Mobile learning development using augmented reality as a biology learning media

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Abstract. The use of mobile technology changes our daily lives without exception in the learning process. The use of mobile in the learning process aims to change learning and teaching methods to be innovative through visualization techniques, thereby transforming students from passive learners to active students. One of the mobile learning methods that allow us to show a given subject's visualization is Augmented Reality (AR). The use of AR as a supporting medium in studying biology subjects. AR development uses the Luther-Sutopo Multimedia System methodology. The results of this study are mobile-based learning media to visualize biology subjects using AR.

1. Introduction
New technologies have continued to develop in the last few decades, without exception Information and Communication Technology (ICT), which is the only smartphone technology that almost all human activities require [1]. Smartphones can help complete tasks more efficiently and effectively. Cellular technology changes the way humans perceive connectivity, communication, learning, and cooperation in everyday life [2]. The use of smartphones in teaching and learning activities has led to the term mobile learning.

Mobile learning has increased student interest and motivation [3]. The use of smartphones in the learning environment encourages students to participate in the learning process, so it can be said that smartphones have become a necessity for students and educators [4]. Student interest from passive learners to active students can be changed through simple visualization techniques. Visualization can help students to improve their understanding of the object being studied [5, 6]. One of the mobile learning methods that allow us to visualize a subject is Augmented Reality (AR).

AR supports students in learning complex objects, one of which is human anatomy. According to Farlex in Jamali [7], human anatomy involves the study of anatomy in a practical dissection laboratory, with exposure to the structure of the human body and internal organs. AR can also be used to visualize other biological problems such as the process of photosynthesis, viruses, and others. So, the visualization of objects through AR is expected to trigger a stronger student memory [8].
2. Method
The purpose of this study is to propose the Luther-Sutopo method in designing AR-based media. Figure 1 shows six steps of the Luther-Sutopo Method, which consists of Concept, Design, Content, Assembly, Testing, and Distribution [9-11].

![Luther-Sutopo Method Diagram](image)

**Figure 1.** Luther-Sutopo Method [9]

2.1. Concept
The concept is the basis of developing a product. The concept will determine the purpose of making the application and target users to be targeted. Apart from the goals, the basic rules in the application are also defined.

2.2. Design
The design stage is the stage for designing the specifications of the product being made. Specifications cover product architecture, style, appearance, and materials for the product. At the design stage, a storyboard will usually be used to display all stages and describe each scene.

2.3. Content
The stage where the collection of materials or materials according to needs and the appropriate digital format. The material obtained at this stage will be applied to a multimedia prototype in an application with the Android platform [12].

2.4. Assembly
This stage is the manufacture of all multimedia materials or materials. The making of this application is based on design, such as a multimedia prototype.

2.5. Testing
The testing technique proposed in this study is the black box method. Testing using this method will ensure that each menu can work properly as expected. Black box testing requires much effort to find bugs in the application [13,14].

2.6. Distribution
After the AR application has been tested, the next stage is distribution. The distribution stage is the stage for creating a master file, then distributing it to users with product documentation and user manuals [15].
3. Result and Discussion

This section will discuss system analysis and design, system implementation, and system testing of augmented reality applications.

3.1 Concept

The first stage in making this AR application is determining the concept. AR application is made using Android. The concept of this application contains the basic materials of metabolism, immune system, phytoremediation, greenhouse gases, nervous system, photosynthesis, COVID-19, food chain, metamorphosis. In order for the AR guide application to be more attractive, designs on the application platform were made with Corel software.

3.2 Design

At the AR application design stage, the design was presented to the research team. Figure 2 is an example of the design used in AR applications.

![Figure 2](image)

**Figure 2.** a) Photosynthesis design, b) Food chain design.

3.3 Content

Figure 3 shows an example of the material collected to make AR applications. At this stage, you can design the assets used in the AR application along with the assembly stage.

![Figure 3](image)
Figure 3. a) Earth texture, b) Sun texture, c) Leaf texture, d) Eagle, e) Icon, and f) Butterfly texture.

3.4 Assembly
At the assembly stage, all materials will be combined to become an AR application. At this stage, the writer uses Unity to combine these materials. Unity is an application used to develop multi-platform games designed to be easy to use. Figure 4 shows the appearance of the 2018.4 version of Unity, which is used for assembling materials, Figure 5 shows the process of photosynthesis in AR applications, and Figure 6 shows the structure of COVID-19 in AR applications.
3.5 Testing

After the assembly stage is complete, the next step is to test the application with Blackbox testing [14]. Application testing is carried out on parties who know about the purpose and function of the application being made. Table 1 shows the results of Blackbox testing.

| Process Name                        | System response                                                                 | Compatible |
|-------------------------------------|--------------------------------------------------------------------------------|-------------|
| Open App                            | If successful, a message to scan the marker will appear.                      | ✓           |
| Scan marker of metabolism           | If successful, a 3D metabolism object will appear.                           | ✓           |
| Scan marker of the immune system    | If successful, a 3D immune system object will appear.                        | ✓           |
| Scan marker of phytoremediation     | If successful, a 3D phytoremediation object will appear.                    | ✓           |
| Scan marker of greenhouse gases     | If successful, a 3D greenhouse gases object will appear.                    | ✓           |
| Scan marker of the nervous system   | If successful, a 3D nervous system object will appear.                      | ✓           |
| Scan marker of photosynthesis       | If successful, a 3D photosynthesis object will appear.                      | ✓           |
| Scan marker of COVID-19             | If successful, a 3D COVID-19 object will appear.                            | ✓           |
| Scan marker of the food chain       | If successful, a 3D food chain object will appear.                          | ✓           |
| Scan marker of metamorphosis        | If successful, a 3D metamorphosis object will appear.                      | ✓           |
| Exit                                | If the successful, application will be closed                               | ✓           |
3.6 Distribution
After Black-box testing and zero bugs, the application is ready for distribution by uploading it to the Google Playstore.

4. Conclusion
This AR program can be used to model biology learning objects using the Unity software. With the help of this AR, it will attract students to do independent learning because it can increase the interaction between students and the object being studied. AR helps students visualize 3D objects making it easier for students to make observations of the object being studied.

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