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Designing Children's Encyclopedia (3D Dinosaur)

Via Augmented Reality Marker-Based Interaction

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***Abstract*—The purpose of this project is to design a new form of interface for children's learning by applying the augmented reality (AR) technology. Our main idea on this project is to explore the method of interaction that most people have yet to know about. The existing methods of user interface have become quite common to the users. Hence, we provide the new approach of interaction called AR Marker-based interaction in solving difficulties in attracting and cultivating children's interest in learning. This study is implemented in a children's 3D Dinosaur Encyclopedia. The motivation for this study is due to the lack of interaction and interest in the common teaching methods. Additionally, our study aims at providing new ways to make learning fun for children.**

Keywords— augmented reality, marker-based interaction, children

I. INTRODUCTION

Previously, augmented reality (AR) is known as a part of mixed reality (MR) in the field of virtual reality (VR). But AR and MR have been seen as the same terms of the technology use. AR is reaching it significance as the new medium in the evolution of MR [1]. However, AR and MR have increasingly been seen as the same in terms of the technology being used. MR is reaching its significance as the new medium in the evolution of VR? The usage of AR has been seen in various fields including architecture, advertising and navigation systems application. Recently, there has been a marked increase in the use of MR in outdoor environments [2].

The need to develop augmented reality applications that assist in learning is because of unexploited dynamic interactive visual imagery [3]. Using augmented reality applications as learning assistants can exploit dynamic visualization. Furthermore, [3] stated that the use of augmented reality will make learning experience more enhanced and users will have better interaction.

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In applications for children, AR has been used to help in visualization. Among others are those which have been developed by Engine Design Puzzle Material Master and Materials Mastermind. Additionally, there are also storybooks in augmented reality that use multimedia elements to represent the story for kids [3]. These applications provide the visualization and interaction that help children to understand the contents. In this project, the development of the AR application is focusing on assisting the children to visualize effectively the content that originally comes in printed format. In a study done by [4], 3D models are overlaid over printed book pages or 2D images which have been captured using personal computer camera. This approach will be used in our study to display the types of dinosaurs and to provide a method for interaction as existing AR application.

There are currently many applications available for learning about dinosaurs in AR form for children. However, they still lack the features to provide means for independent learning. Although there is some form of interaction, its only purpose is to control the view. On top of that the interaction that these applications promote do not convey the information contained in the encyclopedia.

2D illustrations found in printed or book pages may be less effective to convey the context of some objects and it may lead to an incorrect interpretation, particularly those related to spatial representations [5]. 3D visualization contains realistic and detailed objects; and may change to provide first-person perspective as compared to 2D visualization which focuses on flat spatial representation [6]. The 3D graphics can affect the effectiveness and efficiency of how the audience views the graphics [7] and demonstrated better viewed as shown by many studies [8]. In terms of interaction, with recent development of 3D data acquisition there is a possibility of a more efficient manner to reproduce real objects into virtual images and enable users to better manipulate and interact with these images [9].

Augmented reality development aims to provide a new experience to the community to see digitally enhanced objects in a real environment [10]. Since augmented reality is relatively a new form of technology, it can be adapted for learning assistants in the real environment [3]. This technology can be used to better engage students in the teaching materials more effectively. Furthermore, augmented reality enhances children's understanding of dinosaur encyclopedia based on the book through interactivity. It will benefit learners through the capabilities for the userss to control, manipulate and share information subject.

II. RELATED WORK

A. Augmented Reality (AR)

Augmented Reality is a part of virtual reality or virtual environment as its alternative name. Virtual Environment totally brings the user into an artificial world and user is unable to see the real environment. In Augmented Reality, users are able to see the real environment with virtual objects placed on the real environment. In augmented reality the real and virtual objects are superimposed in the same space. Augmented reality can be perceived as the "mediation" of virtual reality and telepresence which is immersive and realistic respectively [11]. Augmented reality was as subset of Mixed reality since they have the similarities of the way they used technologies in which mixed reality technologies will be used as the new medium [1]. Augmented reality was a subset to the virtual reality in which virtual reality fully utilizes the virtual environment seems like the real environment while in augmented reality, user can see virtual objects in their real environment [12]. According to [4], there are also various forms of media that use augmented reality technologies using the printed pages as the markers.

B. Interaction

The interaction mode for augmented reality is named Exploring [13]. The exploring interaction allows user to move through a virtual or real environment that may come from virtual and augmented reality systems. In the physical environment, the system will be embedded with sensing technologies in which the sensing device will detect the presence of physical object, and respond by executing the digital events.

C. 3D Graphics Visualization Enhanced with Multimedia Elements in Augmented Reality

3D visualization or graphics is a presentation and the control of objects in the spatial presence in a computer in which the application program for designing 3D objects give the properties such as height, width and length and the images can be rotated and scaled. There has been an increase in the use and influence of the 3D visualization digital presentation and technology in people's life [14]. Furthermore, the latest technology improvements in 3D data gathering and interaction allow for efficient generation and manipulation of complex real life objects [9]. There are several augmented reality applications that used 3D visualization. In the medical field, the surgeon uses the augmented reality application to visualize the anatomy of the affected area by designing the 3D graphic from the various views and parts. In the engineering field, the prototype will be designed in 3D and displayed and imaged in the client's conference room. Another example will be for the education: Construct 3D in which it is for math learning and geometry in 3D. Although most augmented reality application displaying 3D visualization, the augmentation can be represented in both 2D and 3D graphics [15].

D. 3D Graphics for Children

1) 3D Graphich Perception with Children

Children have their own perception toward seeing the 3D graphic visualization. Children often used to see 3D graphics as more fun when solving a problem although it takes time on understanding how to use the 3D representations [16]. Since the children have understood how to interact with the 3D object, it would be effective in terms of the delivery of the content. 3D scenes may have the characters and other objects that occur in 2D scene. Although the 3D scene displayed its content in a 2D view, children might feel that they are immersed in the 3D spatial environment [17].

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2) Multimedia Driven for 3D Graphic in Augmented Reality

The use of 3D graphics solely is not enough to enhance children's experience towards some multimedia content. Commonly, multimedia content such as a courseware is embedded with several elements in which text, sound, and some animation are also incorporated. As a result, the integration of these elements would make the courseware effective in delivery of their content. In augmented reality, the effectiveness of the content could be improved by enhancing it with several media such as text and sound [18].

III. RESEACRH METHOD

In our study, the following development stages have been used to develop our application. The stages involved were 3D modelling and animating, augmented reality authoring for tracking and interactivity, and lastly the completion. Below were the revised development stages with the addition of prototyping at the first stage.

Fig. 1 shows the process involved in 3D Modelling and Animation followed by the scripting for functionalities. This will be followed by the review of the AR scenes. This process will loop until the process end.

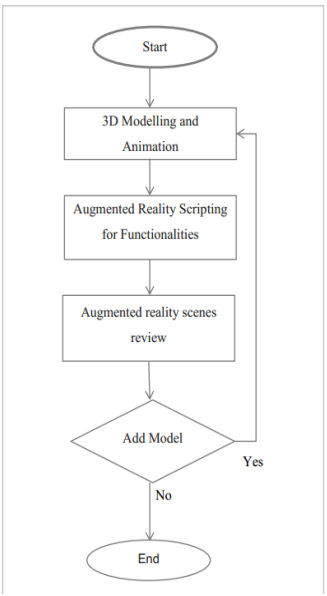

Fig. 1. The Development Flowchart

Stages towards implementation for the design of the AR are describes as follows:

A. Phase 1:Prototyping

Prototyping in the development of the AR interface had been designed in order to test what kind of interface will be produced. In this stage, the object used was the basic 3D model such as a cube, sphere and a teapot that have been made in the 3D tool which is 3D Studio Max. Fig. 2 illustrates the prototyping result.

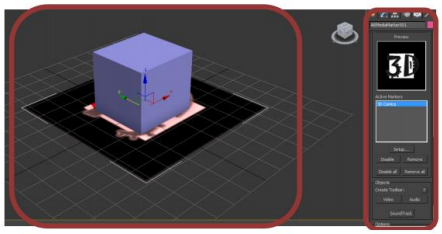

Fig. 2. Prototyping with 3D modelling tool and augmented reality plugin

The illustration above was the process of initial prototyping in which at the right highlighted section shows the option of the augmented reality plugin for 3D modelling tool. The option is used to select the provided markers that are going to be attached to the 3D model. The left highlighted section shows the modelling creation. At this section, the model was positioned above the markers.

B. Phase 2: Modelling and Animation

The dinosaur character should have been designed as the main content for the markers inside the encyclopedia. The characters are limited to ten in which each dinosaur character was designed from each of the dinosaur family. Fig. 3 and 4 illustrates the process of characters modelling.

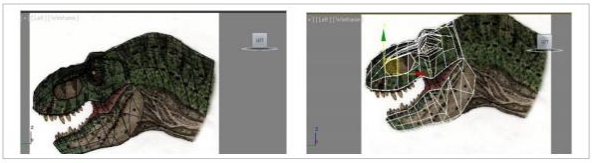

Fig. 3. Character head modeling

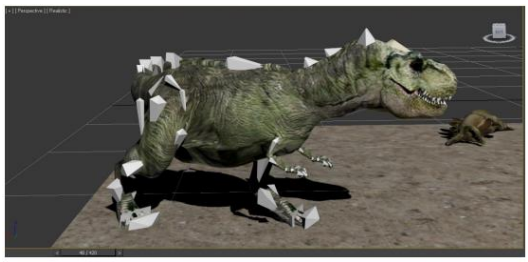

Fig. 4. Animation Creation

In the animation process, character bones needed to be created in order to make the animation movements realistic. The animation was controlled by adding the key frames in the modelling space. It was created repeatedly where the scenes would not stop; the character will walk around the character's base. The modelling and animation process were applied the same way to the other characters that reflected to dinosaur facts.

C. Phase 3: Authoring

The augmented reality authoring is a process of involving those models inside the augmented reality scenes. The plugin uses XML language to create the interaction of the augmented reality. In Fig. 5, the targeted marker refers to the marker that is being used to augment characters inside the scene. A single

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marker may involve several models since the targeted marker will not display only a character but the character base, character ground, character's name label, and feedback content.

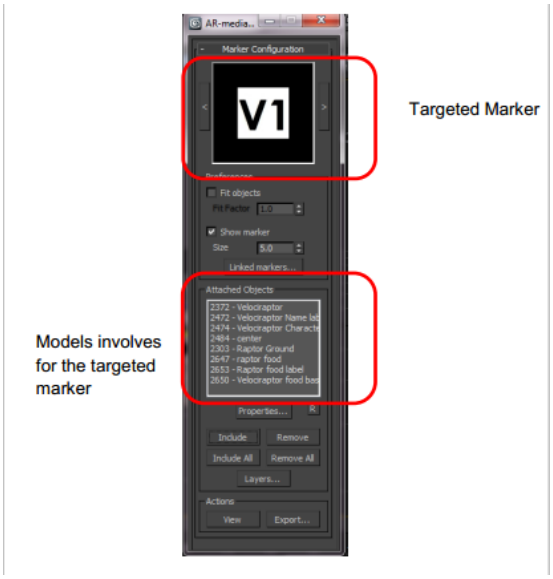

Fig. 5. The involvement of character model in AR scene

IV. RESULT – COMPLETION

The final stage of the augmented reality implementation was the completion stage. Completion refers to the attachment of the character markers for the character models on the pages of each of the dinosaur's facts pages creation. For the facts, the content was taken from several websites that were suitable for children and printed on the pages. The design of the pages is constructed purely for the purposes of testing to achieve our research objectives. Below are the illustrations of the printed pages.

In Fig. 6, the dinosaur's picture was printed together with the character markers on a page. The marker was sectioned at the grey rectangle was used to make the marker visible since the pictures have various colors that may distract the marker visibilities.

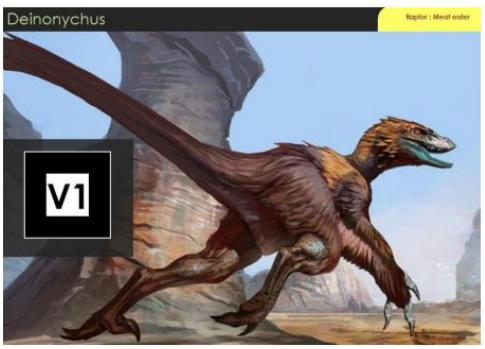

Fig. 6. Attached markers on pages for character model

Figure 7 shows a page that displays the facts about the dinosaur. The marker was not attached on this page and the use of white fonts is due to the readability factor. The printed pages explained the details of each dinosaur.

Fig. 7. The dinosaur's facts on the printed pages

Fig. 8 shows the interaction marker that was used to interact with the character model that has been stated at the design stage. The interaction marker would be printed and attached to the mounting board in order for the user to handle it easily. It was not being attached to the printed pages as it is separated from the pages. The marker is also movable to encourage the user to interact with every dinosaur character of each page.

Fig. 8. Interaction Marker Template

The interaction marker has its own categories which are carnivore marker, herbivore marker, and the size comparison to real object. In order to encourage the user on how to interact with the main characters, messages were printed on the back of the pages of the interaction marker that asks the user to bring these markers to the tracking space during the main characters AR displays.

A. Testing

1) Method 1: Testing without AR Capability

The testing was made in public environment in which 10 students were tested to use the dinosaur encyclopedia that have no augmented reality application. 10 general questions were provided for the purpose of testing the effectiveness of how the encyclopedia conveys the facts to the targeted audience. The

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question was about general facts of dinosaurs. Below was the result of the testing.

Fig. 9 shows that the encyclopedia without an augmented reality in which 9 out of 10 students answered the questions correctly. Most of the questions comes from the illustration and the facts on the printed pages. There was also another question that was not from the printed pages that used to test their knowledge about dinosaurs.

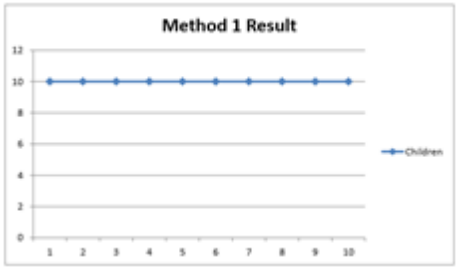

Fig. 9. Without AR capability

2) Method 2: Testing with AR Capability and no Interaction

In this method, there were 3 children that have been tested for the AR application in which the application have no interaction. The targeted audience can only view the augmented reality scenes of dinosaur animation. Furthermore, there were 11 questions provided to them in which they need to answer the questions based on the animation and the information inside the printed pages. Below is a figure that shows on how many questions that have been answered correctly a a measure of effectiveness.

Fig. 10 shows the result for Method 2. The findings show that the first child answered all the 11 questions in which 6 questions out of 11 were answered correctly. The other children answered more than 6 questions correctly. From the observation, the entire 3 targeted user was able to view and control the augmented reality scenes excitedly. Although, they tend to use the augmented reality scenes compared to reading the information inside the printed pages.

Fig. 10. With AR capability and no interaction

3) Method 3: Testing AR with Interaction

This testing method is similar to the second method. The only difference is the AR application has the interaction element to convey the information at the printed pages in the form of a 3D scenery. Fig. 11 shows the improvement of the children in answering the 11 questions about the dinosaurs.

Fig. 11. AR capability with interaction

The results show that after using the AR with the interaction element involved, the first child answered 2 more questions correctly. Some users has answered all the questions correctly. This shows that the 3D visualization has helped some the children to visualize and imagine the real facts of the dinosaurs. On the other hand, only one user had no improvement because of capability of their understanding was different. The children have used the augmented reality according to their own level of interest. This means they used to seek the answer by exploring each of the printed pages and the interactions.

V. CONCLUSION

The design of AR can improve the children's experience in learning especially in supporting the visual conceptualization of various forms. It also possibly will extend and give alternative opportunities beyond our imagination in learning. Currently, the interaction that has been designed was at the minimum capability in which it can be improved to be more interactive with realistic tangible interaction that may provide different experience of interactions. Furthermore, other than the personal computer platform, the application may be made available to the mobile platform rendering the application more ubiquitous. From the perspective of the user interface, the information can be displayed perfectly to increase the effectiveness not only through the 3D visualization but other multimedia elements to convey the content.

From the research goals, we expect two main contributions as follow:

- Promote the imaginative learning
- Obtain another experience of learning with the advance of AR technology.

Besides that it will benefit to all researchers, practitioners in AR, interaction design for children and Human Computer Interaction (HCI) in general.

Moreover, not only the content creation needs to be focused but the performance of the application through different

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platform capabilities and performances. To reach the maximum effectiveness, the performances and error free also plays the important roles. For the developers of multimedia application and augmented reality system, the understanding of the tools will make the development process rapid but at the same time ensuring high quality of the final product.

Generally the most challenging part is the requirement analysis design for children; detailed consideration of each element must be taken into consideration especially for conceptual design in augmented reality applications. Another challenge has been in choosing the suitable tool for development of the prototype for the application so that it was completed within the time frame. As a conclusion, the project was successfully designed based on the design stages of our methodology.

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