AUGGO: Augmented Reality and Marker-based Application for Learning Geometry in Elementary Schools

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***Abstract*— Suitable learning media can be used to achieve learning goals. The more interactive the learning media, the learning process will be more interactive. This paper proposes a learning media named Auggo. Auggo is an Augmented Reality (AR) and marker-based application as an interactive media to learn geometry in Elementary School. To show the impact of Auggo, this research conducts a test to 14 students in elementary school as participants. The test was carried out using the Two-Group Paired Sample T-Test method with those 14 elementary school students. Participants were divided into 2 groups: 7 participants as Group A (experimental class) and 7 participants as Group B (control class). Assessment of participants showed the results of the pretest to posttest in Group A increased by 26%, while Group B only increased by 10.29%. These results indicate that the AR-based AUGGO application can help students in improving the understanding of space concept.**

Keywords*— *learning media, Augmented Reality, Geometry, Elementary School

I. INTRODUCTION

Media education, in general, includes teaching and learning tools. According to [1], the physical means of learning media is to deliver content or learning materials. The learning media can be books, movies, or videos. According to the National Education Association [2], learning is a communication media including printed/non-printed media and technology hardware.

Learning media can be used to achieve learning goals. The more effective the learning media that is used, the learning process will be more effective. There are many kinds of learning media i.e. visual (graphs, diagrams, charts, posters, and comics), audio (tape recorder and language lab), projected still media (slides and over-head projector (OHP)), and projected motion media (movies, television, video (VCD, DVD, VTR) and computers).

Technology in learning media is increasing rapidly. Microsoft Powerpoint became popular some years ago. This application is used to create an interactive presentation. E-Book and web-based learning system or LMS (Learning Management System) become popular to be used in many schools and institutions.

Information, Communication, and Technology (ICT) have been growing fast. Increasing information communication and technology also increase innovation in learning media. Today, many mobile applications are used as learning media i.e. Ruang Guru and Ilmupedia.

AR is one of the information and communication technology that grows rapidly. Augmented Reality (AR) is a technology that provides an interactive experience of the real-world environment. This technology allows users to interact with virtual objects in the real world real-time.

The development of AR applications is better than VR application. The revenue of AR application is higher than VR. One of the factors that can cause this is the increasing mobile device user. AR devices are not as complex as VR, and AR devices is easy to use and install. It is different from VR. VR needs head mounted display and VR headset.

There are many kinds of research about AR. In the medical field, AR is used for simulation and therapy i.e. therapy for neurological disease [3], Parkinson's disease [4], and therapy

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for post stroke-patients [5]. To promote the tourism object, AR is also used to create an innovative promotion media application i.e. iARtour [8], etc. As a learning media, there are many researches that use AR i.e. chemistry [9]. Anatomy [10] [11] [12] [13], and spatial ability [14] [15]. This research focus in AR used as learning media.

In 2017, Remy Giovanny Mangowa [16] developed an application named MathBharata. This application is expected to increase the motivation of disable students to study mathematics. This research was continued by predicting and classifying student's performance in math by using a data-mining technique [17]. The result shows that there are some factors in determining the level of math skill for the normal students i.e. age, gender, grade, and the mark of the level.

Umi Laili Yuhana et.al. [18] continued the research by improving the serious game MathBharata [16] to measure the competencies of disabled students. The new version of MathBharata contains a new design to display the question and new module to measure and display the competencies achieved by the student. This is expected to let teachers understand the log and understand the student's competencies.

AUGGO continues those previous researches by Developing the AR and marker-based application to learn Geometry. The development of AUGGO is expected to develop an innovative and interactive learning media to learn math, especially geometry for the student in Elementary school.

II. Design of AUGGO

The focus of this research is on how to design and develop an interactive and innovative learning media based on the Android device by using AR technology. The steps of this research are described in Figure 1.

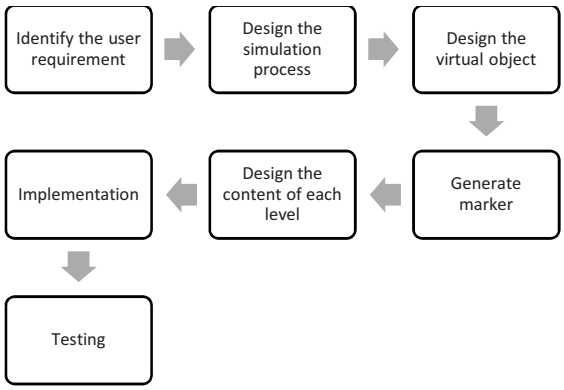

Figure 1. The Research Methodology

The first process is to identify the user requirement. The simulation process design will result the design of each level in the application. The virtual object design is to prepare the 3D object. To implement the AR technology, this research using marker. Each level has different marker and object to show. The implementation process is to implement the control and AR technology used. In the implementation process, this research uses Unity Game Engine and Vuforia SDK. To measure the reliability of software, this research conduct software testing. The software testing is not only to find bug, error, and fault. It is also to measure the user experience. The user experience testing uses the Two-Group Paired Sample T-Test method with 14 elementary school students.

A. Identify the User Requirement

This process is to identify the user requirement. Based on the identification result, the user requirement can be explained as follows.

a. There is a marker that is used to generate the 3D object.

b. There is a manual book to inform about how to use the application.

c. The content of the application is about Geometry i.e. shapes, 3D object, symmetry, reflection, area, perimeter, and volume.

B. Design the Simulation Process

The next step is to design the simulation process in AUGGO. The process is started from the main menu. The main menu has three buttons i.e. Menu Level to choose the level of the game, Guideline Menu to inform the user how to use the application and Exit menu to exit from the application. When the user chooses the Menu level, the application will show the level in the application. Users can choose one of the levels. In each level, theorical resume can be read by users to increase their knowledge about geometry. In the simulation process, the user should use a marker to generate the virtual object and starts the simulation to learn geometry.

C. Design The Virtual Object

In this process, it will be designed some virtual objects. These objects will be used to simulate geometry learning for Elementary students. There are many 3D objects used in AUGGO i.e cube, sphere, beam, and cone.

D. Generate Maker

This research uses Vuvoria SDK to provides AR in the application. Vuforia SDK needs to use a marker generator to generate the marker. This research uses this system [19] to generate the marker and upload it to Vuforia. Vuforia will record the marker and generate the SDK for the application. This SDK will be used by the application to load the virtual object. This site [20] is used to load the marker to the Vuforia server.

E. Design The Content of Each Level

The content of the application is based on a text-book published by Yudhistira. The content can be classified into some grades of students in Elementary school. This classification can be described as follows.

Table 1. The Classification of Content in Auggo

No	Material	Grade
1	Shapes (2D Object)	1
2	Geometry (3D object)	1
3	The characteristics of shapes	2
4	The characteristics of Geometry	2
5	Radial symmetry	3
6	Bilateral symmetry	3
7	Reflection	3
8	The area, perimeter of shapes	4
9	The area, perimeter, and volume of geometry	4

F. Implementation

To develop AUGGO, this research uses the Unity Game Engine [21]. This game engine can be used to develop AR, VR, or MR applications. This game engine can be integrated

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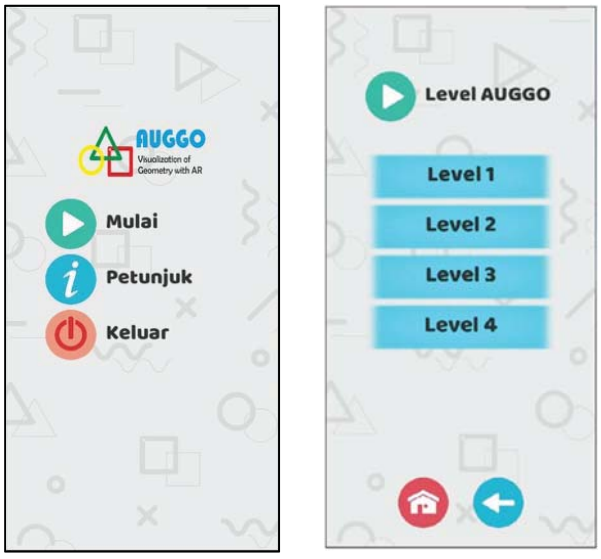
to Vuforia SDK. The Vuforia SDK is used to provide the AR technology. While the Unity can be used to develop the virtual environment of the application. To implement the AR technology, the camera in the virtual world of Unity will be replaced by aRCamera. This aRCamera will recognize the marker and show the 3D object in the real word. The user can interact with the 3D object by moving the marker. AUGGO was developed by using Vuforia SDK. This SDK provides the aRCamera for the AR technology implementation.

In the Figure 2.a. the main menu of Auggo consists of some menus i.e. Mulai to start the application, Petunjuk to show the guideline, and Keluar to exit the game. Auggo uses Indonesia as its language. Because the target of this application is for student in elementary school.

Figure 2.b. shows the level menu of AUGGO. There are total 4 levels in Auggo. Each level consists of material from Yudhistira book for Elementary school. The theory of each level can be shown in Figure 3.a and Figure 3.b. Figure 3.b shows the example of theory in the 3rd level. Figure 4.a and 4.b show the example of a simulation process for symmetry theory by using the 3D cube. From the Figure 4, there are many buttons when we open the camera to recognize the marker. Button with arrow icon, is used to show the previous page. Cross icon button is used to close the camera and show the detail menu of each level. To display the information of the 3D geometry, we can use the red button with three lines icon.



(a) (b)

Figure 2. The Main Menu and Level Menu of AUGGO

(a) (b)

Figure 3. The Detail Menu from Each Level of AUGGO

(a) (b)

Figure 4. The 3D and 2D Objects in AUGGO

G. Testing

To test the reliability of the application, this research conducts the Two-Group Paired Sample T-Test method with 14 elementary school students. Participants were divided into 2 groups: 7 participants as Group A (experimental class) and 7 participants as Group B (control class). There will be pre-test and post-test for each group. Students in group A will use AUGGO as learning media to learn Geometry, and students in group B will use normal learning media (text-book). Both pre-test and post-test from each group will be calculated to measure the impact of learning media used. Figure 5, 6, and 7 show the testing process in SD Muhammadiyah 26 Surabaya.

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Figure 5. Devide Participants into 2 Groups for User Testing

Figure 6. Student Learns Geometry by Using AUGGO

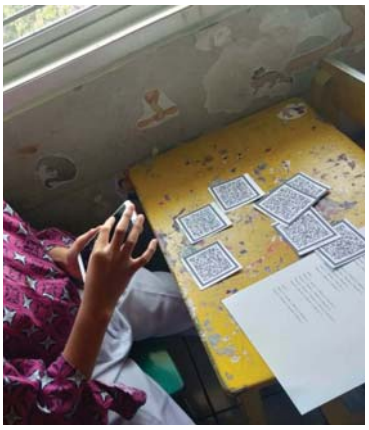

Figure 7. Markers used to Generate 3D Object in AUGGO

III. Result and Discussion

Assessment of participants through questionnaires showed the results of the pretest to posttest in Group A increased by 26%, while Group B only increased by 10.29%. Figure 8 shows the result of the post-test and pre-test from students in group A, and Figure 9 shows the result from students in group B.

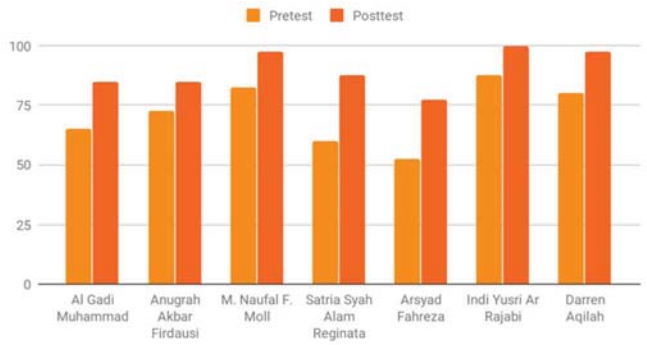

Figure 8. The Result of Pre-test and Pre-test from Students in Group A

Figure 9. The Result of Pre-test and Pre-test from Students in Group B

From Figure 8 and Figure 9, it is known that both groups have increasing results. But in Figure 8 shows that group A has a better result in post-test than group B in Figure 9. It can be concluded that AUGGO can help to visualize the geometry theory better than the textbook.

This research also maps the number of correct answers for each question. From the data, it is known that most students have difficulty in the theory of area, perimeter, and volume in geometry. Students need to do many exercises about these theories. Because visualization is not enough to increase the understanding of this. Besides, most of the students in group A has a better result in understanding the character of geometry, radial symmetry, and bilateral symmetry than students in group B. This is because AUGGO can give a clear visualization for students to understand better than the textbook.

IV. Conclusion

From the observation result in each process of this research, it can be concluded that:

a. AUGGO can help the student to understand geometry. It can be shown from the student in group A's pre-test and post-test results.

b. AUGGO can help to visualize the geometry theory. This can help the student to understand the theory better than text-book.

c. The theory in AUGGO is based on text-book published by Yudhistira for elementary student. From the questionnaires, it is known that the theory in AUGGO is accordance with the Geometry Curricula in Elementary school.

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For future work, marker-less AR-based applications can be developed. AUGGO depends on the marker used. It will be better if the marker-less application developed. This will ease the user to use the application. Besides, there are many theories in mathematics that can be simulated into AR or VR (Virtual Reality) or MR (Mixed Reality) application. For the future work, it is expected many theories in mathematics can be simulated in an interactive and innovative learning media.

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