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Design of Android-Based Augmented Reality Physics Book for Grade XII of High School Chapter 9 Digital Technology

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ABSTRACT

Many senior high school students still rely on printed books for their learning, but these books often only provide 2D images with written explanations. This made Students difficult to fully ubnderstand the 3D nature of the images, especially in subjects like physic. To address this issue, the author developed an application using Augmented Reality (AR) Technology Which focused on Chapter IX of the physics textbook, mainly on "Digital Technology". This AR application helped students with more interesting and interactive learning experiences by showcasing animation and 3D designs. Based on he questionnaire result, from 120 students of SMK Negeri 1 Langsa it was found that 96.17% agreed that this AR app was an effective learning tool and 3.83% disagreed. So it can be concluded that this AR application can be an alternative for students and teachers as a learning media and it easier to understand, interesting, and fun in the teaching and learning process.

I. Background

Reading is the ability to interpret the material being read. The skill of reading involves not only interpreting letters, images, and numbers, but also relates to a person's ability to comprehend meanings and things of interest [1]. Reading interest is an attitude of devoting attention to intellectual curiosity, coupled with a constant effort to explore new fields of knowledge (information), and a willingness to allocate time for reading activities [2].

In the present era of technological advancement, the interest of book readers in Indonesia is dwindling, particularly in the realm of scientific literature. Research results from the "Most Littered Nation In the World 2016" study (a research on reading interests) indicate that Indonesia holds the 60th position out of 61 countries. This signifies that it ranks second to last, reflecting an exceedingly low level of reading interest [3].

Visual media involves the visual presentation of 2D or 3D content, utilizing designed images as a tool for contemplating daily life. Its purpose is to convey messages and provide information to the intended audience. The channel employed revolves around the sense of sight, with messages conveyed through visual communication symbols. Images can serve as effective tools in the learning process, assisting students in grasping the presented material. However, it's crucial to carefully select and use images in alignment with the learning objectives of each subject [4].

Currently, especially for high school students and their equivalents, the educational system still predominantly relies on traditional printed materials, consisting mostly of written text. However, when combined with visual media, the learning experience can become more captivating. Students who struggle with comprehending written texts have a greater chance of understanding the material

more easily through the use of visual media. Thanks to the current technological advancements, educational practices involving visual media are no longer confined to 2D images. Presently, through the use of gadgets, students can engage with 3D visuals and are not limited to static images. They also have access to animations and augmented reality applications that pertain to various subjects. Augmented Reality (AR) is a technology that seamlessly integrates real-time overlays of 2D or 3D virtual objects into the real-world environment. This can be achieved using devices like webcams, computers, smartphones, or specialized glasses. To enable augmented reality projection, a marker is essential, acting as a specific identifier used to detect 3D objects. AR enables users to visualize objects in three dimensions. Its interactive and real-time nature makes it applicable in various fields. In the realm of education, AR serves as a medium for introducing 3D objects into the learning process [5].

The aim of implementing the use of augmented reality is to allow students to visualize 3D objects using smartphones, particularly objects that illustrate concepts such as digital technology, data transmission, and digital data storage.

II. Basic Theory

A. Digital Technology

Technology is advancing rapidly. In the field of audio and visual recording, developments have evolved from vinyl records and cassettes to CDs and DVDs. Cassettes, which were popular in the 1960s, used analog technology for sound and image recording. This required manually rewinding the playback device to the desired data point to select a specific song or image. The progress of digital technology has significantly simplified our lives. Devices such as cameras, radio-tapes, televisions, and telephones have undergone a transformation in signal processing from analog to digital. Digital technology has led to rapid advancements, particularly in the domains of information technology and telecommunications [6].

B. Augmented Reality

Augmented Reality (AR) is a multimedia technology capable of superimposing 2D and 3D objects into the real world using pre-defined marker locations [7]. AR introduces a new dimension to experiencing virtual objects. The fundamental aspect of the Augmented Reality experience is that users become actively involved in real-world activities, with Augmented Reality incorporating digital information into the virtual world. This allows users to interact with the augmented environment in a manner similar to how they would interact with the real world [8].

Mobile devices offer stronger support for augmented reality development because they possess the necessary hardware and software components for AR development. Essentially, the functioning of augmented reality starts with a tracking process on an object used as a marker to ascertain the position and orientation of virtual objects in the real world. Once real-world coordinates are obtained, the subsequent step involves rendering virtual objects and displaying them virtually within the real-world coordinates [9].

AR offers advantages such as increased interactivity and effectiveness in its utilization. Users can engage with a wide range of media and find it easy to operate, with simple object modeling. However, AR does have its drawbacks, including high sensitivity to changes in perspective and a demand for substantial device memory. Augmented reality can be harnessed to support the education system through educational media. With educational content easily accessible via smartphones, learners can study subjects by accessing information accompanied by 2D and 3D object simulations. This approach can pique learners' interest in comprehending subject matter, making it easier for them to grasp the conveyed material [10].

C. Marker

A marker is a specific pattern that acts as a indicator, allowing the camera to detect the pattern when pointed at the marker. This enables the camera to project a 3D object onto the smartphone. In augmented reality, markers are divided into two categories: marker-based tracking and marker less tracking. The difference between them lies in the fact that marker-based tracking employs distinct markers to display AR, while marker less AR can be presented without the use of specific markers,

relying instead on geometric concepts to showcase AR. The design of AR in this application employs the marker-based tracking method. This decision is due to the fact that augmented reality using marker-based tracking is easily accessible, as it enables users to experience AR solely through the use of their smartphone camera. However, a limitation of the marker-based tracking method is that AR is restricted to specific codes that are provided. This means that the rendering of 3D objects is dependent on the location of these markers [11].

D. Android

Currently, the Android operating system boasts the highest usage percentage among users. The utilization of Android in implementing augmented reality from the Physics XII Textbook Chapter on Digital Technology is attributed to the fact that the majority of students nowadays use smartphones with the Android operating system. Drawing data from Stat counter's market share, the usage percentage of the Android operating system in Indonesia in 2022 is approximately 89.77%. Meanwhile, on a global scale, the usage percentage of the Android operating system is about 70.96% for the year 2022. The development of AR in this application employs Android SDK version 23, also known as Android Marshmallow. The use of this Android SDK is aligned with the Unity version and the installed Vuforia SDK. Consequently, smartphones running Android 6 or older versions cannot run this application [12].

E. 3D Modelling

Modeling is the process of shaping a model in accordance with the intended object. Digital modeling entails crafting models of both real and fictional forms digitally, using specialized 3D modeling software. A 3D object represents a graphic rendered in three dimensions along the x, y, and z coordinates. Each object possesses width, height, and depth dimensions and is designed using 3D software [13].

III. Design Method

A. Work Flow

The first step is to conduct a literature study to gather the necessary data for designing the application. After completing the literature study, the acquired data is then divided into two parts: data for designing 3D objects and data for designing the AR application.

Once the data has been obtained, the next step is to create 3D objects using Blender software and save them in FBX file format. The subsequent stage involves uploading images from the 12th-grade High School Physics textbook to the target database on the Vuforia website. This database will be downloaded and then imported into Unity, along with the Vuforia license key. The process continues with voice recording that explains the material in accordance with the content of the 12th-grade High School Physics textbook.

Next, create the user interface (UI) design using Figma as a mockup, which will then be implemented in Unity. Following that, the process involves designing the augmented reality (AR) application. It starts with creating the UI using a canvas in Unity and then creating the AR camera using image targets from the Vuforia SDK package imported into Unity. Import the 3D objects, already in FBX format, into Unity. Then, add the explanatory audio material in MP3 format to Unity. Once the AR application design is complete, you can build the AR application into an APK package for Android smartphones.

Test the application on an Android smartphone. If any errors occur in the application, return to the AR design phase. If the application runs without any issues, then the development of the AR application for the 12th-grade High School Physics Chapter 9 on Digital Technology is complete.

B. Designing the Augmented Reality Application for Grade XII Physics Textbook Chapter 9: Digital Technology

1. Designing Markers

In marker design, images from the 12th-grade High School Physics Chapter on Digital Technology textbook are used. This augmented reality application includes a total of 22 markers, and users can utilize the 12th-grade High School Physics Chapter on Digital Technology textbook to activate these markers and immediately view the corresponding 3D object displays upon detection. Once the marker images are obtained, they can be uploaded to the target database through the Vuforia website.

2. Designing User Interface
   In the design process, it is important to prioritize user experience, ensuring that users can easily understand how to use the application and grasp the functions of each menu created. Before proceeding to the application development phase, it begins with creating designs that serve as mockups and references for developing the user interface (UI). The design is crafted using Figma. After creating the UI design, the next step is to implement these designs into the Unity application. Each application menu is created as a separate scene.
3. Designing AR Camera
   To design the augmented reality camera, start by importing the previously created image target database through the Vuforia website. Additionally, import 3D objects in FBX format into Unity, and remember to enter the license key obtained from the Vuforia website.
4. Build To APK
   After successfully importing the UI, AR camera, and 3D objects into Unity, proceed to build the application. The application is built to run on Android smartphones. The process of building the augmented reality application may take a few moments until it becomes an APK file.

C. Application Testing

After going through a series of augmented reality application design steps, it's time to conduct testing. In this stage, perform checks to identify any functional errors or bugs in the created application. If any errors are found, repeat the development steps according to the flowchart's process.

IV. Results and Discussion

A. Menu Interface

1. Main Menu Display
   This display contains the main menu options of the application, which include the AR camera button, help button, about button, and exit button.

Fig. 2. Main Menu Display.

2. Guide Menu Display

This page contains a tutorial on how to display augmented reality in this application.

Fig. 3. Guide Menu Display.

3. About Menu Display

This page contains information about the augmented reality application for the 12th-grade Physics textbook.

Fig. 4. About Menu Display.

4. AR Camera Display

Inthe AR menu,there are several buttons that function for sound and music, andthere is also a material button to display material according to the 3D object being scanned.

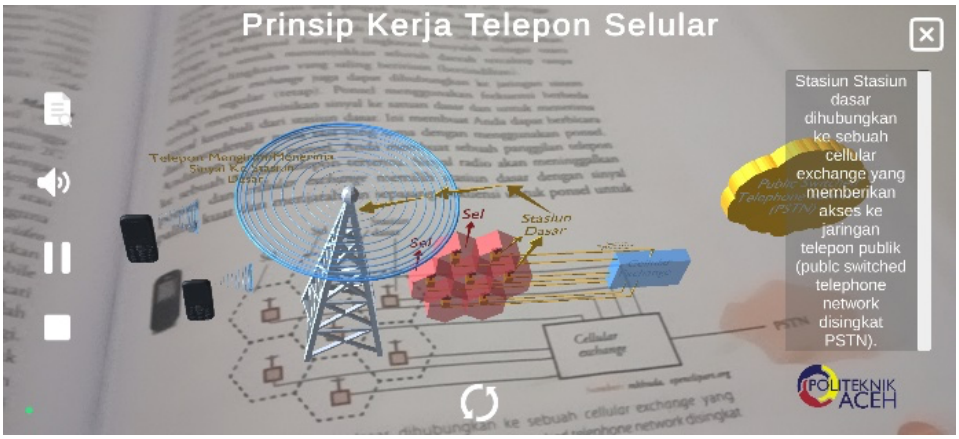

Fig. 5. Display Of Augmented Reality.

B. Questionnaire Test Results

The Android-based Augmented Reality application for the 12th-grade Physics Package Book for High School/ Vocational School/ Islamic School (SMA/SMK/MA) uses data collection techniques through observation. The analysis used in this research is quantitative analysis, involving the use of a questionnaire filled out by students as respondents. A total of 120 students from SMK Negeri 1 Langsa participated in this study, with each questionnaire containing 10 questions.

Based on the data analysis results, students' responses to the application obtained a score of 1.154 out of a total of 1,200 questions. This results in a percentage of 96.17%, which can be categorized as excellent. Therefore, it can be concluded that the use of Augmented Reality technology in the Android-based 12th-grade Physics Package Book for SMA/SMK/MA is suitable as a learning medium that is easier to understand, engaging, and enjoyable.

Here is the questionnaire used to assess the suitability of the application:

Table 1. Questionnaire Test Results

No.	Pertanyaan	Penilaian	
		S	TS
1	Using the application increases understanding and interest in studying the Class XII Physics Package Book	117	3
2	The application has clear instructions for use	113	7
3	The app doesn't crash during use	112	8
4	The application appearance is attractive	115	5
5	The material and animations displayed are clear and easy to understand	116	4
6	This application helps in studying material in the Class XII Physics Package Book	120	0
7	The audio used sounds clear	118	2
8	The 3D objects displayed are attractive	116	4
9	The navigation buttons used are simple and easy to understand	113	7
10	Applications help the learning process be more interactive and fun	114	6

Note:
S = Agree
TS = Disagree

Here is the graph of the questionnaire used to assess the suitability of the application:

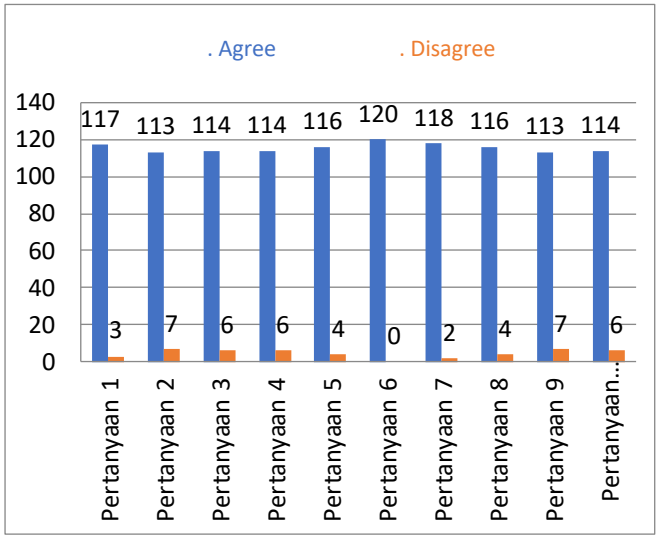

Fig. 6. Diagram of Questionnaire Test Results.

V. Conclusion and Suggestion

A. Conclusion

Based on the discussions in the previous chapters, from the design phase to the testing phase, the following conclusions can be drawn:

1. This application can assist students in visualizing objects in Chapter 9 on Digital Technology with the presence of 3D object animations.
2. The application has been successfully developed using Vuforia SDK and Unity.
3. The application can address issues in conveying content that is difficult to understand without clear images.

B. Suggestion

Here are some valuable suggestions for the future development of this augmented reality application:

1. It is hoped that this application can run on smartphones with operating systems other than Android.
2. The application should aim to be built into a smaller size to save smartphone storage.
3. The application is expected to be directly usable in high schools (SMA/MA).

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