

In this phase, all units developed in the implementation phase are combined. Then all products are tested to check whether the product meets its target. Software and bug defects are reported, if available, repair and retest.

IV. DISCUSSION

A. System Requirements Analysis

1) In this Augmented Reality-based learning media application, it is made for all people but is more specialized to the actors of teaching and learning activities at the junior high school level. This application is a combination of print media and computer technology which will take the form of an android application. In this application a camera is needed to read the marker, where from the marker a 3D object will appear on the smartphone screen.

This application is the final result in the form of print media in the form of mobile-based Augmented Reality markers and applications. In the needs analysis of this Augmented Reality application, it is composed of how the application needs in the manufacturing process. That is with the software and hardware needed in making this application. The requirements needed in the process of making this application are as follows:

TABLE I. SYSTEM REQUIREMENTS ANALYSIS TABLE

Software	Information
OS Windows 10	OS used in making applications
Java Development Kit	Java programming developer tool
Vuforia Master Package	Augmented Reality Library used in making applications

Android SDK	Android program development tool
Unity 3D	Program interface in the form of 3D objects and videos
Blender	3D object maker
CorelDraw x7	2D graphic design maker

3) User Interface

The user interface design in this application can be seen in Fig. 4 is the application's initial page design, Fig. 5 is the main page of the application, Fig. 6 pages of material selection, Fig. 7 examples of page geometry material page design, Fig. 8 design questions, and Fig. 9 is a design output from Augmented Reality.

B. Design Construction

After analyzing the requirements needed in making the application, the next step is designing the design. As for this stage, several design designs are carried out namely algorithm design, software architecture and designing the user interface design.

1) Algorithm Design

The algorithm of Augmented Reality based learning media applications can be seen in Fig. 2:

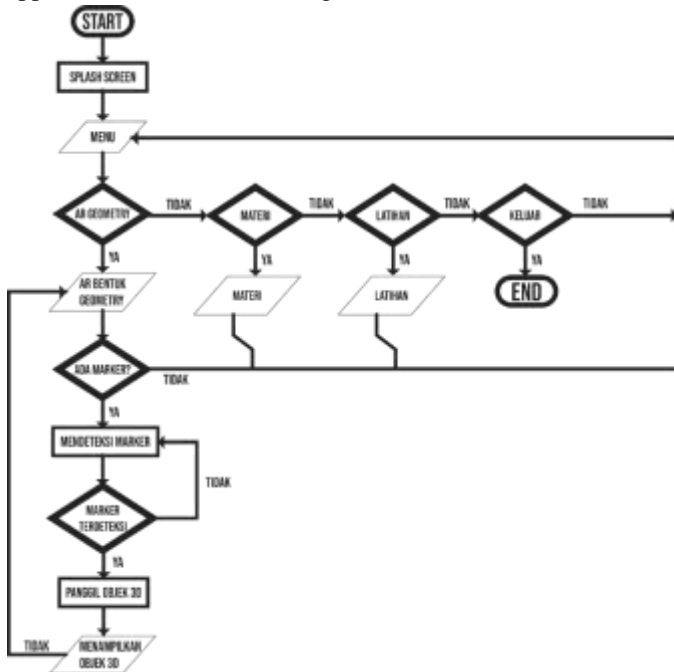


Figure 2. Algorithm of the Augmented Reality application

2) Software Architecture

The architecture of this learning media application can be seen in Fig. 3:

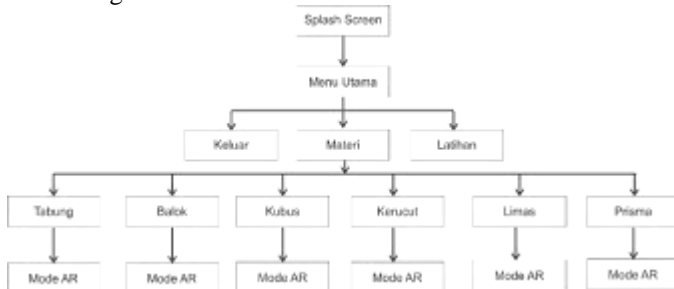


Figure 3. Architecture of learning media applications



Figure 4. Homepage design



Figure 5. Main page design



Figure 6. Material page design



Figure 7. The cube page material design



Figure 8. Practice page design



Figure 9. Page design of Augmented Reality (AR) mode

C. Implementation (Coding)

1) Image Target

To implement a target image into an Augmented Reality environment, the method that must be done is to determine the image, measure its size, determine the quality and quantity of its features and create configuration files and datasets from the target image. The process of assessing the feasibility of images used for target images online. Fig.10 is a look at the Vuforia Development Portal, which is used to create target images for markers in this learning media application.

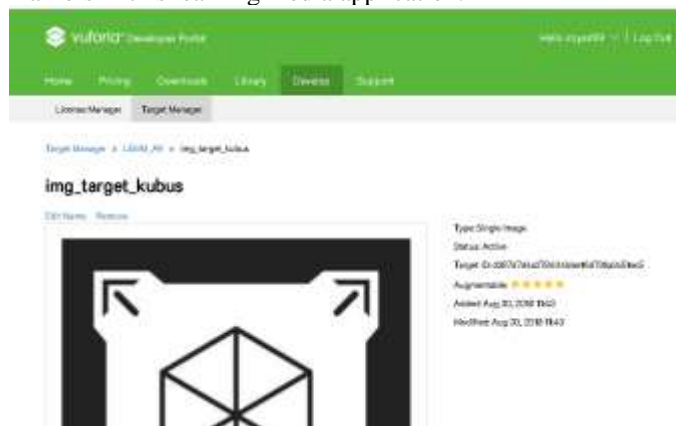


Figure 10. Display on the Vuforia Development Portal

2) Application Creation

• Image Target Preparation

To create an Augmented Reality (AR), a unique image is needed to bring up a 3d object. We create a target image using Coreldraw software. After you finish creating the target image, then we must upload the image to the vuforia database so that it can then be used in unty. After the target image is

uploaded, the download package must be installed on unity.

- Creation of a User Interface
A program requires an UI (user interface). Ui includes button layout, button icons, and background. We made UI with Coreldraw software. After the design is done so that the image can be used in the application we must export the image. We export the image to the .png format because the image does not break if there is a size change.
- 3D Model Making
3D model making is done using the 3D blender software. We use a 3D blender because the software is open source and lighter. What is made with this software is the 3D model and its animation.
- Source Merging on Unity3D
In the step of merging / assembly and coding we use 3D Unity because this software is free and the UI is simpler. All materials needed, including models, UIs, animations, core vuforia, and database packages from vuforia are entered first into this unity project. After everything is ready, then the next is to set the object object and do the coding so that the user can interact with the element elements in the application that will be created. After the application is ready, then we need to do testing first or just try the application by playing on Unity or by making the APK and install the APK on our Android.

3) Exporting the Application to Mobile Application

After, the application is finished, the next step is to build the application to the form (.apk) so that it can run on the mobile device as shown in Fig. 11.

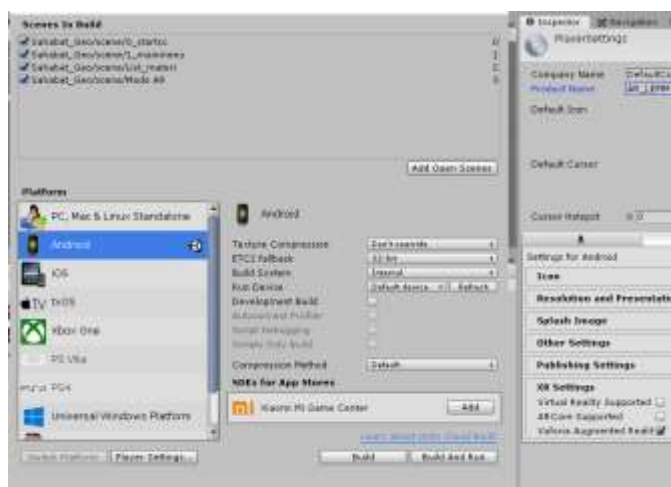


Figure 11. The process of exporting applications in the form (.apk)

D. Testing

1) White Box Testing

In the white box test aspects tested are found in the AR Application Menu on Unity3D based on the flowchart that has been made. Then the flow diagram is formed as shown in Fig. 12.

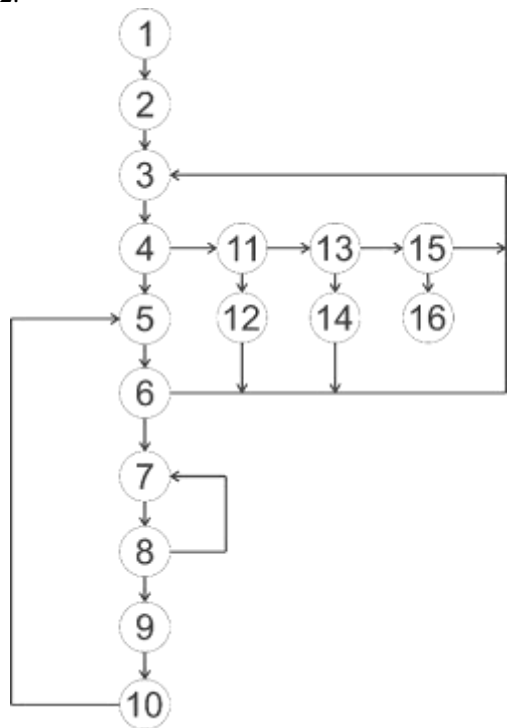


Figure 12. Flow Diagram of the application

Siklomatic complexity from flow charts can be obtained by calculation:

$$V(G) = E - N + 2 \quad (1)$$

Notes :

E = The number of edges of the flow chart marked with an arrow image.

N = The number of flow graph nodes marked with circle images.

Based on Eq. (1) and data from Fig. 12 the cyclomatic complexity is:

$$V(G) = 21 - 16 + 2 = 7$$

The base sets generated from the independent pathways are linear as follows:

- 1-2-3-4-5-6-3
- 1-2-3-4-11-12-3
- 1-2-3-4-11-13-14-3
- 1-2-3-4-11-13-15-16
- 1-2-3-4-11-13-15-3
- 1-2-3-4-5-6-7-8-7
- 1-2-3-4-5-6-7-8-9-10-5

When the application is run, it appears that one of the resulting base sets is 1-2-3-4-5-6-3 and it appears that the node has been executed once. Based on observations of these provisions in terms of software feasibility, this system has fulfilled the requirements.

2) Black Box Testing

To investigate whether the application can be used properly, it also requires testing with the black box testing method. In testing the black box testing tested is the syntax that composes the application. If there is an error, it will be repeated again at the implementation stage (application creation), but if there is no error, it will be tested again in the next stage, namely mobile device. This test is carried out on Unity3D software which is a maker of Augmented Reality learning media applications. The process of testing black box testing can be seen in Fig. 13.

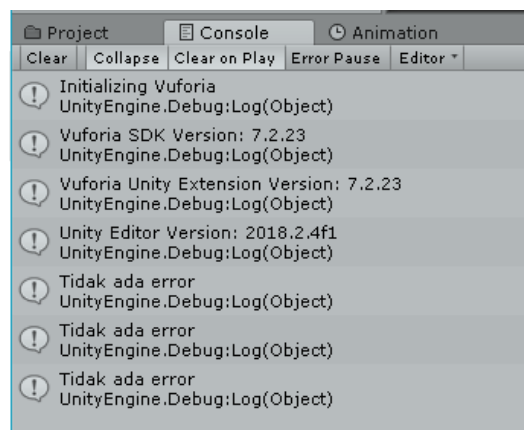


Figure 13. Testing process with black box testing

In Fig. 12 can be seen that there is no error that occurs when doing black box testing.

V. CONCLUSION

The conclusion obtained after making this Augmented Reality (AR) based learning media application. From a managerial perspective, it can be easier to learn the concepts of geometry, and to attract interest in studying geometrical material. From the aspect of the system, this application is a good learning media because it is based on Android and can be accessed anywhere and anytime by everyone.

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