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Development of Augmented Reality as a Learning Medium for Recognition of Layers and Structures of the Earth

Abstract: *Augmented Reality* is a technology that combines real-world measurement with the dimensions of the virtual world exposed in real-time. It doesn't completely replace what's in the real world, like virtual reality, but just adds to it. This is done by "painting" three-dimensional objects on markers, which are unique "patterns" that can be recognised by the application. Smartphones can develop Augmented Reality applications at low prices and can be used by many consumers. Augmented Reality can be consumed in various fields, one of which is the educational sphere as a learning media tool. It can be used to create a more interactive learning environment where students can interact directly with virtual world objects so that students can learn while playing. The application development process in this study is based on the waterfall model. The augmented reality app was developed for teachers and students as a medium in school. The app uses the Vuforia SDK software as a tool to create Augmented Reality. Java and C++ are based on Android. Real-world surface layer applications and earth structure recognition applications can read markers in Augmented Reality geography books. As a medium, they will display 3D models on the screen of android devices and display 3D on the layers and structures of the earth.

Keywords: Augmented Reality, Android, Learning Media, Layers and Structure of the Earth, Geography.

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Introduction

Technology is a tool that consumers use to make their needs more leisurely. The development of information and communication technology itself has proliferated in various fields, one of which is *Augmented Reality (AR)* (Figure 1). It is widely used in the gaming, entertainment, and medical industries (Chytas et al., 2020; Alexandov, 2015; Kenzhaliyev et al., 2021 Pratama et al, 2021a, 2021b). At the same time, in education, the use of augmented reality technology itself is still lacking. *AR* is a new technology that can add interactive digital information to the real world. This technology combines two-dimensional or three-dimensional virtual objects into a natural three-dimensional environment and then projects these virtual objects in real-time (Budiman, 2018). The ability to deliver meaningful information spatially and temporally in real-time makes AR technology an excellent choice to support knowledge-intensive work (Deshpande & Kim, 2018).

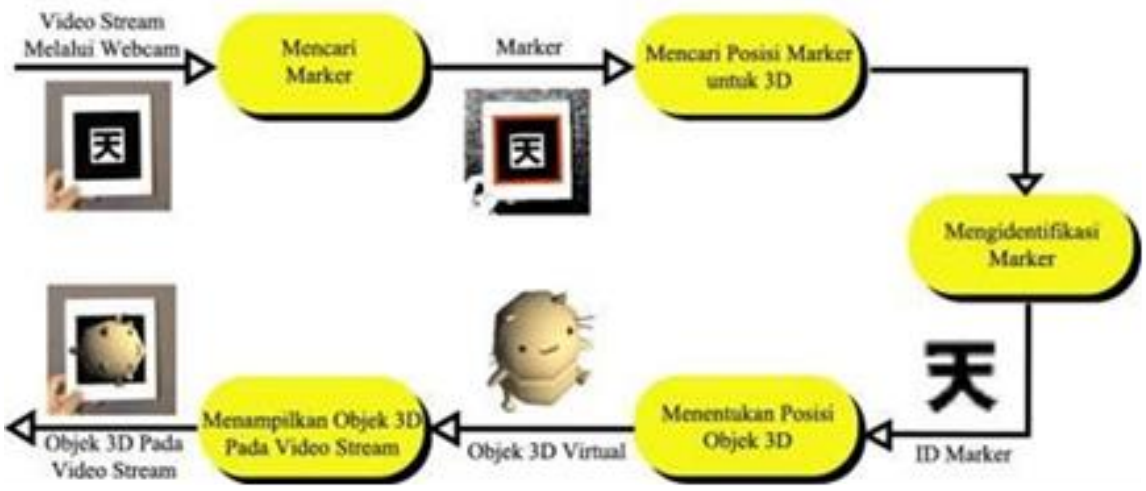


Figure 1. Augmented Reality Overview

Meanwhile, in education, students' interest in learning decreases due to the development of entertainment technology, which increasingly presents exciting and interactive things such as cartoons and 3D animation (Alexandov, 2015). While the learning media used is still dominated by books containing only text and illustrations (Mustaqim, 2016). Using two-dimensional (2D) images as learning support, so students do not feel bored and are more imaginative is now less helpful in solving the problem. The use of pictures in textbooks already makes students passive and less interactive because image media cannot provide reciprocal responses, is less visible, and is less attractive to students (Yusniawati, 2011). Meantime, the development of three-dimensional (3D) image technology, widely used in the entertainment industry, is undoubtedly more attractive to middle school-aged children (Todorova, 2015). The reason is that 3D objects have a more comprehensive perspective than 2D objects with only one angle of view. 3D objects are also considered more interactive and imaginary because they match the original idea (Aditama et al., 2019).

The use of teaching aids based on AR technology is very useful in improving the teaching and learning process because it has got an entertainment aspect that can arouse students' interest to understand concretely delivered through 3D visual representation by involving user interaction in augmented frame reality (Jeffri & Awang Rambli, 2021).

Thus, with the development of AR applications, this android-based technology can be a new learning tool and method in understanding the layers and structures of the earth and can help interactively and interestingly convey information about them (Savinykh, 2015).

Literature Review

Augmented Reality is known as a real-time direct or indirect technology view of the actual physical environment that has been enhanced by information generated by virtual computers to it (Milgram, P., & Kishino, 1994). AR makes it possible to add virtual to the formation of the natural world in real-time (Azuma, 1997). AR technology adds virtual elements to natural scenes coherently so that the ideal user can't distinguish them from natural settings (Amin, & Govilkar, 2015). Amin & Golvikar argue that AR is a technology that provides real-time digital content integration with real-world information and allows direct access to implied information with the context in real-time. AR improves users' perception of the natural world by enriching what they see, feel, and hear in the natural environment (Amin, & Govilkar, 2015; Kassymova et al., 2021).

According to Lytridis & Tsinakos, *Augmented Reality* is a technology that can present new environments and combines real and virtual environments that enrich and stimulate the senses with various information (Lytridis & Tsinakos, 2018). AR application principles use device sensors to view the environment and insert dynamic, context-aware, interactive digital content within it (Savinykh, 2015). Unlike *Virtual Reality (VR),* which immerses users in an entirely new virtual environment, AR aims to add the user's current reality by adding virtual content to the physical environment (da Silva et al., 2016). AR

technology can be used on various platforms such as desktops, notebooks, and mobile devices. However, AR applications are usually available through mobile devices, such as smartphones and tablets or wearable devices. Built-in cameras, global positioning system sensors, gyroscopes, and other sensors are used to recognize objects, images, and scenes. When successful recognition, relevant digital content is available and displayed on the screen. The objective is to combine the environment with digital content smoothly (Hsu et al., 2017). This allows consumers to receive more information about their environment available. The advantages of AR are not only the increase in as much information as there is in the environment but also the creation of certain representations of the touch of the world that appeal to users. For these reasons, AR has been applied to several fields, including entertainment, tourism, trade, engineering, and education.

In recent years, there has been an increasing interest in implementing *AR* to create unique educational settings (Chen et al., 2016). AR tools and environments lead to various positive outcomes and impacts for educational purposes. Tori, Kirner, & Siscoutto argue that the existence of a virtual and real environment allows students to experience phenomena that are impossible to happen in the real world (Tori, Kirner, & Siscoutto, 2006). This will enable learners to imagine complex spatial relationships and abstract concepts and, therefore, develop essential abilities that cannot be developed in other technological learning environments (Wu et al., 2013; Chukmanova et al., 2022). Although the physical world is three-dimensional, most users prefer to use two-dimensional media in education. The combination of AR technology with educational content results in new applications and automated actions to enhance the effectiveness and appeal of teaching and learning for students in real-life scenarios. AR is a new medium that combines aspects of ubiquitous computing, natural computing, and social computing. This medium offers unique capabilities, combining the physical and virtual worlds with continuous and implied user control and interactivity (Kesim & Ozarslan, 2012).

Many studies use in-depth AR technology to improve computational thinking skills or programming in some contexts (Savinykh, 2015). However, there are not enough studies analysing meaningful features or advantages and disadvantages in the field.

Methodology

This study is about research and development using *AR* technology to produce geographic learning media products. The development model used in this study is the waterfall software, development model. According to Bassil, waterfall models have a systematic and sequential approach to software development (Bassil, 2012). In addition, the waterfall model has straightforward stages because it is suitable for developing software learning media. According to Bastero-Gil et al., the waterfall model has 4 steps (Figure 2), which are the stage of analysis, design, program code generation or implementation and evaluation (Bastero-Gil, 2014).

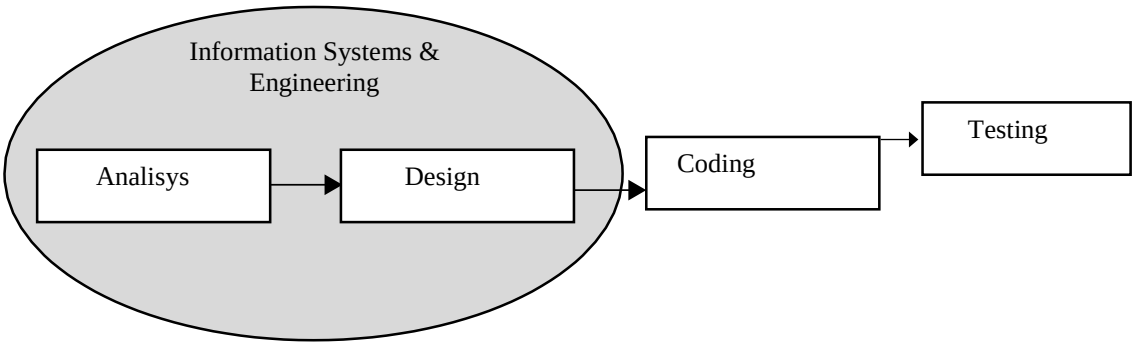


Figure 2. Stages of waterfall model

Analysis

The analysis is done by conducting a needs analysis. Needs analysis is a formal process of representing information, functions and behaviours that can be translated into data, architecture, interfaces and

components. Based on the analysis of requirements, the authors of this study categorised it into four types, namely:

- Specification analysis needs to explain what a system must have to run correctly. It aims to determine what kind of system is appropriate to implement and which hardware and software are needed to develop an application.
- Hardware needs analysis is a process of creating essential learning media to introduce layers and earth structures. The hardware requires minimum specifications for running Augmented Reality development application programs. The main application for developing Augmented Reality technology is Unity 3D.
- Software needs analysis is a run to analyse the software needed to develop essential learning media for introducing layers and structures of the earth.
- Needs analysis for AR books includes all the needs for creating AR books. A selection of geographic materials is the most critical point of the study of the need for inclusion in the AR book. The choice of materials is based on the applicable lesson and refers to the reference book containing the necessary materials.

Design

Design facilitates product development following the analysis of the needs and specifications of products that have been produced. In addition, the results of this design stage will be used as a reference in implementing the program code writing. The design in this study includes an art form of the system and a user interface (Figure 3).

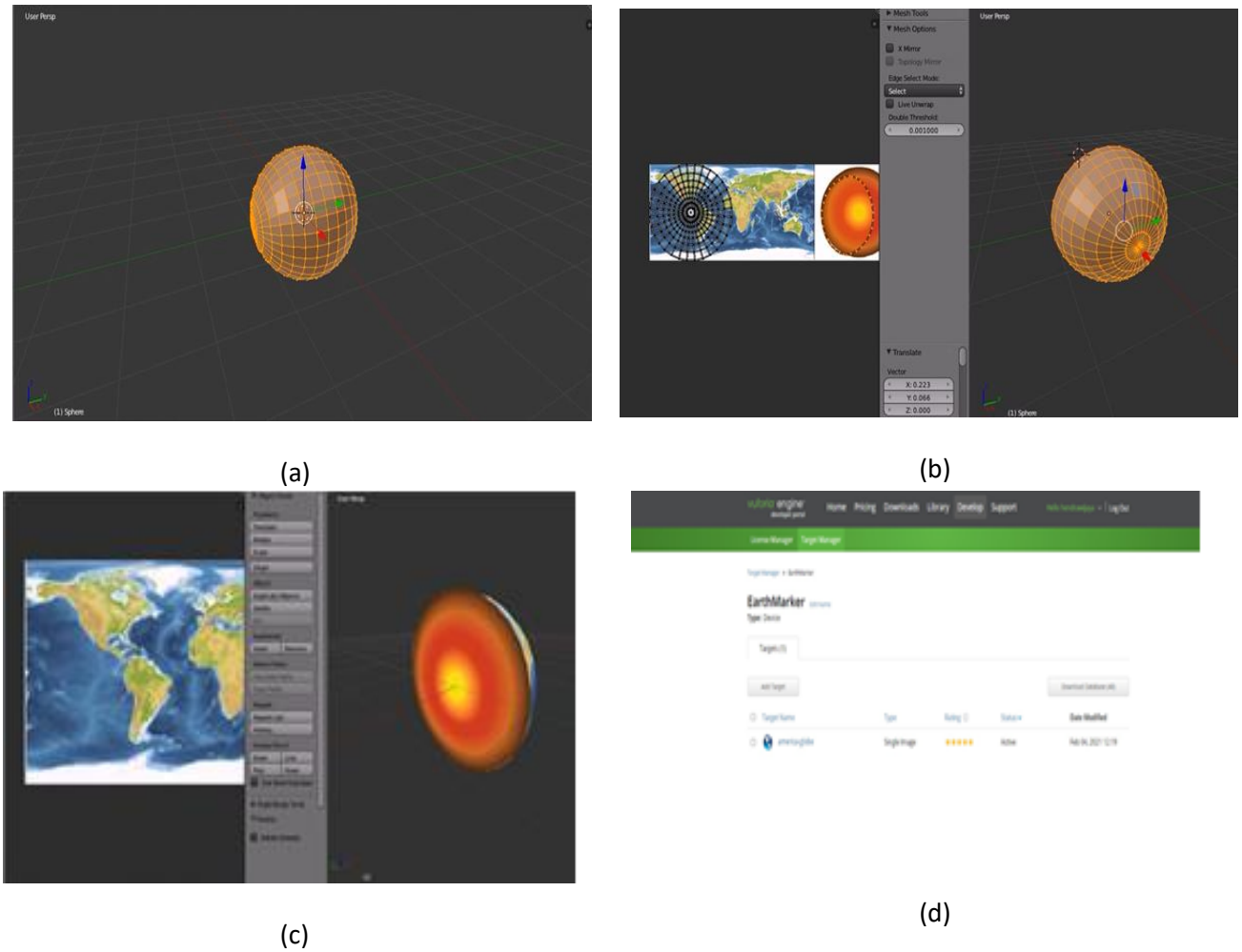
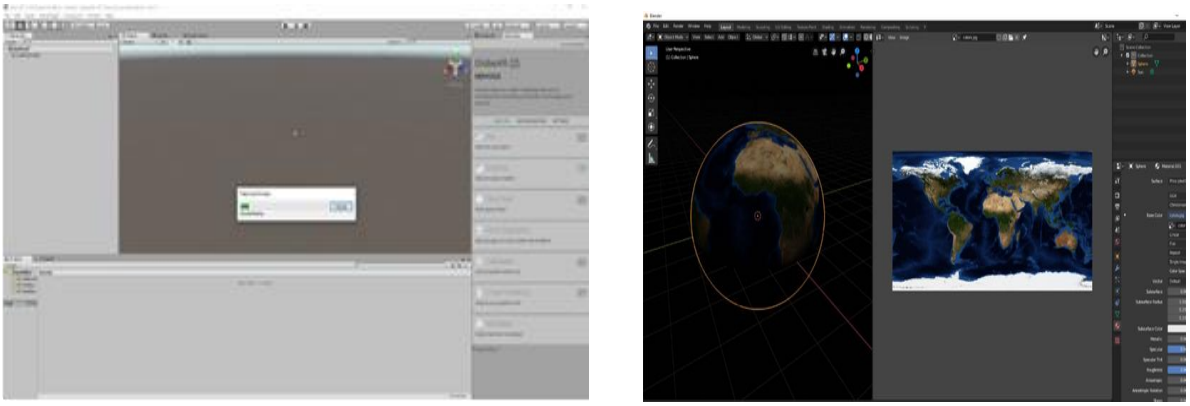


Figure 3. (a) Modeling stages, (b) Texturing stages, (c) Animating stages, (d) Marker making

Implementation

The created design is then implemented into an application program developed in the form of geographic learning media with Augmented Reality technology. Unity 3D was used as a software in this study (Figure 4).



(a) (b)

Figure 4. (a) The process of importing data markers into unity software, (b) Augmented globe process in 3D form

Evaluation

After the process of designing and building essential learning media for the introduction of layers and structures of the earth with Augmented Reality technology and running on Android smartphones, the next step is product testing by media and materials experts (Maiorova et al., 2015). Testing aims to check the performance or function of the developed software. Meanwhile, testing by media and material experts was conducted to assess the possibility of learning media being developed. After the learning media has been tested by experts, it is tested on students to know the student's response to the learning media created. Figure 5 shows the stages of the study carried out.

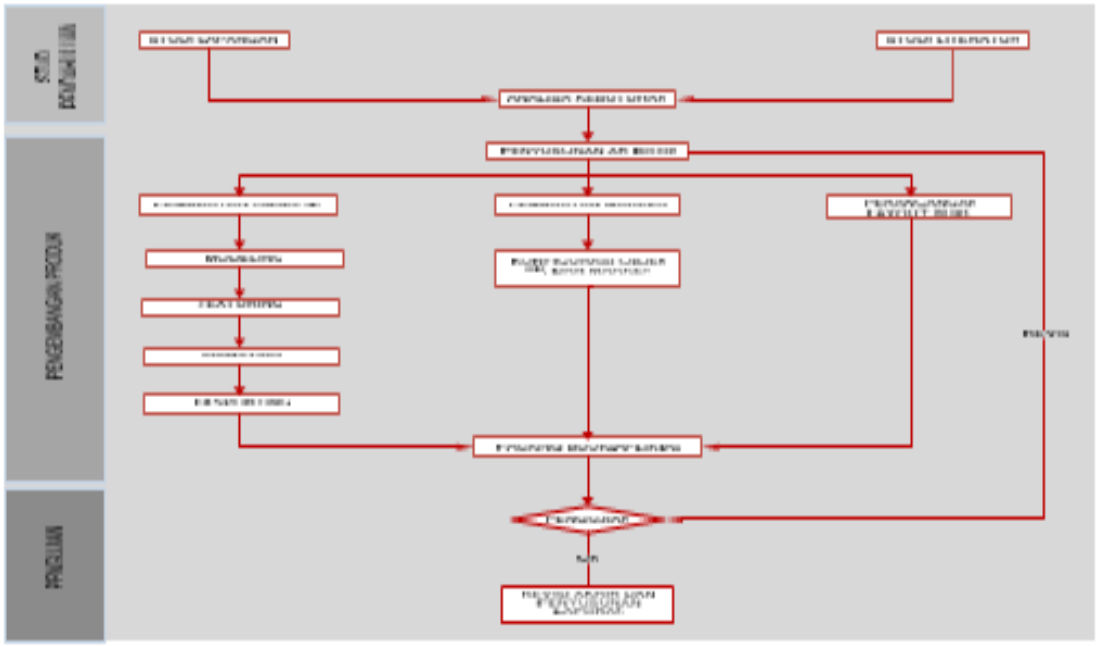


Figure 5. Stages of study

Discussion

The results of the development in the form of learning media products based on Augmented Reality technology on the Android platform for geography subjects on the primary material of the introduction of layers and structures of the earth include material understanding, symbols and characteristics of the design and layers of the world adapted to the subjects in school (Chytas et al., 2020; Alexandov, 2015; Mutalib & Ahmad, 2012). In applying this learning medium, products are created using Unity 3D software and vuforia SDK to support the development of Augmented Reality. Meanwhile, the binding process is performed using Microsoft Visual Studio 2012 software and the process of creating resource objects using Corel draw X7 and Blender 2.80 applications.

The developed product is an Augmented Reality app that can run on devices such as mobile phones with the Android operating system and AR geography books containing instructions for users, material summaries, and bookmark images. E-learning material environments enable students to develop their potential if appropriately used in the education system (Kassymova et al., 2020; Arlinwibowo et al., 2021). The results of realization of learning media design are described in the following section.

Augmented Reality Geography App

Splash Screen. A splash screen page is the first page that appears when a user opens the Augmented Reality app as a medium for learning geography about the layers and structures of the earth. This page is the branding page for Unity 3D products and continues with the branding of advanced AR applications. This splash screen page will be displayed a few moments before entering the main menu (Figure 6).

(a) (b)

Figure 6. (a) Splash Screen Branding Unity Display, (b) Splash Screen Display AR Geography Application

Main Menu Page

The main menu page is primary in this learning medium (Figure 7). On this page, several menu options can be accessed by the user. It contains an augmented reality geography menu, learning materials menu about the layers and structure of the earth, a user manual menu, and a menu about developer information. The augmented reality Geography menu serves to run Augmented Reality. When the button is pressed, the camera will open on the device. The material menu for the earth's layers and structures will summarise the earth's system and layers. The user guide menu serves to open the Augmented Reality user guide page and the menu about the developer information page.

Figure 7. Main menu page view

Augmented Reality Geography Page

The Augmented Reality Geography page includes the Augmented Reality app (Figure 8). When this page is first opened, it will open the camera on a mobile device. This camera helps sing markers contained in geography AR books. If the camera successfully captures the feature, the 3D image will be displayed according to each bookmark's database. On this page, there is also the main menu button that returns to the main menu page.

Figure 8. Augmented reality geography page view

Learning Materials Page

On the learning materials page, information about the geographical materials of the structure and layers of the earth is given about the earth's crust, info about the earth's mantle, and information about the earth's core. Figure 9 shows the page view of the learning materials.

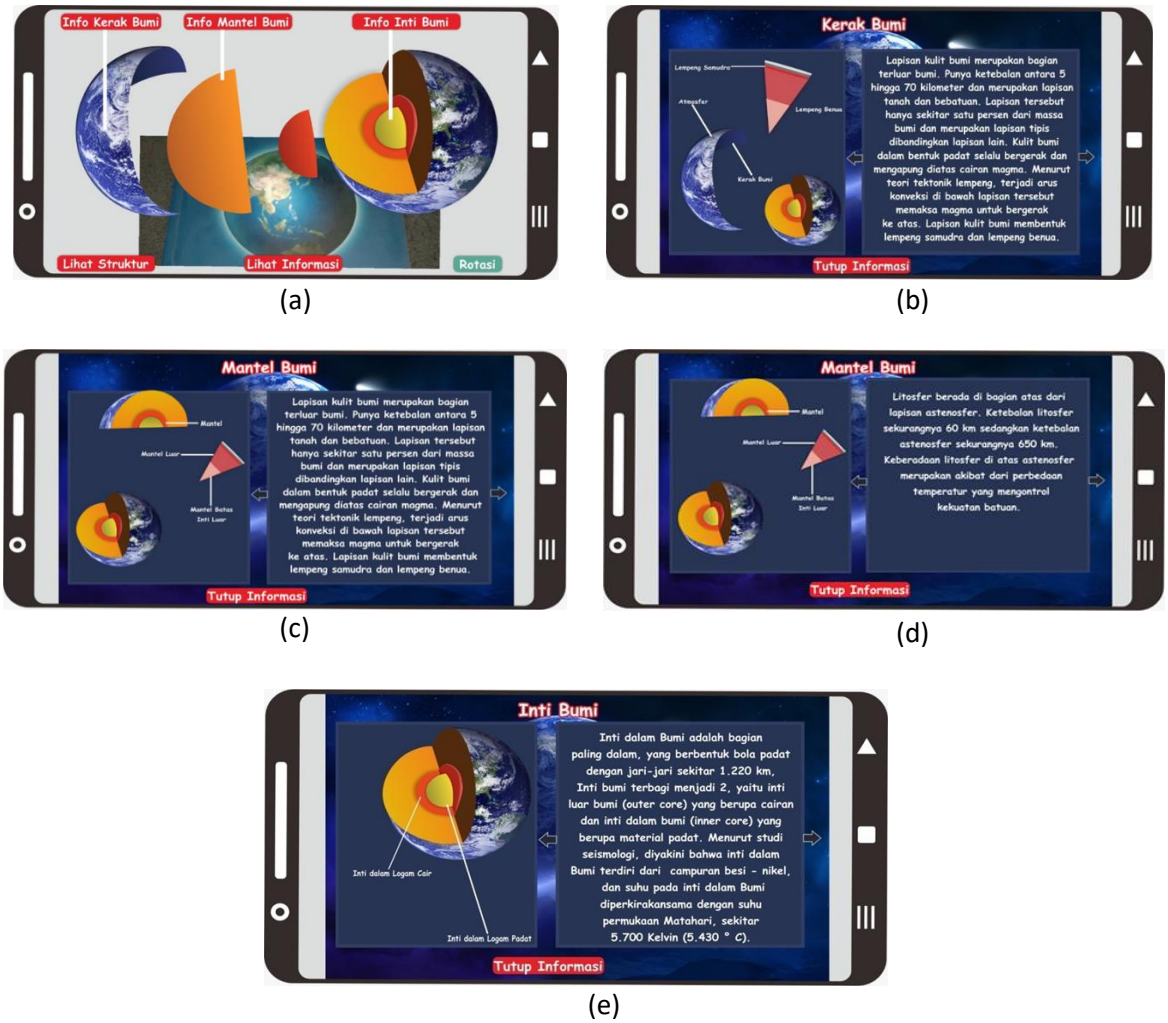


Figure 9. (a) Display of learning material pages, (b) Display of the earth's crustal sub-material pages, (c) & (d) Display of sub-material pages of the mantle of the earth, (e) Display of Earth Core Sub Material Page

Instruction Manual Page

The user manual indicates how to function the button in the learning medium to introduce layers and earth structures and explains how to run Augmented Reality (Figure 10).

Figure 10. How-to page view

Panel MenU

A panel menu is a set of shortcut menus that can be accessed by pressing the 3-lane button in the right corner of the application exposure. This panel menu consists of a button to open the Augmented Reality Geography page, a Learning Materials page, a user manual page, an about page, and a button to exit the app (Figure 11).

Figure 11. Panel menu page display

AR Book Geography

AR Book Geography is a learning module that discusses the layers and structures of the earth applied through augmented reality applications (Mishra, 2013). Geography AR Books is concise, with 24 pages to make it easier to understand for students. The book contains directions for using the AR Book Geography app, a summary of what is in the earth's layers, and structures applied through markers useful to coordinate points that can be tracked by the android geography AR app.

Conclusions

This study focuses on developing AR learning media in geography subjects using waterfall models. The model has four stages, namely the analysis, design, packaging, and testing phases. The results of this study and development are a product in the form of geography learning media based on AR technology that is equipped with AR books as a supporter. AR learning media was developed to introduce layers and structures of the earth consisting of the main components, namely: (a) the main menu page containing the button to the menu in the application, (b) the material page containing materials about the structure and layer of the earth, (c) the geography AR page is the main page in the introduction of the layers and structures of the earth with AR. The initial product of learning media is then continued with testing/ratification by material experts and media experts.

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