Novel Edutainment Learning Concept via Augmented Reality Approach

Wong Guo Hui, H.-F. Neo, and C.-C. Teo

***Abstract*—Augmented reality (AR) empowers virtual and interactive experience through smartphone devices. Nowadays, technologies have become more advanced, and AR is generally compatible with smartphones, thus being more accessible globally. Furthermore, many developers have started to create AR-based applications in fields such as edutainment, games, furniture, biomedicine, geology, and entertainment. AR-based edutainment applications allow students to observe experiments in a safe environment and improve understanding through manipulation and multi-angle observation of virtual three-dimensional (3D) objects. In addition, AR has become increasingly cost-friendly, accessible, and effective. This paper thus aimed to design and create a novel edutainment learning application based on AR targeted at children. This is because AR enhances the learning content so as to be more interactive and exciting as it is projected in a 3D realm. The powerful visual models enable users to have a better understanding to learn a specific theory through visualizations. This research used experimental analysis consisting of a pre-and post-test survey. The pre-test results demonstrated that some respondents were not aware of AR technology and were not supportive of it. In contrast, the post-test result has revealed that the respondents felt that the proposed application is easy to use, user friendly and the learning content is interactive.**

***Index Terms*—3D learning, augmented reality, edutainment, experimental design.**

I. Introduction

Edutainment is a term that combines two distinctive words: *education* and *entertainment*. Its goal is to enable the learning process to be more enjoyable, fun, and effective. Edutainment can be found inside or outside of the classroom, and it is available in different types of media such as books, music, video, or podcast. Today, there are a myriad of edutainment applications easily available in the form of video games, augmented reality (AR) applications, educational websites, and mobile apps. The benefits are manifold, including having a better understanding of the theoretical subject, enhancing creativity and visualisation, improving interactive and collaborative teaching and learning methodologies. In contrast, there are also limitations as edutainment applications emphasised and depending on the usage of electronic devices, for instance a computer or a smartphone and network accessibility.

Edutainment provides an opportunity for students to have a better cognitive understanding of the subject matter. Today, it is possible to use technology to access edutainment applications. According to the Malaysian Communications and Multimedia Commissions survey conducted in Malaysia, 83.2% of the children aged 5 to 17 were Internet users, and 93% of them used smartphones to surf the Internet. However, there are some foreseeable problems associated with the AR technology. The main concern is due to lack of training for educators, and this is unbreakable if educators remain closed minded. Subsequently, there is reliance on hardware that is costly. This is especially true if the AR requires wearable glasses or headsets. The current AR content is limited, which poses the greatest challenge as creating contents is extremely complicated and expensive.

This paper aimed to design a novel edutainment learning concept for children via the AR approach. The learning context focuses on the learning of animals, where children can learn, interact, recognise and observe. The animals would appear in a 3D form with different sounds. In addition, children could learn the animal names in 3D view. The design of the mobile app aims to be easy, simple and interactive.

It is posited that the proposed mobile apps would engage more children's participation, especially in classes. It would subsequently increase their understanding of the learning topic as children could grasp the concepts faster by viewing the 3D motions. Furthermore, interactivity is an important concept of edutainment, and it is achievable when children interact through the incorporated gamification elements. The proposed edutainment learning apps are also useful and enriching for teachers, parents, and educators as an alternative to storytelling. Overall, AR is an interactive visual tool to create the impression and realness of educational concepts.

II. Literature Review

A. Augmented Reality

AR is one of the frenzy trends in the world today. AR is interactive, and the visuals appear in 3D form combining actual and virtual objects [1]. It is an emerging technology which allows computers to generate a virtual image information to cover onto a real-life environment [2]. AR has already gained much attention, and in the future, it may venture into the optics field such as contact lens or wearable devices to replace the phone and tablets. The ultimate purpose of AR technology is to enhance our lifestyle by interacting virtually with the 3D visualisations.

There are four types of AR: marker based, markerless, projection based and superimposition-based. Marker based

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AR requires a visual object such as QR code or a logo to act as a special sign. Users must scan the special signs to view the 3D models. Markerless AR, however, relies primarily on locations or positions. Global positioning system, compass and accelerometer are utilised to deliver data by referencing to user's location. The proliferation of smartphones has encouraged programmers, developers and scientists to create navigation apps, which includes nearby business information. The third type of AR is projection based, which could project synthetic light to the object and interact with it. Finally, superimposition-based AR can replace the original object in the image form with 3D version. IKEA has used the superimposition-based AR for their prospective customers to place the virtual furniture in their rooms.

AR is widely used in educational field due to its many advantages. Students can learn ubiquitously without the constraint of space and time, no matter where they are. Furthermore, it helps students to learn and understand difficult concept such as geological process, biological concept, physics concept and geometry, which have already been used in some classrooms in the advanced countries such as the United State, Canada, China and Japan. The difficult concept is demonstrated through the 3D visual model which enhances understanding. Due to its interactivity characteristic, students become more interested in study.

For example, City of Life, an AR-based games application was created to impart the value of sustainability through city-building [3]. Mini games are incorporated to verify player's knowledge. Teach Me A Story is an AR application serving as a secondary support for History lessons [4]. Students were able to build a 3D Mesopotamian temple and the feedback received was positive. AIEduAR is developed to teach Artificial Intelligence education to non-engineering majors. Through this application, students need to solve the presented problems [5].

The usefulness of AR has prompted researchers to evaluate its efficiency and effectiveness in the education setting. It was revealed that AR can improve children's cognitive capacity, which allows them to retain knowledge and develop creative learning [6]-[8]. Generally, the results are positive, where students have increased confidence toward the subject and shown tremendous interest in learning.

B. AR Related Applications

Currently, there are various types of AR applications in different fields of study such as history, culture, hobby, entertainment, learning and ecology. Several existing learning applications based on AR are reviewed and reported in this section. First the, AR bone puzzle is an analogy to learn about bone anatomy using AR visualisation [9]. It is a medical AR edutainment application to learn about bone anatomy as it is one of the most crucial tasks for medical students. This application captures the user's body frame as inputs to generate virtual bones as the puzzle pieces. In this app, users are exposed to the learning of bone structure, spatial relationship and bone anatomy. In addition, users could interact with a virtual 3D puzzle by using a haptic device.

Physics in AR [10] is a game-based application related to the impact of rigid body on visual perception. The aim of this application is to teach various types of forces in game playing. The game element is set up by XML and AR marker. The former allows the setup of complex object, and the latter controls the position of the 3D virtual objects. The game is atypical to the transportation simulation in which player must move an object from a starting to the ending point. The movement of the object will be influenced indirectly by placing the objects in its path.

Ecology ecosystem is an AR game application related to animals, plants, energy sources and people [11]. It has many interactive activities, for instance feeding the animals and tracking their health status. It is similar to persuasive technology to encourage users to be responsible by taking care of the animals and plants. Ultimately, the aim of this application is to raise awareness on living healthily, taking better care of the environment and using renewable energy for sustainability.

MediaEvo project is an edutainment application based on a Medieval Town in the 13th century. It enables users to experience a historical reconstruction of daily life activities during the reign of Frederick II [12]. The aim of this project is to integrate the multi-channel and multi-sensory platform in the history discipline. Simultaneously, it aims to test new data processing technologies for the realisation of an AR visualisations in medieval history.

Fairy Tales and Technology (FaTe2) [13] is a storytelling web-based application providing 2D and 3D visualisations. The FaTe2's architecture is extended by WebTalk, a powerful software framework to support multi-user interaction. This application has many functions to help users in storytelling, such as exploration, story building, linear stories building, hyper story building, game playing and communication. User is the director of the application to design their stories using the 2D scene maker. It helps to stretch user's imagination and practice the command of language. This application is also supported by games elements.

The subject of physics consists of many hard-to-understand concepts. The development team from Walailak University has manipulated the 3D models with physical properties for interaction experiment in the realistic environment. In this development, they have used Unity3D engines and Vuforia platform to create the games and interactive 3D content. This game named 'Nana's 3D puzzle cube' [14] is a game containing eight pieces of shapes with the same volume but different shapes. This game enables users to test the physical interaction such as collision or other effects. Different weight is also added into each cube, so it is more realistic when playing the game. Users must connect all the blocks together and can observe the collision in each shape. This game can help the users to have more understanding in physics collision knowledge and improving the quality of learning.

ARGarden is an application that enables users to experience gardening in a real world environment [15]. This application supports users to explore the environment's problem and other related problems such as water, fertiliser and so on that affects the real world. The aim is to attain better experience in planting and improving user's

engagement in their learning experience. The application requires special hardware that is an ultra-mobile personal computer integrated with a camera. ARToolkit is being utilised to design the AR 3D model related to the gardening environments. The usability study was carried out, and it was found that the possibilities to learning using AR significantly improves students' learning experiences.

AR museum is a mobile guide targeting children aged between 10 to 12 years. The application is targeted at the Museum of Industrial Olive Oil Production in Lesvos [16]. Users must complete several tasks about the production process of olive oil. A virtual character (avatar) is available to assist users. If users have completed all the tasks, they will be rewarded by taking a photograph with the avatar. It also involves the navigation of the oil-mill building. If a user looks at the building through the camera, a 3D visualisation of the museum appears.

European Media Laboratory has implemented a stage-based augmented edutainment system showcasing AR 3D scenes at different locations in the Heidelberg. In this system, AR and video tracking is probable in some predefined location, and the user will be guided when they are at the location. The system presented history by using virtual character explaining history lesson about the 30 Years War, a European period in the 17th century [17]. The development of this system is based on 'GEIST' and exported by the XML file. In the GEIST system, it consists of four databases, namely 'Geographic Information System' that saves 2D maps, 2D layers and 2D plans; 'Architecture Base' that contains 3D/4D models of spatial objects; 'History Base' that saves persons and event pictures; and 'Fiction Base' that saves fiction, spatial object, persons and so on.

III. Methodology

The proposed novel edutainment learning application was designed using Unity, Visual Studio and Vuforia. Unity is a cross-platform game engine released in 2005. It can develop 2D/3D games and interactive content. Until now, Unity has supported over 20 different platforms. Vuforia Engine is a platform for AR development supporting countless devices such as phones, tablets and eyewear. The Vuforia Engine library includes technical documentation to assist programmers during their development process. Computer vision functionality that is very advanced can be added easily to Android and iOS. Visual Studio is an Integrated Development Environment designed by Microsoft. It provides support to 36 types of programming languages, for instance, C#, C++, VB (Visual Basic), Python, JavaScript, just to name a few.

As for the usability testing, experimental approach is applied in this case. It consists of pre- and post-test survey to evaluate user satisfaction. In the pre-test, an online survey was conducted to a total of 43 respondents. A 5-point Likert-type scale was used to assess their satisfactory level from strongly disagree (1) to strongly agree (5). The purpose is to find out the awareness level toward AR. Data collection was carried out from 9th to 16th September 2020. The whole survey process took approximately 10–15 minutes.

Post-test experiment was then conducted. A total of 12 volunteers were involved in the post-test experimentation. They were given a smartphone installed with the proposed application, to learn and test all features as shown in Table 1. After that, they will fill up an online survey form. The survey form consisted of seven questions to determine their satisfactory level of the application. Similarly, a 5-point Likert-type scale was used to assess their satisfactory level from strongly disagree (1) to strongly agree (5). The post-test survey was conducted from 15th to 18th February 2021, and it took approximately about 20–30 minutes to complete.

TABLE I: Usability Test Cases

Task Number	Test Cases	Expected Outcomes
1	Background Music Playing	Background music keeps on looping in every scene.
2	Scene Switching	User can switch the scene using the correct button successfully.
3	Quit Game	User can quit the game successfully.
4	Augmented Reality Activation	User can activate AR in the learning section successfully.
5	User Touch Input	User can interact with the application by touching the mobile phone's screen successfully.
6	Quiz Function	User can answer the quiz successfully.
7	Joystick Movement	User is able to move the character using joystick successfully.
8	End Game Scene	The end game scene appears when the user finishes and completes the game and quiz section.

IV. Experimental Results

In this section, the outputs of the proposed application will be explained first. This will be followed by the results of user acceptance test. Fig. 1 shows the main menu scene consisting of the following three functions: 'Start', 'Intro' and 'Quit'. This edutainment application is designed for preschoolers or children aged 5–10. If the 'Start' function is chosen, Fig. 2 will be displayed, which consists of 'Learn', 'Quiz' and 'Game'. The 'Intro' function is a simple description of the application, and the 'Quit' function is used to quit the game.

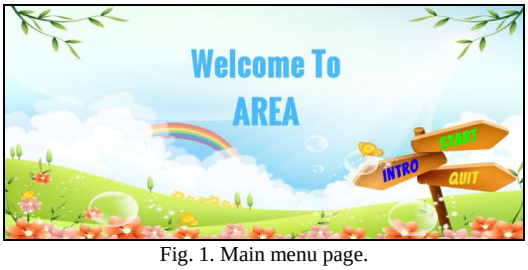

Fig. 1. Main menu page.

Fig. 2. Functions page.

Fig. 3 is the learning page where user can choose 'AR Animal' or 'Animal Intro' as their first learning material. 'AR Animal' showcases 17 different types of land and sea animals for instance bear, cat, cow, crocodile, deer, dog, elephant, giraffe, gorilla, horse, penguin, rabbit, seagull, shark, snake, spider and wolf. A sample of the screen design is shown in Fig. 4.

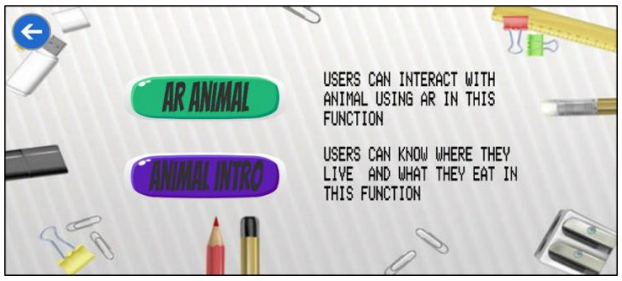

Fig. 3. Learning page.

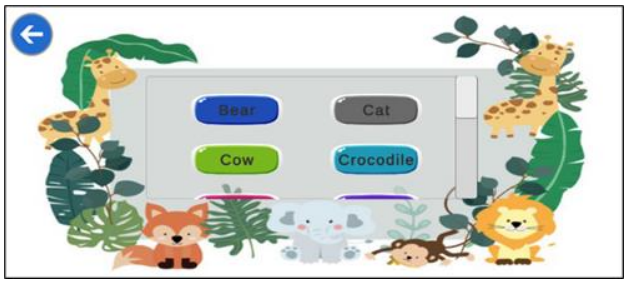

Fig. 4. AR animals learning page via AR.

Once the animal is chosen, various actions associated with the animals can be animated using AR. For example, in Fig. 5, the user can choose the spider to act idle, walking, scared, or attacked. The details button explains more about the animal in a simple and easy manner.

Fig. 5. Animals page.

Fig. 6 shows the types of quizzes that a child can play. The quizzes enforce children's understanding of what they have learnt previously. In the Safari and Underwater quizzes, children need to determine the name of the animal shown. A sample of the screen design is shown in Fig. 7. In contrast, the multiple-choice questions provide options for children to choose the best answers to score and accumulate points.

Fig. 6. Quiz page.

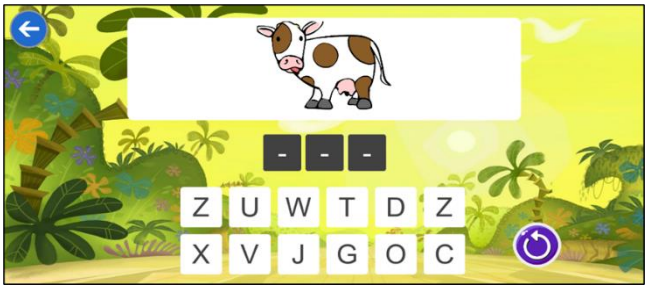

Fig. 7. Safari animals quiz.

Fig. 8 shows the game scene consisting of two parts. Children can either navigate the safari in a 3D mode or play drag-and-drop to match the correct animals to their shades. A sample screen of the safari map is shown in Fig. 9. In the safari, children navigate and explore to locate the correct animals. The animals are constantly moving in random directions. If children identified the safari animals correctly, for instance elephant, gorilla, crocodile and bear, they are awarded 50 points; if they locate inaccurate animals, 50 points will be deducted. To win the game, children must score 300 point. Fig. 10 demonstrates the drag-and-drop scene.

Fig. 8. Game page.

Fig. 11 demonstrates another game: Drag-and-Drop. Users must drag the animal picture and drop into the exactly space. If the users drag it to the wrong space, it will go back to the initial space. If dropped in the correct space, it will stick there. The game will end once all the slots have correct animal pictures.

Fig. 9. Three-dimensional Safari map.

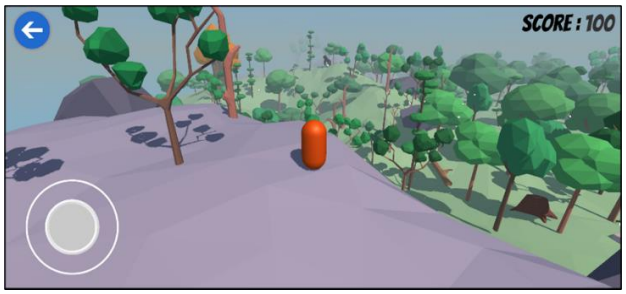

Fig. 10. Three-dimensional Safari map.

Fig. 11. Drag-and-drop page.

In the pre-test analysis, a total of 43 participants have responded. Majority of them were male, which is 76.7%, while females included 23.3% only. In terms of age, 67.4% of the participants are between 21 to 25, 25.6% between 16 to 20, 4.7% between 26 to 30 and 2.3% between 10 to 15 years old. Due to the proliferation of technology, it is expected that the respondents are aware and have used AR technology before. It is proven right when 69.8% of the respondents are positive about AR, while those remaining do not have any experience at all. For the respondents who were negative, it is because their phone was not compatible with AR technology (14.8%), they felt the content was dull (9.3%) and that it lacked of interaction (7%).

In terms of whether AR was suitable to be incorporated into the education realm, 58.1% of the participants were positive, while 30.2% disagree. Nowadays, the high penetration rate of smartphones among students has enabled the exposure to a variety of learning apps. AR apps is one of the useful educational tools that help students in learning, to have better understanding of the theoretical model and complicated knowledge. Moreover, AR makes it more exciting to view the explanations in a 3D mode. This in turn might retain students' attention and engage their learning attitude. Hence, 51.2% of the respondents feel that AR would improve the learning quality, while 32.6% did not think so.

On the other hand, 58.1% of the participants think that AR is easy to use and 41.9% feel the opposite. Finally, in assessing their emotions when using the AR technology, a mixture of feelings co-existed. The most highly emotion felt was happiness, followed by being interesting and enjoyable.

In the post-test analysis, 7 respondents strongly agreed and 5 agreed that the proposed edutainment learning application was very interesting and attractive to use (Mean = 4.58, SD = 0.515). Subsequently, 7 respondents strongly agreed and 5 agreed that it is user friendly (Mean = 4.58, SD = 0.515). In terms of the content interactivity, 4 strongly agreed and 8 agreed with it (Mean = 4.33, SD = 0.492). Four respondents strongly agreed that the quiz feature was enjoyable, while 8 agreed with it (Mean = 4.33, SD = 0.492). Seven respondents strongly agreed and 5 agreed that the games are fun and interesting (Mean = 4.58, SD = 0.515). Five strongly agreed while 7 agreed that the learning content is interesting (Mean = 4.42, SD = 0.515). In a nutshell, all respondents agreed that they will recommend the proposed edutainment learning application to others.

From the above analysis, it is concluded the proposed edutainment learning application has received significant positive user experience and high acceptance. All the participants are interested in using this application to learn and at the same time play games. All the functions proposed such as learning, quiz and games have demonstrated strong acceptance, and the respondents are willing to recommend the proposed edutainment learning application to others. Most importantly, the novel design of the game element is also receiving high commendations.

V. Conclusion

Nowadays, AR has become a trend, and it plays an important role in education. AR enhances the learning contents to be more interactive and exciting as the contents are projected in a 3D realm. The powerful visual models enable users to have better understanding and clearer to learn a specific theory by visualisations. AR also enrich the lessons and increases student's engagement in learning activities. In this paper, the proposed edutainment learning application is targeted at young children to learn better with animals. There are various functions, namely Learning, Quiz and Games. Furthermore, AR learning involves various AR models to demonstrate the animal movements and descriptions. There are also two different types of modes available in the Quiz function. Similarly, there are two different types of games in the Game function. The post-test result has revealed that the proposed application is easy to use, user friendly and the learning contents are interactive.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

G. H. Wong has contributed in application development and original draft preparation. H.-F. Neo is the corresponding author and is the supervisor for this research. She has contributed to writing and editing the research paper. C.-C. Teo is responsible for providing overall research guidance and proofreading the research paper.

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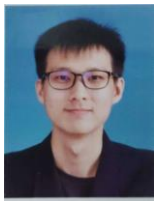

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