Augmented Reality 3D Pop-up Children Book: Instructional Design for Hybrid Learning

Poonsri Vate-U-Lan, Ed.D.
College of Internet Distance Education, Assumption University of Thailand
poonsri.vate@gmail.com

Abstract—Augmented Reality is one of the futuristic technologies that will be universally used given its potential and fascination. The innovation underpinning this research is the Augmented Reality 3-Dimentional pop-up book namely “the Seed Shooting Game”, for Grade three students, in Bangkok, Thailand. This Augmented Reality (AR) 3D pop-up Book employed a research and development process through storytelling technique. This research article, describes what AR is, reports on the completed research, which focuses on instructional design process of a hybrid learning research on the utilization of Augmented Reality as an effective teaching resource. Hybrid learning draws in aspects of different learning styles. The first part of this article outlines the instructional design experience for analysis of a simple example of AR as a teaching tool. The second part demonstrates design, development and implementation of the AR 3D pop-up book which is the major tool upon which the research is based. The last part provides an insight into what was done using AR and provides pictures and captions enabling the reader to place this example of AR in perspective and understand it more clearly using the Seed Shooting Game story, a children’s Augmented Reality book. It can be used in both online and off-line modes. The developed AR media is an “edutainment” in multimedia format consisting of: text, voice, graphic, animation and interaction. The major findings support the high interest of integration of new technology and educational theory in the hybrid learning environment. From the response of the students in this limited study, circumstances indicate that demand for AR will increase exponentially. However like all education the instruction technology innovation of AR needs to be researched and developed to enhance quality of education.

I. INTRODUCTION

This research paper aims to distribute the fundamental experience of an Augmented Reality (AR) application for academic purposes. This is part of the research utilizes an AR 3-Dimentional pop-up book titled “The Seed Shooting Game”, as the teaching material and tool in the hybrid learning environment for Grade three students, at a selected elementary school in Bangkok, Thailand. This article focuses on the instructional design part of the completed research: 1) Analysis of a simple AR as a teaching material, 2) Design, develop and implement of AR 3D pop-up book and 3) Evaluate utilization of the Seed Shooting Game, a children’s AR book.

AR is an application that combines the capacities of computer technology and web cameras. To make AR function the device needs to be installed with AR software. AR technology displays either multimedia or 3D objects on the computer screen when the camera captures a marker or objects through Radio Frequency Identification (RFID) [1]. A marker simply described means a symbol or picture or aspect of a page in a book. AR technology has been voted to be the most inspired and fascinating technologies especially the AR mobile applications [2]. The idea of AR has been coined by Tom Caudell in 1960, in order to invent a new technique for presentation more information of an object on the limited space of the board [3]. AR has been further developed to cater for a broadening imagination among learners. It is fair to suggest that its technical potential, just like the ever changing way people use computers in everyday life, for AR to be a prominent and powerful aid in learning, development and entertainment. It will be an additional dimension to peoples’ interest in computers overall.

II. A SIMPLE EXAMPLE OF AR

A simple AR refers to an AR application on a computer or a device which installs software; it superimposes a 2D or 3D object or multimedia when a web camera meets a marker. The simplest AR is when one application works together with one marker, which normally augments (emphasises) one object. The simple AR application becomes more interesting when it superimposes a 3D object such as building on a paper-based marker. This simple AR can be controlled easily when the user turns on an AR application and holds a marker. At Assumption University of Thailand, an AR application has been used to simulate the main building (Fig. 1).

Fig. 1. AR application presents Cathedral of Learning, Assumption University of Thailand

As can be seen this example in Fig. 1 emphasises the cathedral and takes it momentarily out of scale with the surrounding buildings. The simple AR application of 3D building is very useful for guiding people geographically to gain a feel for the area as though they are actually there. This kind of AR can be a very useful to teach history subjects which need to present fossils, old buildings or ruins, land marks, or animals in the wild. This idea can extend to
advertising buildings or tourist attractions, or properties for sale easily to name a few examples among limitless applications. Users can simply rotate the marker to see different views and sites of the objects. This AR strategy has definitely impressed people more rather than a normal picture or video would [1].

The markers can publish on different materials such as on paper-like card, a leaflet, a book and on a fabric like a shirt. The collection of multiple markers printed in the textbook format can also apply to expanding the knowledge obtainable form encyclopaedias and other books by emphasising key aspects in pictures or illustrations [4] and other books including children books [5]. The advantages of AR book are multiple. Take one simple example of the first flight by the Wright brothers and how AR could explain the science behind flight. AR has the capacity to:

1) Increase the fascination and engagement among students through the contents by using multimedia blended with 3D objects on each page,
2) Be easy to control and operate the 3D object without a computer mouse,
3) Make the text and pictures and general information in books very user friendly,
4) Enhance the attention and retention of reader and,
5) Value added to printed media.

Given these benefits of AR, the application for academic benefits is one area but also has the added advantage of creatively (if not innovatively) entertaining the reader whilst learning. This is a key bonus. It is in effect a way of coaxing development whilst engaging the learners. However, it is not without some planning and preparation and there are some points that need to be considered to ensure the quality of the simple AR applications is of suitable standard. For example it needs to be noted that AR:

1) Consumes more time to produce applications – as each book needs to have its own application,
2) Involves amplification – meaning there is a return on investment with recurring use of the resource once it is prepared and it can still be improved further as the technology advanced further – as it undoubtedly will,
3) Initially decreases the opportunity for marketing as a mass product given the expense but history has shown decreases in cost with computer technology,
4) Must have the applications installed properly to view each project,
5) Has complexities in terms of the controls and functions for a video or music as there is no play, pause, fast forward and rewind facilities - yet.

If the classroom contains a set of in-built multimedia computer facilities all that is needed to make AR work is a web camera in order to provide the hybrid learning environment. The paper-based marker also needs to be prepared before conducting the class. The capability of the AR 3D pop-up book is suitable for both individual and collaborative learning environment which is described in the next section.

III. DESIGN, DEVELOP AND IMPLEMENT OF AR 3D POP-UP BOOK

AR would be widely used for educational purposes within 2-3 years according to the 2010 annual report by the New Media Consortium and the EDUCAUSE Learning Initiative [3]. According to the Emerging Technology Hype 2010 by the Gartner Firm from the United States of America, the study explored more than 1,800 technologies and the result on the Gartner Hype indicated that AR was near the peak of expected changes in uses of technology [6]. The Gartner Firm predicted that AR will be widely recognized in 2-5 years from 2010 [6]. AR from an education perspective needs to be designed to serve the best of learning objectives, since the production part is not straightforward and requires sound planning and resources.

AR for education is emerging along with AR for marketing and social purposes due to the availability of portable devices with cameras and wireless technology. Its impact in other areas such as engineering and design cannot be underestimated particularly considering it potential symbiotic relationship with computer aided design (CAD). The installation of AR on smart phones has increased dramatically from 8 million in 2009 to more than 100 million in 2010 [7]. The Mobile AR has grown dramatically as forecasted by Juniper Research to reach US$1.5 Billion by 2015 [7]. The potential of AR support for education purposes and a host of the applications are guaranteed. AR can function now by voice recognition, gesture recognition, paper-based marker, global positioning systems (GPS), 2D and 3D recognition. It is going to be pervasive and knowledge in this dimension of technology is growing extensively. AR for example is mentioned prominently and with increasing occurrence on social networking platforms such as Twitter [8].

The simple AR applications which usually can display one 3D object become an inflexible feature to deliver a series of content for education. An important function of teaching resource material is the capability to deliver the contents that flow logically and connect the information almost seamlessly. The nature of a book which includes multiple pages is flexible and suitable to use in the learning environment especially for linear learning approach. The 3D book is a form of electronic book displayed on a computer screen which can flip to the next page. The pop-up feature of a book has been designed to increase children’s interaction with the media. The pop-up object is intended to enhance children’s engagement. Thus, the AR 3D pop-up book has been selected as a main research instrument of this study. The rationale to accept the AR 3D pop-up book involves many flexible options in terms of adding multiple pages up to 50 pages and supporting multimedia such as text, sound and graphics. Additionally, the pop-up book feature is suitable for the child centric learning approach. Therefore, the AR 3D pop-up book has been designed to be a tool for teachers to deliver the story of a children’s book namely “The Seed Shooting Game” [9]. The story underpinning this book is about two boys playing a shooting game with the watermelon seeds. The reader will
gain an added insight from the pictures presented later in this paper. Whilst entertaining the students, the learning objectives of this AR 3D pop-up book were to:

1) Understand where to put quotation marks, 
2) Demonstrate an understanding about the story, 
3) Place the events in chronological order correctly, 
4) Match pictures with the vocabulary correctly, and 
5) Use the vocabulary of preposition to describe the image.

The researcher selected “Zooburst” [10], a commercial online application as an AR Creator to produce this AR 3D pop-up book. The product created by Zooburst can be viewed in two modes 1) screen mode or 3D pop-up book (Fig. 2) and 2) webcam mode or AR book (Fig. 3-5).

The web cam mode or AR mode of Zooburst product can be viewed in three orientations:

1) In front of the marker; users need to hold a marker faces to the camera (Fig. 3),
2) On the top of the marker; users need to adjust the camera to capture the marker, the AR will superimpose on the marker (Fig. 4), and
3) Always on screen; the AR is shown without a marker - therefore meaning “markerless” (Fig. 5).

The instructional design issues - which are summarized below and based on the practical experience of conducting research - are a key piece of information for the reader. The usage of AR as a teaching material in the hybrid learning environment needs to be prepared and practiced prior to implementation. The issues of concern are as follows;

1) The mode of orientation which relies on a marker is the most exciting for users who hold a piece of paper but see themselves and the object or the book superimposed on the screen. This marker mode might be suitable for an individual not for a group since a user prefers to move the marker in the direction that they need to see.
2) The light must be right during the demonstration as it affects AR as the object might not appear or it may but it vanishes abruptly and reappears disappears once again thus disappointing and frustrating the users while studying.
3) The quality of ink on a marker whether it is printed using light inkjet printer or printed on glossy paper - all affect AR. Similar to the previous point mentioned, it might take longer time than usual to turn the object on the marker and keep flashing on and off because RFID could not work properly.
4) The crispate (or unclear) marker gives a poor quality AR. To overcome this it is recommended gluing a marker on a piece of paper board. When using AR, if something interrupts the signal such as finger paste on the marker, the AR object will turn off.
5) The camera is simulating the same site users are reviewing, thus the users will see the reflected picture as if it were a mirror reversed. This happens only when the camera is embedded on the top of the computer screen. If the users need to solve this, a separate and adjustable camera is recommended.

Whilst conducting the research, it was decided to use the “always on screen orientation” since it offered the free hand function for the researcher and reduced the flashing AR. Turning pages of the ‘always on the screen orientation’ could be controlled easily by gesture recognition. While this AR Book is on a screen, the page of the book can be turned by waving a hand from right to left or left to right in the air which is recognized in the grey area on the top of the AR screen (Fig. 6).

IV. EVALUATE THE SEED SHOOTING GAME

The learning outcome dominates learning objectives and they are a core aspect of this research. The completed AR application in 3D pop-up forms a series of learning materials which contains 32 pages. Each page presented a linear flow of information. The format of a book simply delivered the long contents into detached chunks. The completed media consisted of 1) pre instruction section and 2) the story of the
Seed Shooting Game. This was developed as a multimedia AR 3D pop-up book and contained: text, sound, and pop-up cartoon graphics. The sound of each item was separately controlled. This "edutainment" media delivered by storytelling technique was highly suitable for the grade three level English subject in Bangkok, Thailand. This subject was sued as the English subject is very popular in Thailand by students with varying interests and was therefore seen as the best option for research. According to learning objectives which presents on the previous section of this article, the researcher analysed and cross checked the contents of a created story with five learning objectives as revealed on Table 1, to guarantee the usage of instructional design precisely.

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The Seed Shooting Game was used due to its suitability to assess the impact of the five learning objectives. Certain aspects relating to the learning objectives were highlighted or augmented, but the story for interest was maintained. The learning curve is heightened when the students are interested and the data outcome supports this hypothesis. The first draft of the AR 3D pop-up book has been evaluated by five educational technologists. The feedback requested involved what needed to be changed such as the colour of the text and objects within the graphics which needed to be clearer on the computer screen. These issues were revised and other important factors such as the quality of the sound and graphics including their colour, and the flow of the story. Each combined were considered appropriate to assess the impact and assessment of the learning objectives as the basis for the project. Basically the end product being the AR pop-up book was developed through comprehensive research to establish a foundation research tool to provide the platform for accurate quantitative data development and analysis. To be more succinct no stone was left unturned in this important research project. The demonstration and evaluation of story on each page are as follows:

In relation to the cover page (Fig. 2), students knew the boys in green and red shirts were Joe and Ben respectively. The introduction section of this book converted to AR also informed students that the “!” symbol means that particular item include an interaction of display "voice". Meaning when this symbol was pressed the students would hear the actual words of the character – either Joe or Ben or the narrator. Moreover, the red mascot of each page is a narrator who read the script of the story see Fig. 7 for example among others. After viewing the cover of the story, students were introduced to the first page (Fig. 7). At this page Joe was speaking, so his mouth opened and as he had the exclamation signal above his head (“!”) and it was clicked on the users would hear what Joe said. The researcher also hinted the students to observe the different colours of the water melon seeds of each boy.

The first shooting game started on the second page (Fig 8). Students have been encouraged to observe the action of the boys and compare with learned vocabulary. Students have been practiced more about quotation marks, chronological order of events, pronunciation of vocabulary especially the similar homophone (sound) between the words seat and seed.
The story continued to the third page (Fig. 9), the objects above which are the small yellow curves represents each “step” which is used as a measure of the distance the seed travelled but in the AR mode it is used as a pop-up to show the sequence of events – and the red-shirted Ben’s glee when his water melon seed went further. Fig. 9 also enables to understand that the red seed belongs to Ben. Students will also have comprehended the emotion and actions of each boy. The learning deepens with the emphasis possible with AR - bringing the book to an enhanced life.

The fourth page (Fig. 10) described the position of the seed. One for example was next to the seat and the other was passed the seat. The term past was not correct in the book, but has since been amended. Students definitely have a better understanding about the preposition since the prepositions are presented in visual.

The fifth page of the story (Fig. 11) presented the result of the first shooting game.

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The second shooting game started on the sixth page (Fig. 12). Students were encouraged to read the story and practice to cover all learning objectives.

The result of second shooting game started on the seventh page (Fig. 13).

On the eighth page, the tied score is a result of the second shooting game (Fig. 14). Students can understand the meaning clearly from the information on the board.
The shooting game continued on the ninth page (Fig. 15), while students experienced continued enjoyment of the story plus learning in context with the objectives. The difficulty of combining enjoyment with learning can never be underestimated. It is complex to achieve and extremely valuable when it occurs. AR assists this process and taps into multiple learning styles.

The tenth page (Fig. 16) presented the result of this shooting game which stimulated the users to think and discuss further. It is important for you as the reader to know the end of the story.

The last page (Fig. 17) of the Seed Shooting Game presented all important objects of the story and left the ideas and issues learnt for the users to absorb. In order to deliver a story, the action and emotion presented through the face of each character is important. The very obvious feedback from all students who participated showed clearly that they liked both the story and AR 3D pop-up book. By the students’ innocence most of them requested the researcher to return and kept asking for the next AR 3D pop-up book. One of the comments returned on the satisfaction survey was “AR 3D pop-up book is a miracle. I enjoy (sic) study from this media the most.”

V. CONCLUSION AND RECOMMENDATIONS

The children story namely the Seed Shooting Game, has been developed as the AR 3D pop-up book, an innovation media for teaching purposes. The researcher was inspired by AR technology, and then selected Zooburst as a tool to create the AR 3D pop-up book. Readers who are interested in this research could locate articles published by the same researcher to gather information on this research in other aspects such as the development process, the students’ achievement and satisfaction results. Instructional design has influenced the research methodology and increased the quality of the production part for the teaching material thoroughly. The experience of conducting research of the utilization of the AR 3D pop-up book for teaching material presents positive results for future research. The experience of the researcher detailed in the article should be considered as a guideline and prevent the pitfalls of AR as well as that which may befall future researchers. There is a high demand of research using AR for education in other subjects and forms since the fascination of AR technology and quality of education in future is heading in this direction.

REFERENCES