

Reading Augmented Reality Story Book in Enhancing Learning Perceptions

Chow Tang Soon, Han-Foon Neo , Chuan-Chin Teo

Faculty of Information Science and Technology, Multimedia University, Malaysia

Abstract. Augmented reality (AR) technology comprises elements of three-dimensional (3D) images, videos and animations. It encourages creativity, improves interactivity and bringing better learning experience. It has the potential to bring new ways to improve the quality of teaching and learning activity. In this research, the aim is to create a short story with moral value and to incorporate AR technology to bring the story to life. It is an integration of mobile application with AR technology using physical book. The target group for this application is early childhood children who are between aged 2 to 6 years old. This application aims to motivate their interest in reading by engaging in enhanced learning environment when viewing the 3D objects and interaction. In order to assess the learning perception, a survey was conducted to a group of 25 participants. Their feedback was generally positive indicating that the proposed application is indeed attractive, useful and easy to use.

Keywords: augmented reality, 3D, story book, interactive, teaching and learning

1. Introduction

Education is the process of facilitating learning or the acquisition of knowledge, skills and habits. Educational methods include teaching, training, storytelling, discussion and directed inquiry which are commonly used. Nowadays, there exists various types of education applications to attract students' attention, motivate their learning and engage the learning process. One of the methods is by using augmented reality (AR) technology. AR technology comprises elements of three-dimensional (3D) images, videos and animations. It encourages creativity, improves interactivity and bringing better learning experience.

AR has potential to bring new ways to improve the quality of teaching and learning activity (Nincarean et al., 2013). It has the ability to allows users to see the scene in the real-world environment while manipulating virtual object and physical object (Azuma, 1997). To augment the traditional colouring experience, AR is used to project the coloured contents to create 3D virtual scenes and textured model overlaid the physical colouring book (Clark and Dünser, 2012). A study was conducted to investigate the effect of cognitive load, motivation and attitude towards using AR book and it was found that the students perceived lower cognitive load, stronger motivation and better attitude (Cheng, 2017). Similarly, "The Thirsty Crow" is created to enable pre-schoolers in learning numbers (Bin et al., 2013). It has transformed the traditional book into another immersive learning experience.

However, some educators may struggle to use AR in the teaching activity since their previous training does not provide them with the requisite abilities. Only the most open-minded teachers and forward-thinking educational institutions are ready to use AR technology in the classroom. In addition, the adoption of AR technology requires hardware. This in turn results in the challenge of equipment cost, difficulty to use and improper operation. Many schools cannot afford the cost of equipment and as a result, restraint the use of AR technology in classroom. Moreover, there is a limited AR related teaching and learning contents.

This research aims to answer two research questions, whether AR story book is able to enhance reading experience and how would AR story book beneficial the children. The objective of this research is to create an interesting story book with moral value and integrated with the design of AR elements. Ultimately, it is hoped that the AR story book could cultivate children's interest in reading.

In this research, an AR based story book with a specific moral value is designed and developed. The design process takes into consideration the ease of use as the main target users are children aged 3-8, with the supervision of parents or guardians. The deliverable is simple to use which does not necessitate high-level operation. User could just point the camera of the smart device towards the story book, and the contents will appear in 3D form. The application provides an immersive reading experience so that users can enjoy and have a better comprehending theory in an

interactive setting, as well as increasing their interest in reading.

2. Related Works

2.1. Augmented Reality (AR)

Today, AR technology is a big trend as it presents the information in registered 3D visualisation in both virtual and reality (Chen et al., 2019). AR is a technology that uses computer to generate virtual information composited to the real world and allows the user to see in the real time (Azuma, 1997). During the Covid-19 pandemic, mobile devices has become one of the integral parts of our lives. Therefore, AR could have a great impact for everyone in learning or entertaining. One can easily gain new knowledge through AR applications because AR is very powerful visualisation tool, bringing an object to the reality. It can be an alternative to story-telling applications during the pandemic especially for children who could not attend school. It would be a whole new learning experience to the children.

There are four types of AR technology which are marker-based, markerless, projection-based and superimposition-based (Aggarwal and Singhal, 2019). First of all, marker-based AR is used as an anchor to connect the virtual information with the reality. It is linked to a specific image pattern marker so that the virtual information may superimposed on top of the marker. Marker-based AR image recognition system requires a camera which will capture, process and track the image.

The second type of AR is markerless which is also known as location-based. It refers to the software that does not require any camera to mark for image pattern recognition and user can control environment via their location to overlay the virtual information. A popular markerless AR is Pokemon GO where user only required to have a smart device with Global Positioning System (GPS) capability, digital compass and accelerometer.

Project-based AR is based on projection technique to visualise the image dynamically. This method is used to provide digital data in the stationary situations as its focus is on rendering virtual 3D objects within the user's physical space while superimposition-based AR is known as overlay AR. In principle, superimposed AR is used to replace the original view of the object with the latest virtual image. This method provides multiple views of target objects with options for displaying additional relevant information.

In the recently years, AR technology is used greatly in the education realm. Learning via AR technology is more effective as compared to the conventional method [9]. With AR, students would enjoy reading the textbook due to the 3D visualisations and augmented textured models which allow students to better comprehend a specific theory (Kasinathan et al., 2021). Moreover, by interacting with the 3D displays, students are able to visualise undetectable measure which would encourage the students to explore and learn the new information in a fun way

(Karagozlu, 2019).

AR enables students to learn ubiquitously, at their own convenience. It gives them the luxury to use their time learning a curricular subject while spending less time on the social media platforms. AR also allows experiential learning where students can interact with the real world in new ways, allowing them to create experiences that would not be feasible in real or virtual environment. Most importantly, AR enables greater engagement in learning activities and motivation to learn. Hence, the students would more likely to reach higher levels of education (Di Serio et al., 2013). On the other hand, AR interactive storybook would provide an attractive learning experience for children for a more enjoyable learning process (Dünser and Hornecker, 2007).

2.2. Related AR Tools

Big bang AR is a new application developed by European Council for Nuclear Research (CERN) for discovering the history of the universe based on storytelling and AR application. Through AR, this application immerses viewers in the adventure of the origin of the universe. Users can explore the whole of the universe in a fun way by moving around the object. Moreover, it enables users to travel back to 13.8 billion years ago to discover how space, time, and the visible universe were created. Furthermore, users only need to bring the camera view closer to their palm to see the shape of the universe on the palm. They could also witness the formation of the first stars, solar system, and the planets. Users are able to immerse in the primeval mysteries of the early universe in space and observe the events unfolding at their own physical environment. To have a good experience, users may use an earphone because this application contains various sound effects and there is an assistant to explain the process step-by-step.

Voyage AR is another application related to the learning of science. Voyage AR provides users a series of categories, such as geography, science, mathematics, culture, animals and virtual tour. It also provides textual narratives about the specific topics you choose to study. It also has a built-in quiz section that allows you to easily analyse how much you have learned. Based on memory evaluation, Voyage AR is more interactive, attractive and immersive in classrooms and lectures, rather than static. Other than that, users may scroll down and download the markers from this application and users may use their smart phone to point to the particular AR marker. Thus, users may choose the topic that they want to study, and it consists several chapters. Users just need to select the Play function to start learning the topic.

Assemblr EDU is a unique platform for students and teachers to enjoy 3D and AR learning. Teachers can present interactive 3D lessons with picture, videos, and text within a minute. Teachers can also set up virtual classrooms by subject, so it is easy for everyone to share their work and find things. There is a lot of topics provided by Assemblr EDU such as life science, physics, mathematics, chemistry, geography

and history. Student may join any classes according to the subject they want to learn. In the topic feature, student may choose either official content or user content to experience different types of gamifications and tutorials. Thus, teacher can create one virtual class and invite students to join the class. In the class, students can view all the materials shared by the teacher and students can also share their projects and works. There are two types of markers that user can scan with Assemblr EDU which is QR Marker and Custom Graphic Marker. The former is a square that is in black and white which resembles a QR code while the latter can be scan at any image that user set as a based marker for their AR learning.

Alphabet AR is an educational and interactive AR application that allows children to explore examples of English letters and words through realistic animated 3D objects in the real world. By using this AR application, children can interact with 3D model with realistic textures. Most importantly, children can listen to the audio and practice the correct pronunciation. This is helpful for teachers teaching the pronunciation. There are two game modes in this application which are 3D-AR and Learn and Play. Children may learn the English letter and also how to read the word in 3D-AR mode by scanning the card which is the maker-based image. After the children go through all the learning and practice in the 3D-AR mode, children can play the quiz which is in Learn and Play mode. Different sound elements are embedded in the application to enhance learning process.

3. Methodology

3.1. Research Participants

There is a total of 25 participants involved in this research. Convenience sampling is used in the sampling design. It is a type of non-probability sampling method where the sample is taken from a group of people that can be easily reached. The advantages of convenience sampling are expedited data collection, ease of research, ready access and cost effectiveness. The participants were chosen from friends who are having younger siblings.

There are two processes involved during the data collection. An email was sent to each participant for an invitation to participate in this research. The participant was required to watch a short video clip (3 minutes) and it is available at <https://youtu.be/oU4uSKh0i6A>. After that, the participant would fill up the online questionnaire which will take approximately 5 minutes. The whole data collection process for each participant is approximately ten minutes.

Overall, the participants aged between 4 to 12, where some of them are primary education students. This is to compensate the difficulty of approaching infants aged 3-5 where visiting to a childcare of kindergarten is not recommended during the pandemic.

3.2. Survey Form

The duration of data collection started from 1st March 2022 until 20th March 2022. There is a total of eleven questions. The questions focus on assessing the learning perceptions whether the AR story book is easy to use, interesting, attractive and whether the participants would recommend it to others. 5-point smileyometer is used to receive feedback from the participants ranging from 1-very unsatisfied to 5-very satisfied (☹️ Very dissatisfied, 😞 Dissatisfied, 😐 Neutral, 😊 Satisfied, 😄 Very satisfied).

3.3. Prototype Development

Fig. 1 shows the flowchart diagram of the entire AR story book application. There are three main functions created. User can choose to “Play” to start the AR feature, attempting the “Quiz” feature or play “Mini Games”. The main programming tool used for the AR story book development is Visual Studio 2019. It is a creative launching pad that we can use to edit, debug and build code. Vuforia and Unity are used to develop 2D and 3D games, as well as AR games.

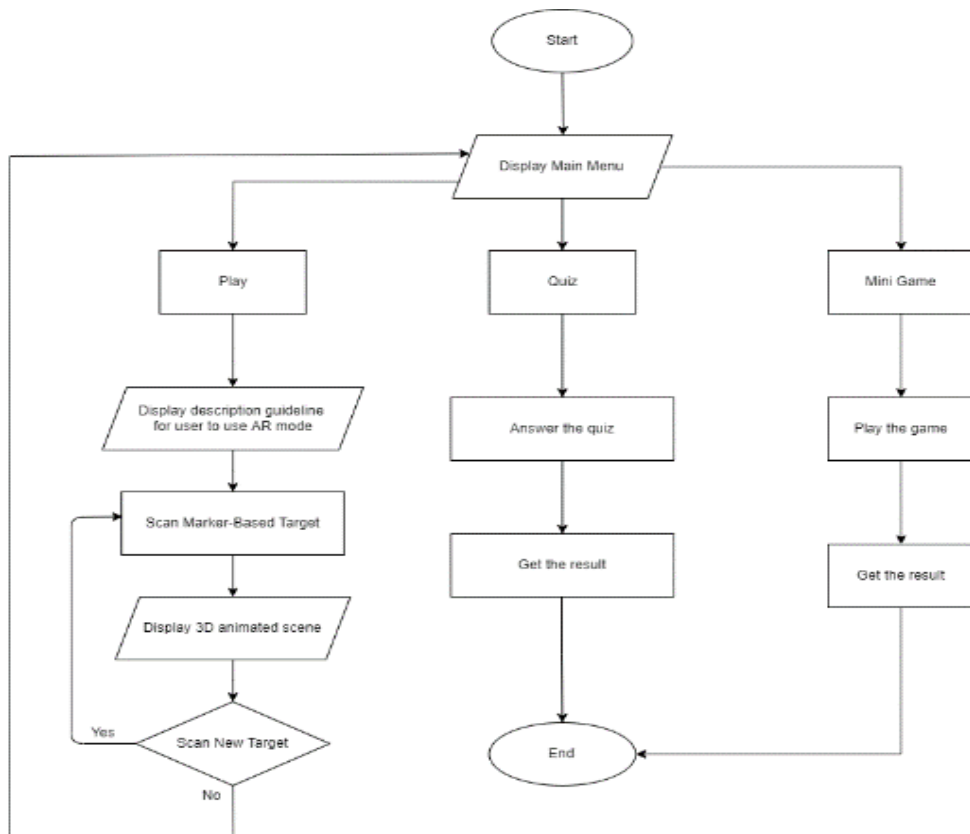


Fig. 1: AR Story Book Flowchart.

3.4. Tangible Story Book

The title of the tangible story book is Happy to Help. There is a total of eight pages and each page has its corresponding 3D objects. The moral value embed in this story is helping each other in need. The reason is to encourage good habit in children so that they are always willing to care for people in need. In this story, Timmy is willing to help a stranger old lady who does not have an umbrella and it was raining. Timmy's mother has always taught him the value of helping people in need. He is setting a good example and role model for the readers.

3.5. AR Elements

Fig. 3 shows the mobile based AR story book application interfaces. This is the main page of the application and the features' function is to Play and Quit. The play function will take the user to the starting page and starts the application. The Quit function allows the user to exit the application after using it.



Fig. 2: Eight scenes of the tangible story book

In activating the AR, user needs to point their camera with mobile device to the specific image target. 3D animated object would then appear. When user enters the main menu, the background music is played. Users can choose to mute the background music by tapping on the sound button.

This application consists of three functions, which are PLAY, QUIZ, and MINI GAME. Users can click on the PLAY to start the AR story reading. Subsequently, users can also choose to play with the QUIZ and MINI GAME functions. The question mark icon would display the application brief information while the “X” icon is to quit and exit the application.

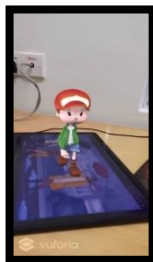
Via the AR story book application, users could scan the image target from the physical book. Users will able to see the 3D AR object as shown in Fig. 4. The conversation in the storybook is narrated. Sound effects such as the rain is incorporated.



a) Main menu



b) Introduction



c) Timmy the AR character



d) Quiz page



e) Sample of quiz question



f) Puzzle game scene

Fig. 3: Sample of application scenes.

4. Results

25 participants have contributed in the survey of this research. Majority of the participants is male which is consist of 64% and 36 % of female. Majority of participants are aged between 6 to 9 year-old (52%). Both group are 24% which is aged between 2 to 5 years old and 10 to 12 years old. Figure 5 shows the statistical results of the questionnaire collected.

When activating the AR contents, user would need to point the camera to the target image in the tangible story book. So it is handy and easy to use without much effort. Majority of the participants are very happy and contented with the application (Mean=4.72; SD=0.4583). 72% of them are very satisfied and 28% is satisfied.

On the other hand, 48% of the participants expressed great satisfaction of the application's attractiveness while 52% of them responded satisfied (Mean=4.48; SD=0.5099). AR contents are dynamic, fun and interesting as the real environment is augmented with virtual objects for instance 3D models, sound effects and narration (Dayang et al., 2012). The augmented environment provides additional information to the users. Higher level of perceived attractiveness is able to motivate and stimulate user's learning enthusiasm.

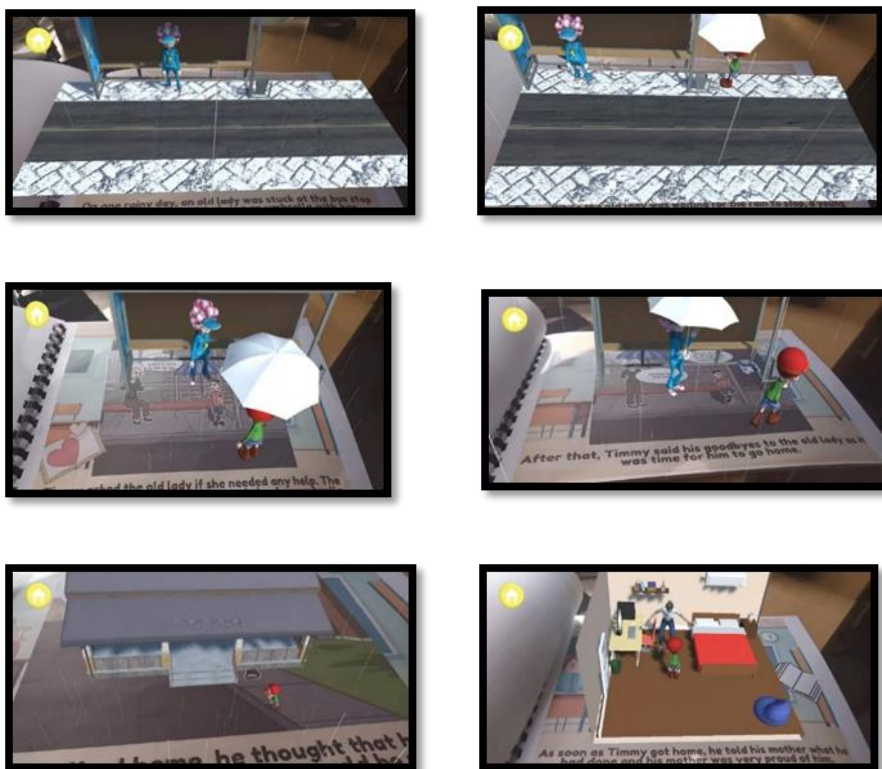


Fig. 4: AR Elements

The application is designed with simplicity as the target users are young children. Rich colours are incorporated as children are inclined to rich and bright colours visual effects (Xu and Jiajun, 2019). It has easy-to-understand menu and icons as figurative graphics are more acceptable than the abstract design (Shuhui et al., 2012). The feedback with respect to the application’s user friendliness is equally positive (Mean=4.8; SD=0.4082). 80% of the participants expresses great satisfaction while 20% is satisfied.

Whether the story book and AR content are interesting, 36% of the participants are very satisfied while 64% is satisfied (Mean=4.36; SD=0.4899). This is coherent with Purificación and José (2018) where the participants felt interesting and fun that the activity contents are not bored, allowing them to learn the concepts by playing.

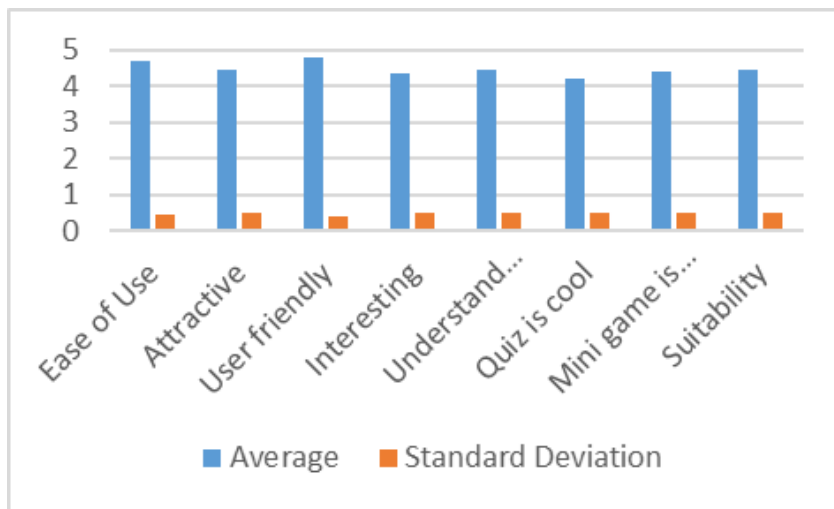


Fig. 5: Statistical Results

AR is able to enhance visual and auditory learning by the 3D visualisations of models, animations and sounds making the learning easy to understand (Chen et al., 2017). Besides, the learning perceptions based on multi-sensory contexts facilitates the understanding of abstract concepts (Fujimoto et al., 2012). Better understanding of the subject improves children’s cognitive function and memory efficiency. 48% of participants shows very satisfied with the story reading understanding while 52% is satisfied (Mean=4.48; SD=0.5099).

With regards to the perception of the quiz feature, 72% of participants are very satisfied and 24% of participants are satisfied (Mean=4.2; SD=0.5). 4% of them is neutral with it. On the other hand, 40% of the participants are very satisfied with the mini game while 60% is satisfied (Mean=4.4; SD=0.5).

AR provides a natural environment where interaction via virtual manipulation related to the real world scenario (Gecu-Parmaksiz and Delialioğlu, 2020). Hence, it

is very suitable to support learning and retain attention. 56% of the participants are very satisfied that AR is suitable to be used while 44% is satisfied (Mean=4.44; SD=0.5066). It is unarguably that it has the potential to be adopted widely in early childhood education.

Finally, all of the participants agree that they would recommend the story telling application to the others. According to constructivism theory, children plays a pivotal role in the learning process and they adapt easily with various learning skills (Narayan et al., 2013). Hence, reading AR storybook is posited to be able to provide an immersive learning perceptions to the children.

5. Conclusion

As technology becomes more ubiquitous and invisible, there is a need for new interfaces that blur the line between reality and augmented reality and allow users to easily switch between the physical and digital domains. This can be achieved through the use of augmented reality applications.

Augmented reality could greatly improve the motivation and attitude of students in learning, and teachers would too find it easy to teach. During this pandemic, augmented reality technology is also one of the important effects for children that allows them to improve their reading skills and their interest in reading. This research aims to create a moral-based story book with integration of augmented reality application which serves as an anchor to motivate and support multisensory learning experience for children who like to read.

The augmented reality technology that includes visual representations that are different from traditional physical books. It encourages children to play and learn which means that the learning process will be more interesting and attractive. Therefore, this application raises children's interest in reading and displays 3D augmented reality objects to make storytelling easier for children to understand. Although augmented reality technology does not replace the traditional learning process, it aims to improve the entire learning perception.

One of the limitations of this research is the quiz and mini game feature. The quiz questions are repeating in different order but it appears static and the mini game is limited. In the future, enhancement can be made to include a quiz bank, gamification and personalisation. In addition, to conduct the experiment in another approach to investigate the different learning perceptions of reading a conventional story book and an augmented reality story book.

Authors' Contributions

Tang Soon Chow 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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