International Journal of Integrated Engineering:
Special Issue 2018: Data Information Engineering, Vol. 10 No. 6 (2018) p. 149-154.
 DOI: https://doi.org/10.30880/ijie.2018.10.06.021

First Discovery: Augmented Reality for Learning Solar Systems

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Received 28 June 2018; accepted 5August 2018, available online 24 August 2018

Abstract: The development of Augmented Reality (AR) systems in educational settings should be given more attention and recognition on its contribution to the evolution of education. Although this shift of pedagogical method may disrupt the traditional curriculum model, it also offers great opportunity to complement and improve the modern age education model. This paper presents an AR-based mobile application for exploring Space and Science for primary school students called the First Discovery (FD). This application supplements a traditional book that contains 10 target images for solar system and its planets, which can be scanned by the AR camera in FD application. Evaluation was carried out among primary school children, elementary educators as well as parents, which showed a highly favorable response. It is hoped that the proposed FD application is able to improve the ability of children in retaining knowledge after the AR science learning experience, to enhance information accessibility of the science learning content for children as well as to develop creative learning and the ability of children in exploring and problem solving.

Keywords: Augmented reality, e-learning, science.

1. Introduction

According to the American Heritage Dictionary, Science education involves observation, explanation, investigational exploration, and hypothetical clarification of the natural phenomena. Active involvement of students in these processes is essential in fostering and preparing a younger generation to thrive and lead the nation. However, numerous studies have pointed out that students often lose interest in Science education at their young age. Research by [1] reported that more than a thousand of children aged between 8 to 11 yearold in elementary education institutions marked a progressive deterioration in their enjoyment of science education. Majority of the children disengage from the conventional learning approaches because it has lack of interactions and it does not integrate with the latest technologies which eventually leading to poor learning outcomes.

[2] stressed that negative perceptions of students towards science education are due to traditional teaching methods that does not correlated to scientific principles and concepts to be taught. Students also found Science education to be abstract due to the complexity in existing ideas and concepts [3]. For instance, theoretical concepts such as air pressure, current flow and photosynthesis are scientific principles that are not visible to human eye. Thus, the learning of those scientific principles and concepts requires comprehensive visualization skills. Whenever students are having trouble visualizing and grasping the concept thoroughly, it will then cause misconceptionsamongthestudents.[4]arguedthatconsidera bleattention should be given to misconception among students by carefully selecting the teaching strategies.

Based on the various problems that have arisen with respect to the Science education stated earlier, this paper presents amobile application called the First Discovery (FD), a Science learning augmented reality book for children that combines the traditional book with additional content by implementing AR technology. It introduces readers to primary Science education that develop their scientific horizons in the areas of earth and space science. AR books are important as they support the superimposing of computer generated three-dimensional educational content over actual environment to deliver an interactive learning experience for readers. Particularly in Science education, it enables the reader to conceptualize the complex and invisible scientific processes with virtual multimedia elements.

The remaining of this paper is organized as follows. Section 2 presents some work related to augmented

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reality in education, Section 3 presents the proposed First Discovery application, Section 4 presents the evaluation and finally Section 5 concludes with some indication for future work.

2. Related Work

According to [5], Augmented Reality (AR) is a technological method that allows the real and the virtual to be visible in the same place by supporting the actual world with 3D computer-generated objects. It integrates real-time immersion of digital augmentations in direct or indirect view of the real-world environment to enhance users visualization and interaction with the real world. The research also suggested that a proper AR system should reflect three distinct aspects, (1) integration of both real and computer-generated objects in a real world [6], (2) interactive and engaging in real-time, and (3) associating virtual elements with the physical object. The virtual objects are essentially anything that can be produced digitally such as 3D models, animation, 2D graphics, text, audio or video stream. Fig. 1 illustrates the reality vs. virtual continuum [6].

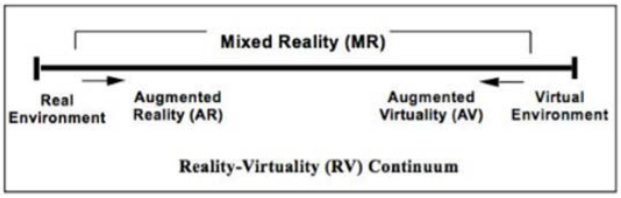

Fig. 1Illustration of reality-virtual continuum [6].

The implementation of an AR-based technology can be classified into five main types, which includes marker-based, markless or location-based, project-based, outlining, and superimposition-based [7]. Due to its innovative nature, AR technologies have been widely used in various sectors of media and entertainment industry, medical [8], educationindustry [9], [10], gaming industry [11], marketing industry [12], military [13] as well as online social networks.

In education, AR have gained momentum as it supports students to engage in level-differentiated learning at their own pace. AR is particularly relevant for education as it engages learners to be at the center of concrete experience by offering rich contextual personalized learning contents and settings for the users [14], [15]. The learners will be highly involved in the most expeditious learning process that provides interactive serendipitous exploration of knowledge in the realworld environment.

The capability of AR technology in offering endless possibilities as diverse pedagogical tools have been increasingly acknowledged by academics and educational researchers. The use of AR in education also ensure users to comprehend the complex contents in a more effective manner,enrichingengagementandpromotinglearningthrough immersive contents [16]. Particularly in learning Science, several AR applications are available such as the iSolar System [17], Anatomy 4D [18], and AR Circuit App [19], which are all available for download from the Amazon, Google Play and App Store. Fig. 2 shows screenshots or similar applications.

As AR technology is starting to evolve in the recent years, the possibilities of AR in the future of education are tremendous. As the new generation is emerging, this new trend of educational paradigm will be able to increase the efficiency of learning process. Although this shift of pedagogical method may disrupt the traditional curriculum model, it has also great opportunity to complement and improve the modern age education model. Hence, the development of AR systems in educational settings should be given more attention and recognition on its contribution to the evolution of education.

Fig. 2(L-R) iSolar, Anatomy 4D, AR Circuit.

3. First Discovery Application

First Discovery (FD) is a mobile application for learning the Solar Systems based on Augmented Reality (AR) technology. Designed for children aged between 4 to 9 years old, FD application supplements a conventional earth and space science learning book as the reference point. Development of the application focused on five most important multimedia elements, which are text, image, audio, video as well as animation. The book comprises of 16 pages of elementary earth and space science curriculum printed in full color. The book is designed with the fundamental multimedia elementsof text as well as both bitmap and vector graphics. This application is developed on Android platform using the object-oriented approach. The use case diagram is shown in Fig. 3.

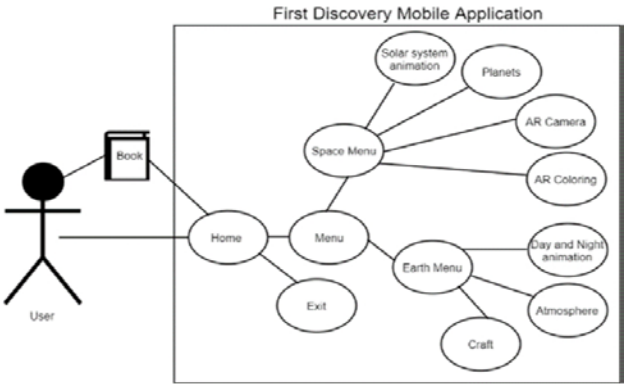

Fig. 3Use case diagram for First Discovery.

FD consists of 11 scenes containing information in the form of various multimedia elements. These scenes include “Home”, “Menu”, “Space”, “Planets”, “Earth”,

"Atmosphere", "AR Camera", "AR Coloring", "Solar System", "Day and Night", and "Craft". All pages are connected by a user-friendly navigation system that can be easily understood by children. Fig. 4 until Fig. 9 show the pages for learning the solar systems.

Fig. 4Home page.

Fig. 5Menu page.

Fig. 6Space page.

Fig. 7Planet page.

Fig. 8Earth page.

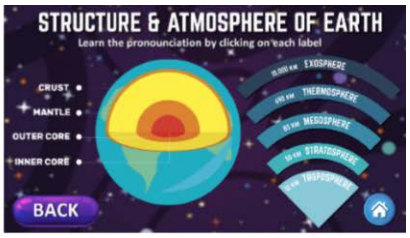

Fig. 9Atmosphere page.

3.1 Augmented Reality Camera

When the AR camera function is launched and the user points the device camera at the target image of solar system or planets, FD application will recognize the target image and display the 3D model of the image respectively. With that, the user can interact and explore with the 3D model by using two fingers to zoom in, zoom out and rotate. Besides, when the target image is being detected, a head up display of its basic descriptions complement by spoken audio will be shown to enhance the user's understanding. Fig. 10 shows the screenshot for AR Camera Page.

Fig. 10 AR reality camera.

It consists of an info button that shows the user manual whenit isclicked by the user.The screenshows the augmented 3DmodelandHeadUpDisplay(HUD)descriptionswhenuser point the AR camera towards the marker. While back button leads to the space page and home button leads to home page.

3.2 Augmented Reality Coloring

AR coloring is another core feature that captures the imagination of user. It enables the user to practice their creativity by painting their very own planet on the AR coloring page. With a slight twist from the AR Camera feature, AR coloring allows the user to witness their own creation came to live. The 3D planet model will appear with the same color used on the book by using live texturing technology when the user pointthe device camera at the target image of AR coloring planet. Fig. 11 shows the screenshot for AR Coloring Page.

Fig. 11 AR coloring page.

The AR coloring page consists of an info button that shows a user manual when it is clicked by the user. The screen shows the augmented 3D planet model with live texturing function when user point the AR camera towards the marker. While back button leads to the space page and home button leads to home page.

3.3 Animations

First Discovery application contains two main animations about the formation of "Solar System" and what causes "Day and Night" on earth. These animations are designed and developed with the use of motion graphics with background music, sound effects and narrations that helps to promote the interest and proactive behavior of children in learning Science. The solar systems as well as the structure and atmosphere of the earth are provided in vector graphics, labelled with names, respectively.

Spoken audio is also supplemented when the user interact with each label. This enables children to practice with the correct pronunciation of words for each label. Fig. 12 and Fig. 13 show the animations in FD

application. It consists of a play button that plays the animation when it is clicked by the user and a back button that leads to the earth page and home button leads to home page.

Fig. 12Solar system.

Fig. 13Day and night.

3.4 Crafts

A step-by-step guide craft is also included in the First Discovery mobile application. The detailed steps of making "Four seasons tree" is displayed and arranged with different buttons. Each step is well explained and illustrated with an image as well as the explanations in text form. It also contains a button that enables the user to download the craft pdf template from. Fig. 14 shows the screenshot for Craft Page.

Fig. 14Craft page.

4. Evaluation

In order to ensure that the system runs smoothly before deployment stage, unit testing and user acceptance testing (UAT) have been carried out. The unit testing of My First Discovery comprises six test case of menu and navigating buttons control, AR marker detection, scaling and rotation of AR 3D models, AR coloring detection, animation as well as background music and spoken audio. Furthermore, the user acceptance testing (UAT) comprises 10 different aspects to be measured such as graphics usage, book design, mobile application interface design, mobile application navigation, 3D model design, animation, AR camera, AR coloring, audio usage as well as the overall system. After testing the AR learning book and application, the tester will need to respond to each aspect with a Likert scale from 1 which indicates poor to 5 which indicates excellent. UAT has been carried out on three target users of a child, an elementary educator as well as a parent.

Based on the testing result, all test cases are functioning well as the expected results. However, attention should be paid to the AR marker detection in order to run the AR Camera operations more successfully. While the user is the detecting the AR marker, the user is advised to perform the action in a well-lit environment to avoid any presence of shadow from interrupting the tracking process. Besides, the paper texture chosen for the book printing should be matte as glossy paper creates glare which makes it difficult for AR Camera to detect the AR marker.

The average point collected for all aspects is 4.7 which indicate that overall system is satisfactory. The respondents pointed out several improvements and additional features that can be added to the project such as including interactive experiments, educational game, animated 3D object, adding more AR coloring as well as replacing the current narrative audio with a more lively voice. Hence, these constructive feedbacks and improvements received will be taken into account for future implementations of the First Discovery application. FD, in general, receives great acceptance and positive feedbacks towards its application for learning Science among children.

In addition, this project also interviews two groups of users; the children as well as the elementary educators and parents. The questions are itemized as the following.

4.1 Interview Question for Children

- Do you love science subject? Why?
- Do you love reading books? How often do you read?
- Do you enjoy the science lesson today? On a scale of 1 to 5, how would you rate today's lesson?
- What can you remember from today's lesson?
- Do you face any problems during the learning lesson? If yes, what is the problem?
- Are you satisfied with this learning method? Why?
- How often do you get to use a mobile device like smartphones or tablets? What do you mostly use it for?

- Have you heard of e-learning? If yes, can you briefly explain what does it means?
- Do you have any experience using e-learning system? If yes, what is the system about? Was it helpful to you?

4.2 Interview Question for Elementary Educators and Parents

- Generally, do you think children/student these days enjoy learning science?
- Do you face any difficulties while teaching your children/student about science? If yes, what is the difficulty? How would you solve them?
- How often does your children/student lose their interest or attention in a science lesson? What you would do?
- In your opinion, what can be done to improve the current science teaching/learning technique?
- In your opinion, what is the right age to introduce children to mobile devices? What do you think they should use it for?
- Do you have any restrictions on your children's use of mobile devices? If yes, what is the restriction?
- Do you have any experience teaching lessons using e-learning? If yes, what is the system about? Was it helpful to you and children/ student?
- Do you think it will be useful to implement e-learning system into science lessons?

The findings from the interview are concluded in the following section.

5. Conclusions

This paper presented the First Discovery (FD) mobile application that has been developed based on augmented realitytechnology. FD comprises of an interactive Science learning book integrated with a mobile application. Five multimedia elements of text, image, audio, video as well as animation to deliver a child-friendly science learning application that complementstheconventionalearthandspacesciencelearning book. This application was showcased in H-Inovasi UKM 2017 competition and won 'Best of Best' award.

Evaluation of the FP application showed that children these days are well-exposed to mobile devices and has developed a habit on using them. With their familiarity with mobile devices, they will be able to adapt to e-learning system that involved mobile devices with ease. Besides, elementary educators and parents agree that e-learning system that includes various multimedia elements with high interactivity could be implemented as the ultimate solution to resolve the issues that have arisen with respect to the Science learning for children. Hence, children's use of mobile devices for educational purposes could be easily accepted by the teacher and parents, despite having restrictions on the duration of the usage of such devices.

Ultimately, there are still many areas that requires improvements and further enhancements to be made for this project. The main challenges were on the advanced computer vision skills, 3D modelling and desktop, web or mobile programming. The additional features that could be added into the project includes covering more earth and space Science topics, adding some interactive science experiments, adding educational games, animating the 3D AR Object, adding more AR coloring pages as well as replacing the current narrative audio with a more lively voice.

Acknowledgement

This project is sponsored by Asia Pacific University of Technology and Innovation.We are thankful to Winnie Tan Jia Ciwho provided expertise that greatly assisted the research

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