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Original Article

Exploring Prehistoric Era in Virtual Reality Walkthrough

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Abstract *- Industrial Revolution 4.0 has changed the direction of innovation, such as Virtual Reality (VR) in the education sector. Nowadays, VR is applied in the education area to enhance students' learning abilities. History education should be integrated with this technology so that students can learn and remember better in history subject. The learning process becomes less interesting, and it is difficult for students to understand and appreciate without appropriate teaching methods. Early exposure to effective learning aids in education is important for increasing student motivation and attracting their interest in the subject of history. In this article, we focus on specific topics, namely the Prehistoric Era, which includes the Neolithic, Paleolithic, and Metal Age. The Prehistoric VR application is built to allow students to gain experience and visualize the prehistorical era in a virtual environment. This application is designed to align with the curriculum outlined in the Form 1 textbook. In addition, the gaze interaction technique is used in this application so that users can control with their eyes. ADDIE method is used to provide a systematic and step-by-step framework to achieve the objectives. Each User Interface (UI) button's functionality and User Usability Testing have been tested using the test case method. This application produced a realistic 3D environment that can visually stimulate VR within a real-world setting.*

Keywords *- Virtual reality, Prehistoric, Virtual environment, Realistic 3D environment, History.*

1. Introduction

Virtual Reality (VR) is an enhanced version of the real physical world, achieved using digital visual elements, sound, or other sensory stimuli delivered through technology. One of the main purposes of an educational environment is to encourage social interaction among users located in the same physical space. This technology is very effective for educational purposes, especially for students. Prehistoric learning is applied using VR technology to provide a new learning environment to students and can attract students' attention to learning, especially in the subject of history. VR has many different implementation models and applications, but its primary objective is to provide a rich audio-visual experience.

To create a virtual environment, VR uses computer technology. It also gives the user the impression that they are immersed in an experience (Bamodu and Ye, 2013). Virtual reality technology attempts to regenerate computer images and videos to produce real-life visual experiences that are beyond those achieved on an ordinary computer monitor and phone. This Prehistoric VR application is clearly designed for educational purposes and effective learning using multimedia methods with gaze interaction techniques. Arrows guide users to get information. This application is divided into three learning modules: Paleolithic, Neolithic, and Metal Age. For this application, the developers developed an application using VR technology that contains information about prehistoric times that is parallel to and guided by the syllabus of the 1st-grade history textbook.

2. Existing Findings

MAN Virtual VR was developed by Museo Arqueologico Nacional on November 30, 2017. The app operates on Android devices and requires internet access to function. This application is to explore various pieces of art throughout history in the National Archaeological Museum of Madrid, Spain. In addition, this application contains multiple different exhibits, such as those for Roman Hispania, Late Antiquity, Greece, Numismatics, Egypt, and the Early Modern Era. This application is available for free download from the Meta Quest website. Table 1 shows the advantages and drawbacks of MAN Virtual VR application.

Discovr Egypt:

King Tut's Tomb was released on April 21, 2016, by Discovr Labs. This application contains information about ancient Egyptian. There are only three rooms provided in this application. The user can take a look around and learn about its contents in Discovery Mode or take all the treasure before time runs out in Treasure Hunt. Therefore, this application is more for entertainment and does not require internet access to use it. Table 2 explains about advantages and drawbacks of the Discovr Egypt: King Tut's Tomb application.

Table 1. Advantages and Drawbacks of MAN Virtual VR application

Platform	Advantages	Drawback
• Gear VR	• Visual image • Clear and colorful	• No animation • Only contain visual • No information details

Table 2 Advantage and Drawback Discovr Egypt: King Tut's Tomb application

Platform	Advantages	Drawback
• Gear VR, Oculus Go	• 3D Model • Clear guide direction	• No animation • No information • Short time and limited content to explore • No multimedia element

Table 3. Advantages and drawback of VR education museum

Platform	Advantages	Drawback
• Android	• Visual image • Information • Interactive	• No animation • No instruction for the user

Table 4. Comparison table of the existing findings

	3D Animation	Video	Text	Image	Audio	Mobile Based
MAN Virtual VR	×	×	✓	✓	×	✓
Discovr Egypt: King Tut's Tomb	×	×	✓	×	✓	×
VR Education Museum	×	×	✓	✓	✓	✓

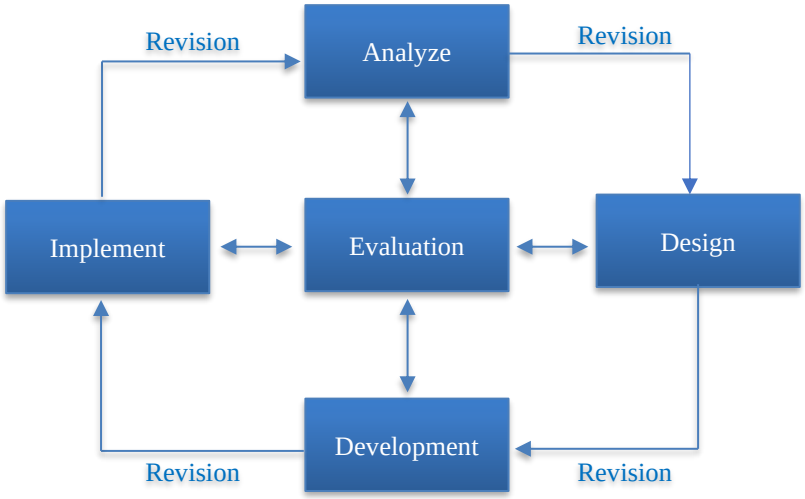

Fig. 1 ADDIE model

VR Education Museum was produced by M. Suzumura on March 3, 2017. This app was made only for educational purposes; users can take a virtual tour inside a museum and learn about great educational projects made using VR technology. VR is a new technology that has the potential to make a great revolution in the field of education, such as history. This mobile application runs on Android devices and requires version 4.4 or higher. In this application, there are advantages and drawbacks stated in Table 3.

Based on the search information obtained from existing applications, these applications discussed advantages and disadvantages. Table 4 shows a summary of the characteristics of each selected application.

3. Methodology

There are many methodologies used for project development such as RAD, Waterfall and ADDIE. Application development defines the process of how the application is made and generally follows a standard methodology. However, the methodology used for the Prehistoric VR application is ADDIE. ADDIE stands for Analysis, Design, Develop, Implement, and Evaluate. ADDIE model is a dynamic instructional design process in which the outcomes of each phase's formative evaluation might lead the instructional designer back to any step previously completed. This is one of the most widely used models in instructional design as a guide to creating a successful design, as shown in the diagram in Figure 1.

This five-step element was kept in the ADDIE model, which includes multiple substages within each of the five basic phases. Due to the hierarchical structure of the processes, the procedure had to be completed in a sequential fashion, with each phase being completed before moving on to the next.

- Analysis Phase: During this phase, an analysis was carried out to determine what was required to develop the Prehistoric VR mobile base application. The analysis stage is the most crucial in this procedure. The ADDIE model's initial phase in the design of courses and teaching materials for online teaching and learning is analysis. It is important to construct an "overall picture" of the integrity of the instructional design at this point. The history education content is the emphasis of the VR application. A market survey of existing products is also conducted as part of the analysis. As a result, the present product's flaws can be detected.

- Design Phases: This stage includes all objectives, performance indicators, tests, subject matter analysis, planning, and resource allocation. Learning objectives, content, subject matter analysis, lesson preparation, assessment tools used, and media selection are all priorities throughout the design phase.

- Storyboard: Storyboard is also part of the multimedia process. The storyboard shows the look and feel of the application that will be developed.

- Development Phases: Development is the next step. The transition from "contemplative" to "physical" implementation takes place during the development phase. This is the phase in which the overall design is developed and used as a guide for the authoring process. Multimedia applications should be used in accordance with the designs that were created throughout the design phase. This design's development refers to the process of creating software employing several pre-existing applications, like programming, authoring, graphics, video, and animation, among others. The course's final structure and content are created at this point. During this step, all the multimedia components are prepared.

- Modeling 3D for Prehistoric VR application: 3D modeling is the process of creating three-dimensional visuals in a digital environment in its most basic form. Modelling, texturing, and rendering are the general steps involved in the creation of 3D animation.

4. Application Framework and Development

To achieve the project goal, the project was carried out within the framework of the structure and system flow. A Prehistoric VR application was created using virtual reality technology. An analysis should be performed before developing the application, and a project framework should be established to see and understand the process flow.

The approach framework is depicted in Figure 2, which is divided into three sections: user, hardware such as VR Box, and Prehistoric VR experience application. For user interaction with virtual environments, the gaze technique has been used. During the user-computer interaction, the user's point of gaze is recorded and used as input in real-time (Zolkefly et al., 2018; Mokhtar et al., 2023).

The gaze pointer can be used in place of the joystick to click buttons in the virtual scene. A walkthrough speed has been set using the gazing technique to ensure that users do not get motion sickness while learning in the virtual reality environment (Chang et al., 2020; Anua et al., 2022).

The implementation phase refers to the actual delivery of the instruction. The purpose of this phase is to ensure the effective and efficient delivery of a fully functional application. This project aims to develop and implement an Android application using the main software, 3D Maya and Unity 3D, that integrates with Virtual Reality. Furthermore, this project uses C# as the programming language for writing scripts. Figure 3 shows the home page of the application. The home page will appear until the user clicks the Enter button.

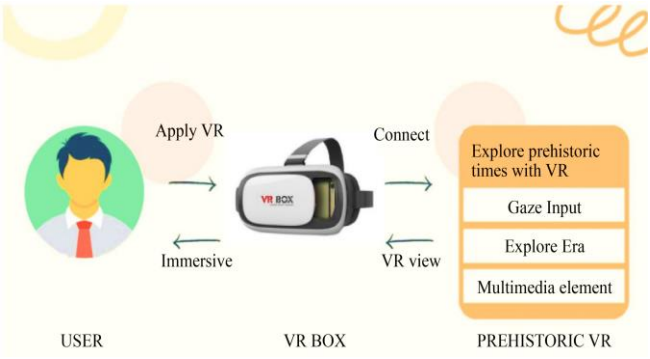

Fig. 2 Prehistoric VR application framework

Fig. 3 Prehistoric VR application home page

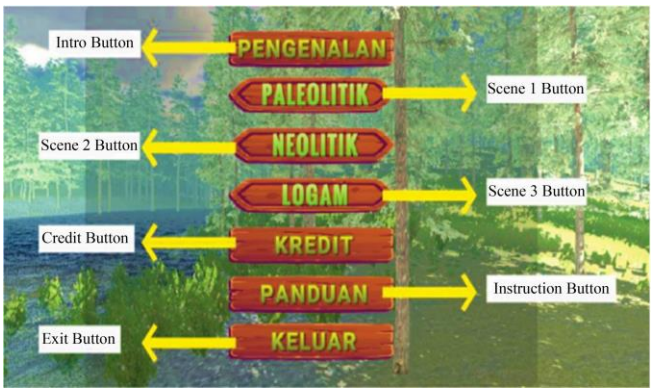

Fig. 4 Prehistoric VR application main menu

Figure 4 shows the user's menu page for the Prehistoric VR. The *Pengenalan* button, *Paleolitik* button, *Neolitik* button, *Logam* button, *Kredit* button, and *Panduan* button are among the navigation options. The quit icon is used to allow the user to exit the application.

Fig. 5 Prehistoric VR application instruction scene

Figure 5 represents the instruction page for Prehistoric VR. To access the instruction scene, the user must look at the *Panduan* button. The data displayed in the video and explain how to use this application.

The page shown below in Figure 6 is the video background of the application. Users can tap on the close button to go to the menu page.

Fig. 6 Prehistoric VR application introduction scene

5. Application Walkthrough

When the user looks at the *Paleolitik* button, the user is automatically transported to the *Paleolitik* scene environment, which is shown in Figure 7. Users can walk through the cave to explore the maze within.

Fig. 7 Paleolitik scene

When the user looks at the hamburger button, a board page that contains a home button and exit button appears, as shown in Figure 8.

Fig. 8 "Neolitik" scene

In each scene of the era, an info button on the display board will include a sound button so that the user can hear the details information. There is also a next and previous button for information, as shown in Figure 9.

Figure 10 shows the process of building the 3D model using Autodesk Maya. This process was built with textures and assigned materials.

Fig. 9 "Zaman Logam" scene

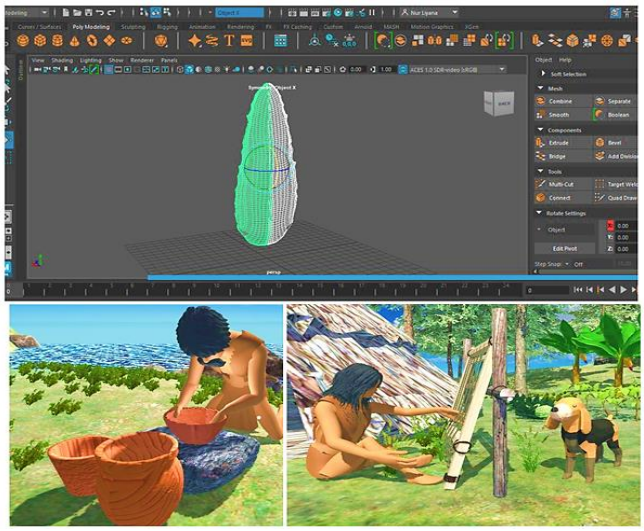

Fig. 10 Pottery making and Fabric manufacturing model using Autodesk Maya

6. Application Function Testing

After the application's development is completed, it has undergone testing to ensure it can work properly without any errors. The application is first installed into the phone, VR page, audio, button etc. The results of each test case plan are recorded in Tables 5 to 10.

All the main functions are tested, and it works as planned. Finding issues with requirements or application design may be improved by the process of developing test cases. In this test, it involves one step for the user to interact. When the application successfully opens, the user will see the home page of the Prehistoric VR application.

On the homepage, there are six steps involved. When the user clicks all six buttons on the homepage, it will show the output as it has been set up. All buttons are functioning well and showing the expected output. Table 6 shows the details of the steps and their results.

On the Introduction page, there are five steps involved. When the user clicks all five buttons on the introduction page, it will show the output as it has been set up. All buttons are functioning well and showing the expected output. Table 7 shows the details of the steps and their results.

In the instruction menu, there are four steps involved. When the user clicks all four buttons in the settings menu, it will show the output as it has been set up. All buttons function well and show the expected output. Table 8 shows the details of the steps and their results.

Table 5. Test case for successfully opening the application

Step	Procedure	Expected Result	Pass/Fail
1	Go to the first page and tap on the Enter button	Redirecting to the Menu Page	Pass

Table 6. Test case for success of the homepage

Step	Procedure	Expected Result	Pass/Fail
1	Click Introduction button	From Menu Page to Introduction page	Pass
2	Click Credit button	From Menu Page to Credit page	Pass
3	Click Paleolithic button	From Menu Page to Paleolithic page	Pass
4	Click Neolithic button	From Menu Page to Neolithic page	Pass
5	Click the Metal Age button	From Menu Page to Metal Age page	Pass
6	Click Exit button	Application closed	Pass

Table 7. Test case for successful of about introduction page

Step	Procedure	Expected Result	Pass/Fail
1	Click Introduction button	From Menu Page to Introduction page	Pass
2	Click Next button	From the text introduction to the video page	Pass
3	Click the Play video button	Video Play	Pass
4	Click the Pause video button	Video Pause	Pass
5	Click Close button	From the Introduction page to the Menu page	Pass

Table 8. Test case for successful of instruction page

Step	Procedure	Expected Result	Pass/Fail
1	Click Instruction button	From Menu Page to Instruction page.	Pass
2	Click the Play video button	Video Play	Pass
3	Click the Pause video button	Video Pause	Pass
4	Click close button	From the Instruction page to the Menu page.	Pass

Table 9. Test case for successful of credit page

Step	Procedure	Expected Result	Pass/Fail
1	Click Credit button	From Menu Page to Credit page.	Pass
2	Click Close button	From Credit Page to Menu page.	Pass

Table 10. Test case for successful of three scene pages

Step	Procedure	Expected Result	Pass/Fail
1	Click Era button	From Menu Page to Era page	Pass
2	Click Information button	Pop up and close information.	Pass
3	Click Next button	Go to the next information.	Pass
4	Click Previous button	Go to the previous information.	Pass
5	Click Play audio button	Audio play	Pass
6	Click Stop audio button	Audio stop	Pass
7	Click Home button	From the Era page to the Menu page	Pass
8	Click Exit button	Application closed	Pass
9	Click Hamburger button	Pop up the home and exit button	Pass

On the credit page, there are two steps involved. When the user clicks all two buttons on the credit page, it will show the output as it has been set up. All buttons are functioning well and showing the expected output. Table 9 shows the details of the steps and their results.

On the three Scene pages, Paleolithic, Neolithic and Metal age, there are nine steps involved. When the user clicks all nine buttons on the scene page, it will show the output as it has been set up. All buttons are functioning well and showing the expected output. Table 10 shows the details of the steps and their results.

Fig. 11(a) Respondent from SMK Kuala Besut, Terengganu

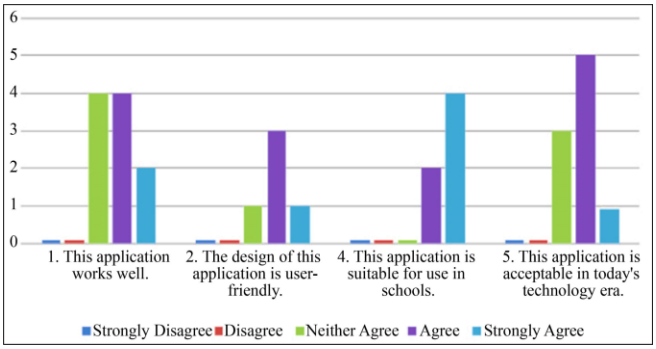

Fig. 11(b) Result questionnaires for prehistoric VR application

7. Usability Testing

Usability testing refers to evaluating the product by testing it with representative users to determine if an application's requirement is partially or completely met (Awang et al., 2019).

The respondents and questions for the feedback survey can be referred to in Figure 11(a, b). The following are the respondents and results of the survey calculated and presented as graph charts.

Figure 11(b) shows the graph chart of the questionnaire that provided 5 levels of satisfaction, from strongly disagree until strongly agree. It can be seen that 75% agree and neither agree with question 1, which shows that the application works well, while question 2 is at the average level, which is 50% agree. Also, 25% neither agree nor strongly agree, which is that this application is very user friendly. Meanwhile the highest strongly agree 75% is at question number 4 where

the application is suitable to use in school. The responses give good feedback about the application, but the lowest level of strongly agree is 20% at both questions 2 and 5.

For question 2, it is because some of the buttons and movements inside the application may maybe hard to gaze and control. While for question 5, it was because the application did not meet the user expectations from different aspects, and the technology was unrecognize to some users. Overall, the average result from the questionnaire that has been asking the response. This response can be used for future improvement of the application.

8. Conclusion

The Prehistoric VR Application helps secondary school students who are taking the history subject learn about prehistoric history more interestingly with the use of 3D animation, text, video, and narration audio. The ADDIE model is suitable for this project's analysis, design, development, implementation, and evaluation. The prehistoric world can be learned more effectively by the students, according to virtual reality technology.

Due to the application's ability to successfully combine multimedia components, learning will be a much more enjoyable process. It is also extremely useful. After all, it is an Android application that can be used anywhere because it does not require an internet connection. People can also try out virtual reality technology while learning more about it.

Acknowledgements

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