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IMPLEMENTATION OF EARTH STRUCTURE LEARNING APPLICATIONS USING MARKERLESS AUGMENTED REALITY USING SURFACE TRACKING METHOD

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Abstract: In science lessons at school there are materials that are taught, one of which is a lesson about the layers of the earth. As an alternative learning media, Augmented Reality technology is needed which can help teachers have a variety of learning media, so that they can accommodate the learning needs of students who have various types of learning characteristics. In this study the authors made augmented reality using markerless so that they could display or show how the structure of the earth's layers looks like seeing directly without markers or markers. Using EasyAR as a Software Development Kit (SDK) because it has many features and methods that can be used for creating augmented reality.

Keywords: Structure of the Earth's Layers, Markerless Augmented Reality, Surface Tracking

INTRODUCTION

Augmented Reality (AR) is a combination of virtual objects and real objects. Apart from being used in fields such as health, the military, the manufacturing industry, augmented reality has also been applied to devices that are used by many people, such as smartphones by utilizing the camera features that are on almost all smartphones today. The main goal of Augmented Reality is to create a new environment by combining the interactivity of real and virtual environments in real time so that users feel that the environment created is real (Susanna, 2018).

Markerless augmented reality is a term that refers to Augmented Reality technology that does not require special knowledge about the user's environment to display virtual objects at a certain point. The system must identify objects and places in the real world without special markers, identification is done using information such as location coordinates, orientation and movement (Dany, 2018). Interactive learning media is a teaching and learning process for digital products and services (multimedia) provided by teachers to students by presenting learning content such as text, moving or animated images, video, audio to video games (Pijar, 2020).

Earth is one of the planets of the solar system which is in the Milky Way galaxy. Earth is the third planet from the arrangement of planets in the solar system. The earth has layers of structure that are layered up to the core of the earth (core). Earth has a diameter of 7,926 miles, the earth has at least 4 layers that make up the earth including the earth's crust, mantle, outer core, and earth's inner core (Gramedia, 2021). Unity is an application used to develop multiplatform games that are designed to be easy to use. Unity is a great and full mix of professional apps. The unity editor is made with a simple user interface. The graphics on unity are made with high level graphics for openGL and directX. Unity supports all file formats, especially common formats such as the format from artaplications. Unity is compatible with the 64-bit version and can operate on Mac OS, Windows, Wii, iPhone, iPad and Android (Khoirul, 2016).

EasyAR is a Software Development Kit (SDK) to help make it easier for application developers to create Augmented Reality Applications. Of course, we are no strangers to augmented reality, which is a technology for displaying a visual/object in 3D or 2D through a camera by detecting markers, planes, faces, and so on. EasyAR has several methods for creating an Augmented Reality, including

Face Tracking, 3D Object Tracking, Surface Tracking, and Motion Tracking. EasyAR is an easy-to-use and free Augmented Reality engine (Mukti *et al.*, 2022). EasyAR offers a variety of very interesting features to be utilized in the development of Augmented Reality media including gradual addition of targets, hardware decorations, screen recording, and more than 1000 local targets. The SDK provided by EasyAR with its latest version is a number of improvisations, especially in terms of accuracy and compatibility with host applications such as Unity. Simple, easy and fast API, making AR application development easier (EasyAR, 2020).

Surface Tracking is a surface tracking that implements cross-platform from surface environment. It can be used in augmented reality games, short augmented reality video recordings, and augmented reality product displays. Surface Tracking has been simplified by tracking devices and feature points of reference (Nurhayati, H. Andi Tanra Tellu, 2019). Compared to EasyAR motion tracking, EasyAR surface tracking supports more devices and no initialization is required. The coordinate system and camera used in surface tracking are the y axis pointing up, the z axis pointing towards us and the x axis pointing right. to establish correspondence between real and virtual spaces, surface tracking uses camera and IMU information. Surface tracking can recognize important features in camera images, i.e. track differences in feature positions across frames (Nurjanah *et al*., 2019). At start-up, virtual objects are placed in the center of the screen. During the movement of the device, the position will be continuously updated and the virtual object will fit on the surface point. When the base point being tracked is blocked, another point is automatically selected as the new reference point (EasyAR, 2020).

METHOD

The research method used in building augmented reality learning of the earth's layer structure based on Android is the Multimedia Development Life Cycle (MDLC). Researchers decided to use this method because this method is suitable for research in the field of multimedia. The Multimedia Development Life Cycle aims to develop a more interesting and efficient learning media by utilizing Android/iOS smartphone camera features. Where this method has 6 stages, namely concept, design, material collecting, assembly, testing and distribution (Despi, 2018).

The Likert scale is a scale that measures a person's perception, attitude or opinion of something or event. In the Likert scale there are two forms of statements, namely positive statements and negative statements. In the positive form, statements that strongly agree get a high score and strongly disagree get a low score, conversely in the negative form, statements that strongly agree get a low score and statements that strongly disagree get a high score (Pranatawijaya, 2019). An example of a scale with positive statements is (5,4,3,2,1) while negative statements (1,2,3,4,5). In a Likert scale, five rating scales are usually provided, namely:

1 = Strongly Disagree (STS)
2 = Don't agree (TS)
3 = Doubtful (RG)
4 = Agree (S)
5 = Strongly agree (SS)

The total Likert score can be seen from the calculation below:
Answer Strongly Agree (SS) = 30 respondent x 5 = 150
Answer Agree (S) = 30 respondents x 4 = 120
Undecided (RG) = 5 respondents x 3 = 15
Disagree (TS) = 20 respondents x 2 = 60
Strongly Disagree (STS) = 15 respondents x 1 = 15
Total Score = 360

Maximum Score = 100 x 5 = 500 (number of respondents x highest Likert score)
Minimum Score = 100 x 1 = 500 (number of respondents x lowest Likert score)
Index (%) = (Total Score / Maximum Score) x 100
Index (%) = (360 / 500) x 100
Index (%) = 72%
Rating Intervals:
Index 0% – 19.99%: Strongly Disagree
Index 20% – 39.99% : Disagree
Index 40% – 59.99% : Doubtful
Index 60% – 79.99% : Agree
Index 80% – 100% : Strongly Agree
Because the Index value that we get from the calculation is 72%, it can be concluded that the respondent "AGREE".

RESULTS AND DISCUSSION

1. Application Concept

Application Concept is the stage for determining the purpose and who is the user of the program. The goals and users of the program influence the delivery of information to be more easily understood, as well as paying attention to an easy-to-use user interface application concept as shown in Table 1..

Table 1. Application Concept

Title	Designing Learning Media Applications for the Structure of Earth's Layers Using Markerless Augmented Reality with the Surface Tracking Method
Objective	As an Educational Means of Introduction to the Structure of the Earth's Layers
Audience	Grade 8 Junior High School (SMP).
Image	Using .png & .jpg formats
Audios	Uses .mp3 & .wav formats
Text	Object-related descriptions
Animation	Using frame by frame animation making techniques
Fill in the Application	Augmented Reality, Materials & Quiz
Software	Unity3D, EasyAR, SketchUp, Photoshop CS6, Visual Studio 2019

2. Design

Design is making detailed specifications regarding application architecture, style, appearance and material requirements for making applications. The specifications are made detailed enough so that in the next stage, namely collecting and assembling materials, new decisions are not required, but use what has been determined at the design stage.

2.1. Navigation Structure

The navigation structure is the flow used in the created application. Before compiling a multimedia application into a software, we must first determine what flow will be used in the application that is made. The following is the navigation structure of the earth's layer structure application, shown in Figure 1.

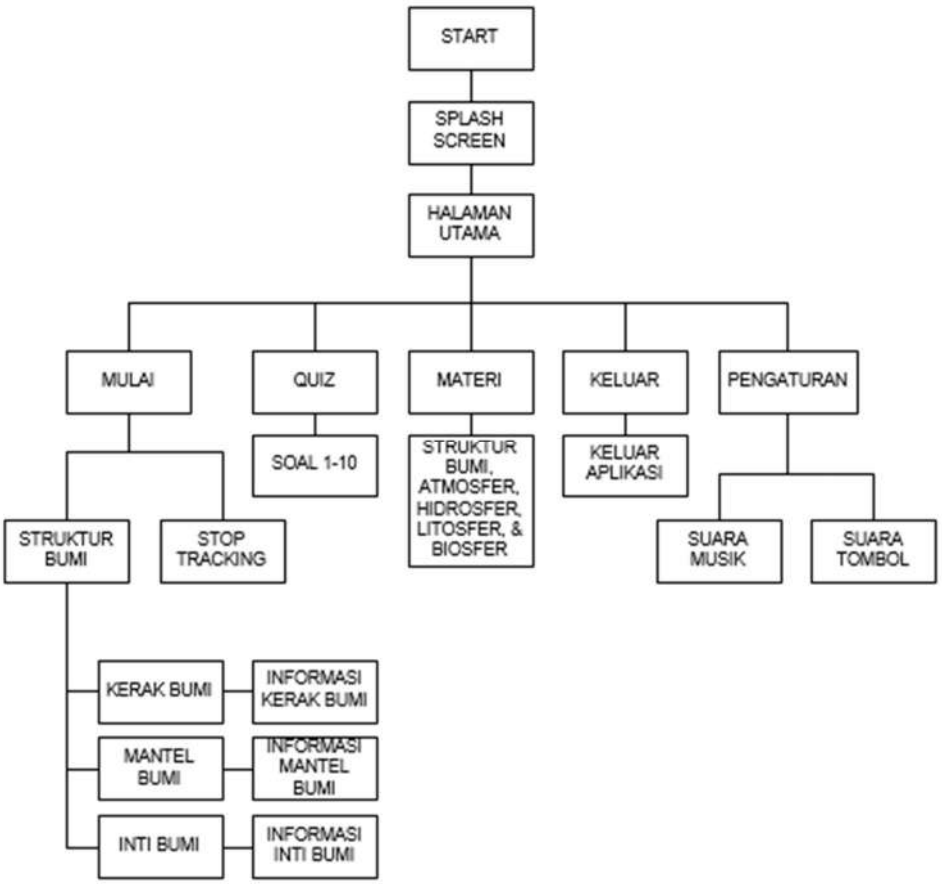


Figure 1. Navigation Structure

2.2. Application Flowcharts

A flowchart is a graphical depiction of the steps and sequence of procedures for a program. Usually affects the resolution of problems that especially need to be studied and evaluated further. The following is a flowchart of the application of the earth's layer structure, shown in Figure 2.

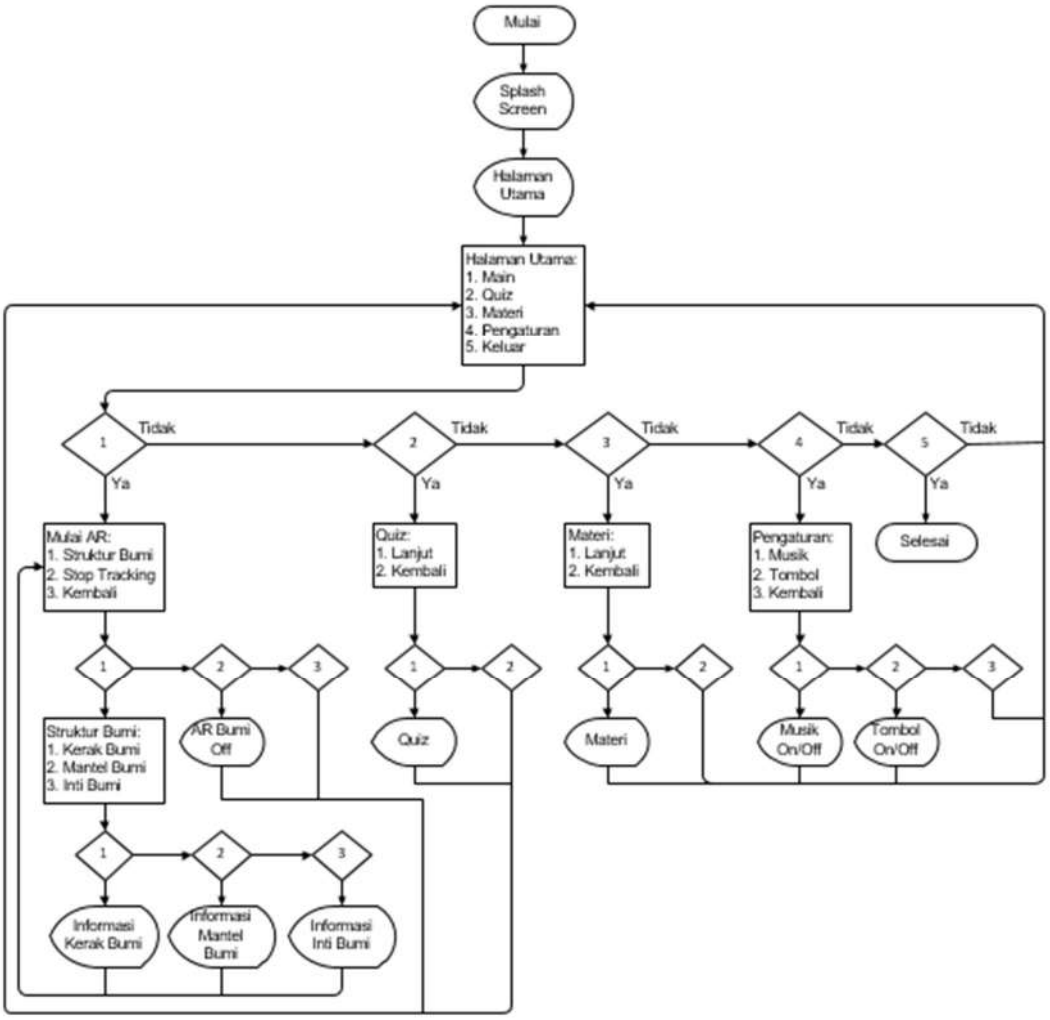
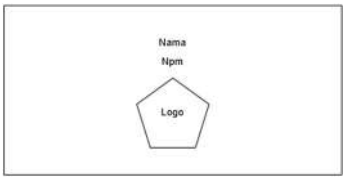


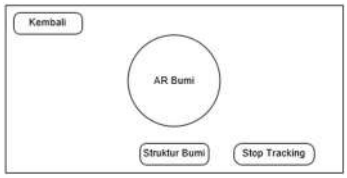
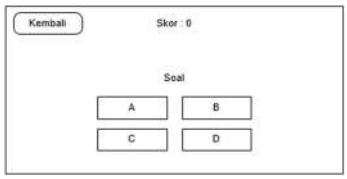
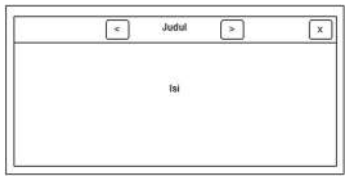
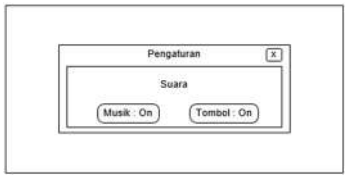
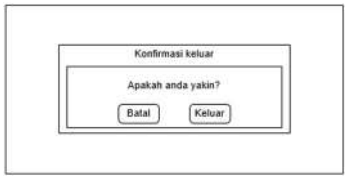
Figure 2. Application Flowchart

2.3. Application Storyboards

Application storyboard is a description of the scenario for each stage of the scene in the application, in other words, a storyboard is a series of sketches of images used to describe the storyline.

Table 2. Application Storyboards

Scene	**Visual**	**Button**	**Text**	**Image**	**Audio**	Information
Scene 1 SplashScreen		-	-	✓	-	The first view that will appear after the application is opened.
Scene 2 Main Menu		✓	-	✓	✓	The main menu display will display the features in

						the application.
Scene 3 Start AR		✓	✓	✓	✓	Display when selecting the Start menu, it will display AR 3D earth.
Scene 4 Quiz		✓	✓	✓	✓	Display when selecting the Quiz menu, it will display questions to choose the correct answer.
Scene 5 Material		✓	✓	✓	✓	Display when selecting the Material menu, it will display material about the structure of the earth's layers.
Scene 6 Settings		✓	✓	✓	✓	Display when selecting the Settings menu, it will display sound settings, namely Music & Keys.
Scene 7 Exit		✓	✓	✓	✓	Display when selecting the Exit menu, then there will be an Exit or

	Cancel option, if you select Exit then the application will exit & if you select Cancel then you will return to the main menu.

3. Results

At this stage it will be displayed and described regarding the pages used in the Learning Media application for the Structure of the Layers of the Earth. In the application there is only 1 level, namely the user. This application provides features for conducting learning where there is material and practice questions. After the user has done the pre-test online, the user can work on the post-test questions in the application to measure the increase in learning outcomes. In making this application using several manufacturing techniques such as coding and making animation.

3.1. Splash Screen Display

Splash Screen is the first display that will appear after the application is opened. Created using Adobe Photoshop software. The following is a splashscreen display.

3.2. Main Menu Display

The main menu is the main view that will display the features in the application. Created using Unity 3D software. The following is the main menu display.

3.3. AR Start View

When selecting Start menu, it will display AR 3D earth. Made using Sketchup software. The following is a view of the 3D model of the earth

3.4. Quiz View

When selecting the Quiz menu, it will display questions to choose the correct answer. Created using Unity 3D software. The following is a quiz display

3.5. Material Display

When selecting the Material menu, it will display material about the structure of the earth's layers. Created using Unity 3D software. The following is a display of the material, shown in Figure 3.

Figure 3. Material Display

3.6. Exit View

When selecting the Exit menu, there will be an option to Exit or Cancel, if you select Exit then the application will exit & if you select Cancel then you will return to the main menu. Created using Unity 3D software. The following is the output display.

4. Testing

The testing or trial phase is to carry out a simulation by running the application on an Android device. With the trials carried out, we can find out the shortcomings or weaknesses of the applications that are made, such as knowing menus don't work, buttons don't work and so on. This application has also been tested on several Android devices.

4.1. Structural Testing

Structural testing is a conformity stage to find out whether the application has been structured properly according to the design that has been made. After testing each menu, it can be seen that the structural validation of this application can be seen in Table 3.

Table 3. Structural Testing

No	Channel	Results
1	Welcome Page → Splashscreen → Main Menu → Start AR → Earth Structure → Crust Information → Main Menu	In accordance
2	Welcome Page → Main Menu → AR Start → Earth Structure → Earth Mantle Information → Main Menu	In accordance
3	Welcome Page → Main Menu → AR Start → Earth Structure → Earth Core Information → Main Menu	In accordance
4	Welcome Page → Main Menu → AR Start → Earth Structure → Earth AR → Main Menu	In accordance
5	Welcome Page → Main Menu → Start AR → Stop Tracking → Main Menu	In accordance
6	Welcome Page → Main Menu → Start AR → Start Tracking → Main Menu	In accordance
7	Welcome Page → Main Menu → Quiz → Main Menu	In accordance
8	Opening Page → Main Menu → Material → Main Menu	In accordance
9	Welcome Page → Main Menu → Settings → Music Sound → Main Menu	In accordance
10	Welcome Page → Main Menu → Settings → Key Sound → Main Menu	In accordance
11	Welcome Page → Main Menu → Exit → Cancel → Main Menu	In accordance
12	Welcome Page → Main Menu → Exit → Exit	In accordance

4.2. Functional Testing

This functional trial phase is carried out to find out whether the application made is functioning properly. At this stage an experiment is carried out to find out whether the function of each button or menu on the page can function properly. Based on the trials that have been carried out, overall the buttons or menus on each page can function and run as desired. These results can be seen in Table 4.

Table 4. Functional Testing

No	Scene name	Appearance	Results
1	Splash Screens	Animation	Succeed
2	Main Menu Scenes	Play	Succeed
		Quiz	Succeed
		Material	Succeed
		Arrangement	Succeed
		Go out	Succeed
3	Scene Start AR	Animation	Succeed
		Audio Background Music	Succeed
		Audio Button	Succeed
		Back To Main Menu	Succeed
		Earth structure	Succeed
		AR Earth	Succeed
		Stop Tracking	Succeed
		Start Tracking	Succeed
		Earth Layer 3D Model	Succeed
		Layers of the Earth Information	Succeed
		Layers of the Earth Information Audio	Succeed
4	Scene Quiz	Back To Main Menu	Succeed
		Score	Succeed
		Question	Succeed
		Answer	Succeed
		Continue Question	Succeed
5	Material Scenes	Back To Main Menu	Succeed
		Continue Material	Succeed
		Back Material	Succeed
		Content Material	Succeed

4.3. Feasibility Testing

The results of this questionnaire test are intended to determine the quality or feasibility of the learning media application for the structure of the earth's layers based on Augmented Reality. This test was carried out on 1 science teacher, 1 guardian teacher and 30 eighth grade junior high school students based on their respective expertise backgrounds. respectively. The maximum total value is obtained from the number of questions multiplied by the maximum questionnaire value, which is 5.

Table 7. Science Teachers

No	Aspect	Question Items	Value Result	Total Max Value	Appropriateness
1.	Software Aspect	1, 2	9	10	90%

					(very decent)
2.	Material Aspect	3, 4, 5, 6, 7, 8, 9	32	35	91.4% (very decent)
3.	Learning Aspects	10, 11, 12, 13, 14, 15	26	30	86.6% (very decent)
Number of Results			67	75	89.3% (very decent)
Average Amount			22.3	25	89.2% (very decent)

Based on the table above, it can be concluded that respondents from science teachers for each aspect answered with an average score of 89.2% including the very decent category. It was found that the lowest aspect value is the learning aspect and the highest is the material aspect and the software aspect.

Table 8. Questionnaire Results for Guardian Teachers

No	Aspect	Question Items	Value Result	Total Max Value	Appropriateness
1.	Software Aspect	1, 2	8	10	80% (worthy)
2.	Material Aspect	3, 4, 5, 6, 7, 8, 9	32	35	91.4% (very worth it)
3.	Learning Aspects	10, 11, 12, 13, 14, 15	28	30	93.3% (very worth it)
Number of Results			68	75	90.6% (very worth it)
Average Amount			22.6	25	90.4% (very worth it)

Based on the table above, it can be concluded that respondents from guardian teachers for each aspect answered with an average score of 90.4% included in the very decent category. It was found that the lowest aspect value is the software aspect and the highest is the learning aspect, and the material aspect.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the use of learning media applications can make it easier for students to understand the material on the Structure of Layers of the Earth and assist teachers in providing learning. There is an interactive 3D simulation model as well as theoretical explanations and exercises regarding the material being discussed. This application can be used on Android devices with a minimum operating system of Oreo 8.1, minimum 4GB of RAM and a minimum processor of 1.95 Ghz Octa-core CPU. For pre-test and post-test testing, there was a significant increase in results, namely 82.3% increase, given material in the form of interactive simulations. Testing the feasibility of the application through questionnaires to respondents obtained satisfactory results, for science teachers responding with a score of 89.2% which was included in the very feasible category, for guardian teachers responding with a value of 90.4% which was included in the very feasible category, and students responded with a value of 89, 4% which is included in the very decent category.

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