Development of learning media for earth physics based on augmented reality as an interactive learning media

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Abstract. Augmented Reality (AR) technology has been applied in various fields, including education. One of the courses that can apply AR technology is the earth physics course. The use of AR as a supporting tool can help visualize things that cannot be seen directly in their form to improve learning that is directly difficult to imagine. AR supports studying complex subjects, in particular, geology and geophysics as part of earth physics. AR development using the Rapid-Application Development (RAD) technique. The results of this study are mobile-based learning media to visualize geology and geophysics subjects using AR.

1. Introduction
Information and Communication Technology (ICT) has developed a lot in the last decade, especially cellular technology; this technology has been used in almost every aspect of life [1]. The use of smartphones makes tasks completed more effectively and efficiently. Cellular technology has changed human life in many ways [2]. Mobile learning is an activity that utilizes mobile devices in teaching and learning activities.

Learning using mobile can increase the interest and motivation of students [3]. Besides, mobile devices in the learning environment encourage students to be included in learning activities. So, it can be said that students and educators need mobile devices in learning [4]. Learning with visual techniques will attract students’ interest and turn them from passive learners to active learners. Students’ understanding of the lesson will increase with visualization in learning. One of the ways in mobile learning to visualize a subject is through Augmented Reality (AR). AR acts as a supporting tool in the learning process because it helps visualize things that cannot be seen directly in real forms and are difficult to imagine. AR supports students in studying complex subjects such as earth physics to assess and assess the conditions and locations of challenging subsurface infrastructure, especially as assets are buried underground, in uncertain locations, and often in dense 3-D configurations. In geoscience classes in the physics room where the skills to think and visualize real-world phenomena are the key to increasing understanding, experiential learning uses AR constructs to be very effective. Geoscience itself is an observational science, presenting a challenge for an educator because it provides a geological understanding of time-scale earth processes that are difficult to reach in the classroom's confines. When discussing AR applications in detail, visualizing internal structures can serve as more vital memory triggers for students.
2. Method
AR development using the Rapid-Application Development (RAD) technique [5-6].

![Figure 1. RAD Model [7]](image)

Based on Figure 1, the RAD consists of [8-13]:

2.1 Business Modeling
Business modeling is a part that shows the movement of information between various functions contained in the system. A business analysis really needs to be carried out in full to obtain useful information.

2.2 Modeling Data
The information obtained from the business modeling phase will be refined into a set of objects, then the relationships between the objects are identified.

2.3 Modeling Process
Data objects from business modeling will be changed to support the flow of information when implementing the business model. The process of adding, changing, deleting, or retrieving data objects is carried out in the process description.

2.4 Application Generation
This stage is the stage in building the actual system using automatic tools.

2.5 Testing and Turnover
Prototype testing is carried out independently at each iteration, thereby reducing the overall testing time. Testing is carried out on all components, both data streams, and interfaces.
3. Result and Discussion
At this stage, an Android-based AR application has been successfully produced, which is filled with earth objects. The display of this application is as Figure 2.

![Figure 2. AR application.](image)

A prompt will appear on the screen to perform a marker scan (Scan Marker). The marker here indicates the objects used in this application. If the application has found the appropriate marker, the display will change, as shown in Figure 3.

![Figure 3. Survey form](image)

The application will display the object according to the marker that was scanned. Furthermore, the application is also equipped with various buttons, namely buttons for zooming in and out on objects, buttons for rotating objects, and buttons for listening to the narration of the object.

The marker used in this AR application is a special marker that has been set to represent an object. The marker consists of 6 different markers, which include markers to represent earth objects, earth structures, metasequoia stones, and other objects. Figure 4 is an example of a marker used by the AR application.
Direct testing using the black box testing technique so that can reduce errors that might occur. Function testing is done by providing input to each function to ensure that the function results are working correctly. The black box testing requires a long computational time because the testers do not know the application's internal structure, so it requires a lot of effort to find bugs [14,15]. The black box testing results are shown in Table 1.

Table 1. The black box testing

| Process Name | System response                                      | Compatible |
|--------------|------------------------------------------------------|-------------|
| Open App     | If successful, a message to scan the marker will appear | √           |
| Scan Marker  | If successful, a 3D object will appear               | √           |
| Rotation     | If successful, the object will rotate                | √           |
| Zoom         | If successful, the object becomes larger or smaller  | √           |

4. Conclusion
Based on the results that have been concluded, it can be concluded that learning Earth physics can be modeled using AR media. With the help of AR media, it will make the learner closer to the object being observed because AR media provides an interactive and interesting picture.

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