

Mobile-Based Interactive Learning Media Design Using Augmented Reality Concepts

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Abstract - One of the natural disasters that currently occurs frequently in Indonesia is earthquakes. An earthquake is a situation where the earth shakes due to volcanic activity, or collisions due to the movement of the earth's plates. Earthquake activity causes many problems. One of them is liquefaction. Liquefaction is an event that shows a loss of soil shear strength caused by an increase in pore water pressure. This occurs because the earthquake load occurred so quickly and briefly. Liquefaction is a description of the effects of an earthquake so that the soil layer loses its strength. Not many people know the process of earth movement which is the precursor to earthquakes. Especially people who have hearing limitations. For this reason, education is needed to be conveyed to the public. Educational techniques in virtual form will be a special attraction for people, especially deaf people. Augmented Reality (AR) technology is a technology where virtual objects and real objects are combined. In this research, an application was produced in the form of learning media that utilizes Augmented Reality (AR) technology with the Marker Based Tracking method. To make learning media more interactive, the technology was developed using the MDLC (Multimedia Development Life Cycle) method. The results of the tests carried out concluded that the application could be used as an interactive learning medium to increase knowledge about the occurrence of earthquakes and the effects of liquefaction for the community.

Keywords – Augmented Reality, MDLC, earthquakes, mobile-based

1. INTRODUCTION

Recently, Indonesia has experienced many natural disasters. One of the natural disasters that is currently occurring frequently is earthquakes. An earthquake is a situation where the earth shakes due to volcanic activity, or collisions due to the movement of land plates. The earthquake phenomenon is related to the movement of slow waves which ultimately penetrate the rocks that make up the layers of the earth. Earthquakes are genuine vibrations that originate from within the earth and then move to the earth's surface. An earthquake is an event where a certain amount of energy in the rocks of the earth's crust is released. One of the energies released is wave energy known as seismic waves. Earthquake activity causes many problems. One of them is liquefaction.

Liquefaction events generally often occur in granular soil layers where this soil has a large volume of water. The increase in water pressure in the pores is triggered by the effects of earthquake vibrations which cause soil particles to contract very quickly and in undrained conditions. Liquefaction is the process of changing soil from a solid form that is full of water in

an undrained state to soil in liquid form which occurs due to cyclic loads. This cyclic load is caused by propagating earthquake shear waves so that pore water pressure increases. This liquefaction will occur if the pore water pressure has the same level as the effective soil pressure. The liquefaction phenomenon of an area can be evaluated through the relationship between soil depth and effective soil stress.

The phenomenon of earthquakes and the resulting effects in the form of liquefaction is very rarely known by the public. The process of earth movement due to volcanic activity or the movement of earth plates which is the precursor to earthquakes is not widely known by the general public. Especially people who have hearing limitations. They can only feel an earthquake without having extensive knowledge about how an earthquake occurs. One of the reasons for their limited knowledge is that there is no learning about earthquake phenomena and their consequences. For this reason, there is a need for education to be conveyed to the public. The current trend in society is for virtual learning. This virtual learning will also make people who have limited hearing feel helped. Educational techniques in virtual form will be a special attraction for people, especially deaf people. One technology that is now widely used to create virtual and interactive learning media is Augmented Reality.

Augmented Reality (AR) is defined as a technology where the real and virtual worlds are combined into one, is interactive from the real-world side and is designed in a three-dimensional animation model. Augmented Reality is a kind of technology with the concept of combining the virtual world and the real world. The purpose of this combination is to provide information whose data is taken from a system on real objects. AR technology is able to create a correlation between the real world and the virtual world. All information can be added so that the information is real time as if the information were interactive and real. Augmented Reality technology is now developing in various fields, especially education. One use of Augmented Reality is to create interactive learning media as a means of delivering and disseminating certain information.

In the research carried out this time, a software was built in the form of interactive learning media based on Augmented Reality (AR) technology using the Marker Based Tracking technique. To make this learning media more interactive, the application was developed using the Multimedia Development Life Cycle (MDLC) technique. This learning media application contains animated 3-dimensional objects that describe and narrate the occurrence of an earthquake which resulted in the liquefaction phenomenon. The application is designed to be more interactive so that it can provide understanding and knowledge for the public, especially deaf people, about earthquakes and their impacts

2. RESEARCH METHOD

The research method describes the research process starting from preparation, implementation process to drawing conclusions on the tests carried out.

2.1. Research Activity Flow Diagram

The flow diagram of research activities describes the stages that are followed to carry out research to the process of developing research results. The stages of implementing research activities shown as in Figure 1.

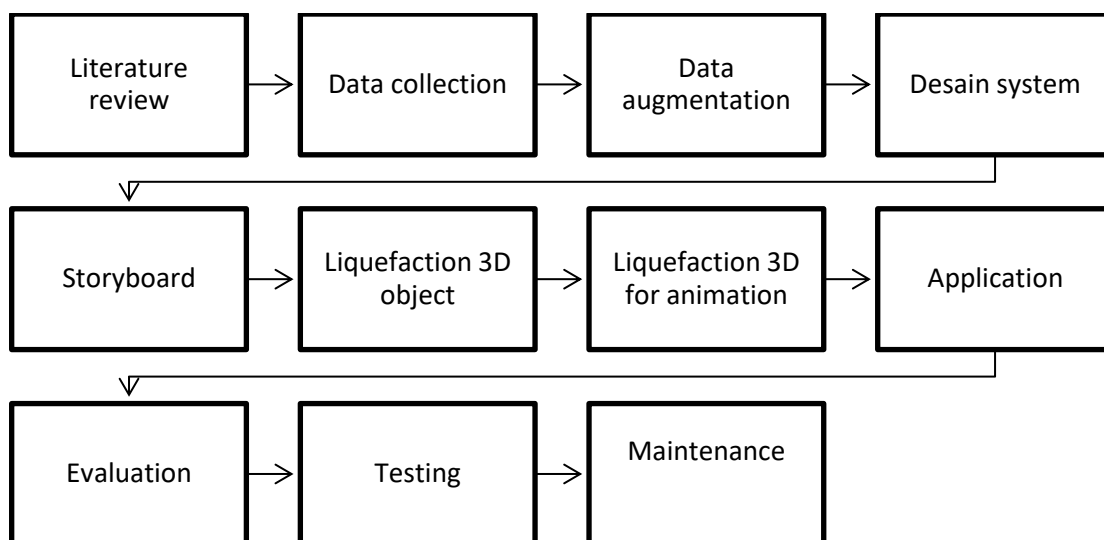


Figure 1. Research flow diagram

2.2. Application Development Methods

The result of the research process carried out is an interactive learning media application using the Augmented Reality concept called LiAR. Specifically, this application was developed using the Multimedia Development Life Cycle (MDLC) method where there are 6 phases that must be passed as shown in Figure 2.

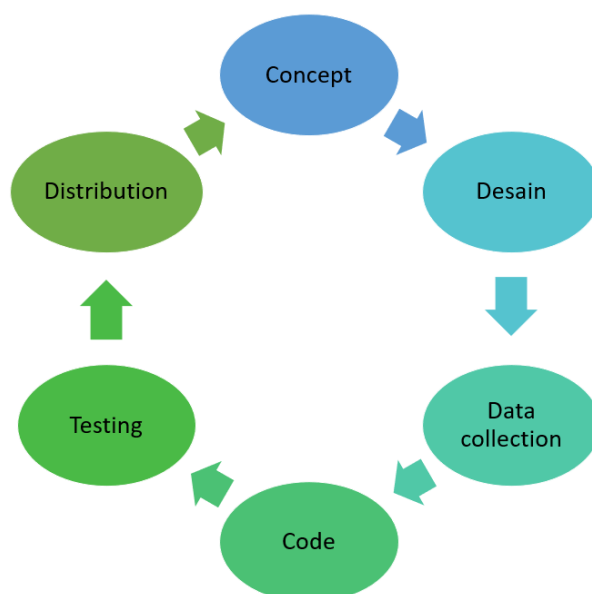


Figure 2. MDLC phase

From the MDLC phase in Figure 2, the following explanation can be given:

1. **Concept.** The concept stage is the initial stage in the MDLC cycle. At the concept stage, the research team held discussions related to determining the purpose of creating the application and determining the users of the application. The application created aims to help provide virtual socialization and knowledge about post-earthquake phenomena and the occurrence of liquefaction. This application is intended for the community, especially deaf people.

2. Design. At this stage, a design is carried out as a basis for making the application. The design is realized in the form of a storyboard that describes the operation of the system and the features in the application.
3. Collection of materials. This stage is an important stage where the data needed for application development begins to be collected. These materials include 3D objects which are gradually created one by one using Blender. Next, each 3D object that has been created is then put together so that it becomes one unit. After the 3D object is formed as desired, an animation is created for the object. The next stage is making markers using Vuforia and videos with text.
4. Manufacturing. At this stage, all the materials that have been collected begin to be arranged one by one according to the application needs. One example is creating 3D objects with Blender software. Then to create the appearance of this application, Unity Engine software is used.
5. Testing. Testing is carried out to ensure that the results of making the application are in accordance with the plan. At this stage the testing carried out is testing the user directly and then asking for input or feedback on the application used.

The application produced in this research is a learning media application called LiAR (Liquefaction Augmented Reality). This application can display 3D objects using an Android-based smartphone. This application was designed and developed with the aim that users, especially deaf people, can imagine and see virtually the process, impact, prevention, and management of the natural phenomenon of liquefaction due to earthquakes. These 3D objects can be displayed on a marker that has been provided in the form of a book as supporting media. There are 6 markers that correspond to the 6 3D objects provided. The 3D object displays an animation that can explain the process of liquefaction, the impacts it causes, prevention and how to deal with it. The added feature is a video using sign language accompanied by translated text so that it can be captured and understood by the public, especially deaf people.

2.4. Analysis of System Functional Requirements

Functional requirements are requirements that are available in the LiAR application. The functional requirements are listed in Table 1.

Table 1. System functional requirements

Page	Main Menu	Sub Menu 1	Sub Menu 2
Splash screen Loading Bar	- -	- -	
Main Menu	Main menu of application	AR Menu Liquefaction Process	<ul style="list-style-type: none"> • AR Process • AR Impact • Preventative AR <ul style="list-style-type: none"> - Soil improvement - Socialization • AR Countermeasures <ul style="list-style-type: none"> - Choosing a foundation - Building structure
		Game Menu	<ul style="list-style-type: none"> • Liquefaction process • Impact of liquefaction • Prevention of liquefaction • Mitigating liquefaction • Try again

2.5. Analysis of Non-Functional System Requirements

Non-functional requirements are limitations of the services or functions offered in the LiAR application. The following are the non-functional requirements for the LiAR application as in Table 2.

Table 2. Hardware requirements

Hardware	Informations
Laptop	The expected minimum specifications include: 1. Intel Core I5 as the processor 2. Memory of 4 GB 3. Hard disk with a capacity of 500 GB
Smartphone	Smartphone with Android OS minimum Android 4.4 KitKat

Table 3. Software requirements

Software	Informations
Operating system	The operating system used to create/design applications
Blender Engine Application	Application used to create 3D objects
Unity Engine 2017	Applications used to create and run Augmented Reality

3. RESULTS AND DISCUSSION

In this section, we will explain the concept of Augmented Reality (AR)-based learning media design to explain phenomena following an earthquake.

3.1 Creating 3D Objects for Home Liquefaction Process

At this stage, 3D objects will be created in the form of house objects, house poles, electricity poles, soil, mud, earthquake text, liquefaction text and examples of liquefaction events with house objects as shown in Figure 3.

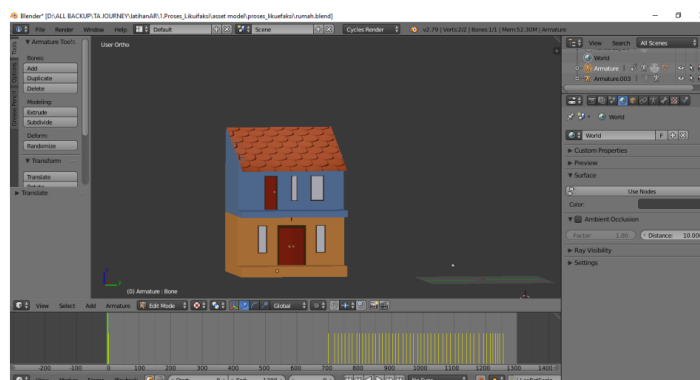


Figure 3. Illustration of objects in the form of a house

To create a 3D house object as in Figure 3, the following drawing steps are required:

1. Add a cube-shaped mesh.
2. Set the scale section on the x, y and z axes which are used to draw the land plane template.
3. After that, add the mesh plane used as grass, scale it according to the width of the land in step 2.
4. Add another mesh cube, then set the scale on the x, y and z axes. The scale size on the x and y axes must be larger than the width of the land in step 2, and the scale on the z axis

must also be smaller. This object will be used as the second soil layer. Place it in a slightly higher position on the object created in step 2.

5. Next is the process of adjusting the texture and giving color to the building. Change the object's position to edit mode on the time line.
6. Next, click face select, then click on the wall you want to color by pressing shift.
7. Once the part of the wall you want to color is selected, click mesh, edges, mark seam. This section is used to mark the boundaries of faces that have been colored with different colors.
8. To add a new color file, click the material on the right side and click the (+) icon.
9. Click new. In the color selection box, activate image texture then select the desired file.
10. Once finished, move to screen layout and change it from default to composting. 11. Open the image file that has been selected in the material section.
11. The selected image is changed to edit mode by pressing the letter U then selecting unwrap on the bottom right side of the screen.
12. Select the node tree type, then drag the BSDF line to the displacement.
13. To see the results, please go back to the screen layout and change it to default again

3.2. Making 3D Objects for the Liquefaction Process of a Plot of Land

After the house object has been created, the next step is to create a 3D object of a plot of land as shown in Figure 4.

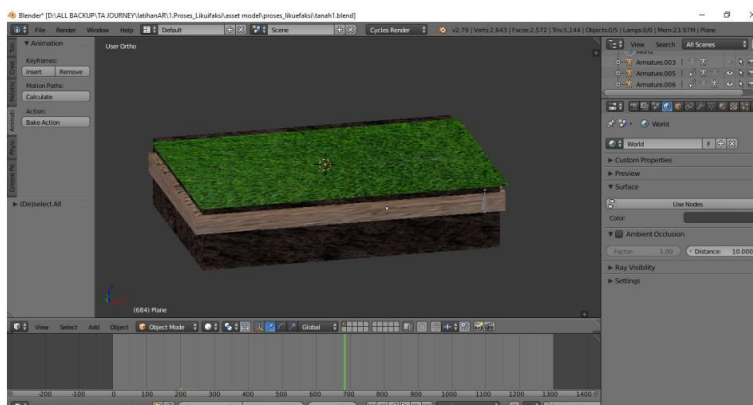


Figure 4. Land plot object

To create a 3D object on a plot of land, the following drawing steps are required:

1. Add a cube-shaped mesh.
2. Set the scale section on the x, y and z axes which are used to draw the land plane template.
3. After that, add the mesh plane used as grass, scale it according to the width of the land in step 2.
4. Add another mesh cube, then set the scale on the x, y and z axes. The scale size on the x and y axes must be larger than the width of the land in step 2, and the scale on the z axis must also be smaller. This object will be used as the second soil layer. Place it in a slightly higher position on the object created in step 2.
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12. The selected image is changed to edit mode by pressing the letter U then selecting unwrap on the bottom right side of the screen.
13. Select the node tree type, then drag the BSDF line to the displacement.
14. To see the results, please go back to the screen layout and change it to default again

3.3. Making 3D Animation of the Liquefaction Process

At the stage of depicting 3D objects in the liquefaction process, there are several objects that move simultaneously. To create an effect like this, a single bone armature can be used as well as animated location and size. This setting is used to animate several objects so they can run simultaneously. The first animation created was an animation of an earthquake on the ground. At this stage, an animation clip of an earthquake on the ground is saved using a single bone. Steps that can be taken include:

1. Add bones by pressing shift + A.
2. Select an armature, select a single bone, place it on the ground.
3. Make a bone block and a ground object, press CTRL+P, select with automatic weights.

3.4. Making Markers

The marker function in this research is used to make 3D objects visible when the cell phone camera is pointed at the material book. Below is a picture of the marker and how to make it:

1. Prepare the image object that will be used as a marker. An example is shown in Figure 5.
2. Uploading Markers. So that the marker that has been designed can be used, the first step is to upload an image file in Vuforia which will be used as a database in Unity. So Vuforia will convert the database into a file with the extension *.unity which can be read by Unity.

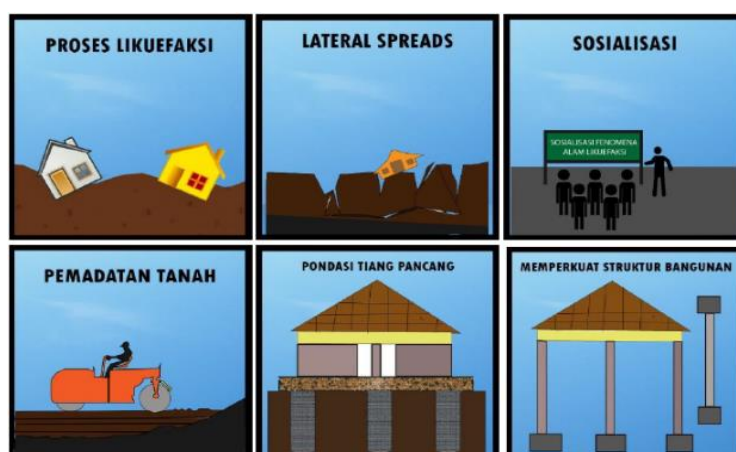


Figure 5. Example of Marker

3.5. Applications of Creation

At the application creation stage, Unity 2017.3.lf1 software was used as a tool. The initial stage is to create an AR video first. Next, create a new project by selecting new, then giving the project a name and choosing a place to save the project. One thing to note is that because the object to be created is 3D, do not forget to select 3D. The final step is to click create project. Then it will appear as shown in Figure 6. Next, after the initial Unity window opens, we can select the file menu, build and settings, select Android, then select switch platform. The next step is to select the file menu again, build and settings, select player settings, check Vuforia augmented reality support. When making this application, assets provided free by Unity can be used, namely Vuforia Core Samples.

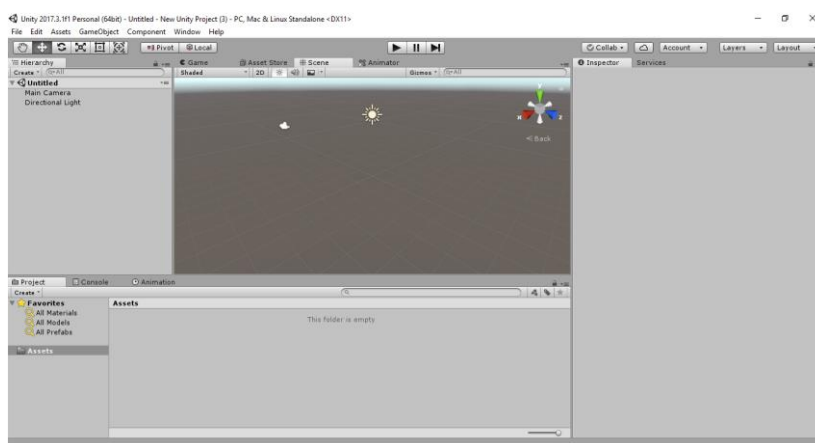


Figure 6. Unity Visualization

At this testing stage, application performance analysis is carried out in relation to the devices provided. The results of this test are shown in Table 4.

Table 4. Device test result

Device Name	RAM (GB)	Android Version	Application performance	Information
Oppo F5	4	Nougat	Good	No error
Xiaomi Redmi Note 5	3	Oreo	Good	No error
Samsung Galacy A6+	4	Pie	Good	No error
Samsung Galaxy J5	1,5	Lollipop	Not Good	Marker detected unstable

3.6. Functional Testing

Functional testing is carried out to test whether all the features available in the application can function according to their function or whether there are still functional failures found. Based on the tests carried out, Table 5 shows the final results.

Table 5. Functional testing

No	Feature	Result
1	Splash screen page	Running well
2	Loading bar page	Running well
3	Main Menu page	Running well
4	Button AR likuefikasi	Running well
5	Button AR process	Running well
6	Button AR countermeasures	Running well
7	Button choose a foundation	Running well
8	Button building structure	Running well

9	Button game menu	Running well
10	Button liquefaction impact	Running well
11	Button prevention of liquefaction	Running well
12	Button liquefaction management	Running well

4. CONCLUSION

Based on the entire series of design and system testing, it can be concluded that an interactive design based on related references using the concept of Augmented Reality technology is able to provide interesting education for people, especially those with hearing disabilities. The system built can run well on the operating system and software that have been described in the discussion.

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