

An Augmented Reality 3D Pop-Up Book: the Development of a Multimedia Project for English Language Teaching

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Abstract— Augmented Reality (AR) for academic purposes is growing in the same upward direction as the expansion of smart multimedia into education and lifelong learning. This paper reports on an AR curriculum materials research and development project which employs storytelling as a teaching technique in a blended learning environment for Grade Three students in Bangkok learning English. It involved an AR 3D pop-up book as a tool for teachers to deliver the story of a children's book, namely *The Seed Shooting Game*, to teach various English language aspects to young children. The primary rationale supporting this research was the high demand and appreciation of the potential to integrate Augmented Reality into classrooms effectively to enhance learning. This article aims to detail each phase of the production process: pre-production, production and post production. The population for this study were 484 Grade Three Thai students of whom 99 were purposively selected. An added finding was the depth of learning - comprehension and engagement gained from the English lesson were higher than their pre-test scores. The majority of participants indicated that the Augmented Reality book was a stimulating educational resource that increased the desire to learn.

Keywords—component; 3D pop-up book, Augmented Reality, blended learning, children's book, e-learning, elementary level, multimedia, storytelling, teaching English as a foreign language

I. INTRODUCTION

This research paper focuses on the production process of a smart innovation in education. This innovation is the Augmented Reality (AR) 3D pop-up book based on the utilisation of a storytelling technique for Grade Three students. AR is an application that combines the capacities of computer technology and web cameras. The general concept of AR technology has been described as an amalgamation of at least three main sections "combining real and virtual information, being interactive in real time, and being registered in 3D" [1]. AR contains the capacity to superimpose virtual objects, particular 3-dimension (3D) objects, and computer graphics in a real environment [2]-[3]. The fascinating elements of AR technology in education which drives its usability and popularity are two fold: 1) to increase students' interaction and 2) to decrease students' cognitive load inherent in foreign language learning [4]. Educational AR projects produce a better learning curve from students since AR technology raises the level of student

interaction [5]. It represents a very worthwhile direction incorporating technology for the classroom because AR is an active computer application which provides more options for students in terms of interaction with the curriculum material rather than a passive mode of study [5]. To make AR function, the computer device needs to be installed with AR software. AR technology superimposes either multimedia or 3D objects on the computer screen when the camera captures a marker or objects through Radio Frequency Identification (RFID). A marker simply described means a symbol or picture or aspect of a page in a book.



Figure 1. A Multimedia Augmented Reality 3D pop-up book

Figure 1 shows the function of voice controlling the main learning innovation exemplifying the technology of AR 3D pop-up book. This quasi experimental research provides for an AR environment instead of an orthodox teaching approach and uses a storybook as the innovation to demonstrate the potential value of this new type of curriculum material. This AR 3D pop-up book delivers the story of a children's book, namely *The Seed Shooting Game*. The AR 3D pop-up book has been selected as the focus of this research because of its suitability to demonstrate AR's potential as a form of media which, as demonstrated, enhances the learning environment.

This was developed as a multimedia AR 3D pop-up book containing text, sound and pop-up cartoon graphic. It has 32 pages, each page presenting different information based upon the learning objectives. The format of such a book simply delivers the extensive content into detached chunks. The sound of each item is separately controlled. The colourful pop-up cartoon items of each page encourage students to continue their study. This smart edutainment helped to deliver an English class for Grade Three students in Bangkok, Thailand.

This AR 3D pop-up book was created under an AR creator which was a cloud computing application based on web 2.0 technology. The AR creator also integrates the social media function onto the application which assists users to share and exchange updated information. This AR creator provides other facilities to complete class activities such as an online Learning Management System which records all online activities of students after log in. The product can be viewed as 1) 3D pop-up book which is called 'screen mode' (Figure 2) and 2) AR 3D pop-up book which is called 'web camera mode'. The web camera mode which presents the 3D pop-up book in an AR environment can be presented in three orientations:

- 1) **In front of the marker:** users need to hold a marker face to the camera (Figure 3),
- 2) **On top of the marker:** users need to adjust the camera to capture the marker, and the AR will superimpose on the marker (Figure 4), and
- 3) **Always on screen:** the AR is shown without a marker - therefore implying "markerless" (Figure 5).



Figure 2. Screen Mode of 3D pop-up book



Figure 3. Fig. 3. In front of the marker orientation



Figure 4. On the top of the marker orientation



Figure 5. Always on screen orientation

This research used the ‘always on screen orientation’ (see Figure 5) since it offered the free hand function for the researcher. The ‘always on screen orientation’ is still considered AR because 1) the 3D book overlays the virtual info in reality, 2) users interacted with the 3D book in real time and 3) the pop-up book registered in 3D. Moreover, the ‘always on the screen orientation’ can be controlled easily by gesture recognition. When this AR 3D pop-up book is on a screen, the page of the book can be turned by waving one’s hand from right to left or left to right in the air which is recognized in the grey area at the top of the AR screen.

II. AR AND LEARNING OBJECTIVES

From an educational perspective the potential and popularity of AR indicates wide applicability in the future. It is user friendly and supports interactions between person and the computer device that bring people into the new era from anywhere and at anytime to assist learning, using wide-ranging and relevant material. For example, AR can function with voice recognition, gesture recognition, paper marker-based, markerless, Global Positioning System (GPS), 2D recognition and 3D recognition. The interesting fact is that the Mobile Augmented Reality is forecast to reach US\$1.5 Billion by 2015 [6]. According to Juniper Research’s report, the installed base of AR capable smart phones increased dramatically from 8 million in 2009 to more than 100 million in 2010 [6]. On social networking applications such as Twitter, AR was mentioned at least five times an hour in 2009 [7]. AR will become a successful application that most people exposed to it will consider fascinating and it has been used to drive the viewer’s engagement.

AR was integrated into book form to enhance the educational purposes. The book is one of the most well know formats to deliver knowledge and information for learners of all ages because of its simplicity and flexibility. The pioneer innovation project integrated AR technology on the physical book form namely the MagicBook which had been designed to enhance a traditional 3D pop-up book version [8]. Users of the MagicBook looked on the book through an Augmented Reality Display or Handheld Display (HHD) to find 3D virtual models appearing out of the pages [8]. The concept of AR on a physical book had been expanded to be an educational computer game, 3D multimedia with real time interaction [9]. The Interactive Alien Book was another AR on the physical book which uses the same concept but adds on a function of multi-languages of AR [10]. AR adds value to the book, especially the children’s book business since AR was nominated as the best interface to view the virtual scene [8], [11].

In order to increase the learning impact and draw attention to the blended learning environment, the main objectives of this current research were purposively intellectual. *The Seed Shooting Game*, the AR 3D pop-up book, was mainly used to serve five learning objectives for these young Thai children:

- 1) understand where to put quotation marks,
- 2) demonstrate an understanding of the story,
- 3) place the events in chronological order correctly,
- 4) match pictures with the vocabulary correctly, and

- 5) use simple prepositions to describe the image.

This AR 3D pop-up book integrated the knowledge with entertainment through storytelling techniques and colourful cartoons. The storytelling technique was much enhanced, given its potential after its testing of its capacity to win students’ attention [12] - [13]. Almost nine out of ten (88%) students indicated storytelling can positively influence the learning environment [13]. This might be because storytelling generally develops ways of learning, knowing and talking about issues, which has the potential to influence how students will approach their professional practice.

Thus, three main sources of knowledge were drawn upon before developing the AR 3D pop-up book for academic purposes: the basic knowledge of AR, the in depth know-how of AR and related educational theory and principles. Therefore, the hypothesis of this particular part of the study is: if the AR 3D pop-up book is an enhanced teaching strategy, then the average achievement scores of children being taught through this method will increase.

III. RESEARCH METHODOLOGY

This study is a quasi experimental research which developed the AR 3D pop-up book in multimedia mode for English language teaching purposes. The developed AR 3D pop-up book has been evaluated systematically both qualitatively by experts from relevant fields and quantitatively with several trials with students. This paper aims to describe only the development process which was comprised of three phases: 1) pre-production, 2) production and 3) post-production.

1. Pre-Production Phase

The pre-production stage comprised: the preparation and refining of the contents of the story, the script and the illustrations for the cartoon graphics for the production stage. The first draft was a 2D cartoon story, which contained graphics and the text of *The Seed Shooting Game* Story. The story was refined by an expert in children’s storytelling, both its graphics (visual) and its script (text) until it was concise, clear, and suited for Thai Grade Three students. Then, the pre-instruction part of the media production comprised developing the introduction, the learning objectives, the vocabulary, the quotation marks and the prepositions. This pre-instruction part was checked by an English teacher with native proficiency and a degree in teaching English as a foreign language for elementary levels. All tests were drafted based upon the learning objectives. The first draft exercise was created as a crossword game (10 words) and a word finder game (10 words). The first draft of the achievement assessment included 30 items of three-option-multiple choice. All tests were piloted with 44 students who studied from the package of *The Seed Shooting Game*. From class observation, students were very excited with the cartoon graphics and story, however, the crossword and search word activities took too long to complete during class. To evaluate the difficulty level and discriminating value of each item and the reliability level of the whole achievement test, the results were computed. It was found that only 25 items of the

achievement test were deemed appropriate for evaluation purposes and thus selected to use in the next stage.

2. *Production Phase*

Based on all the advice from the expert of storytelling and the native English teacher, the researcher revised the script and the graphics. Obviously to create the AR 3D pop-up book with multimedia features and to underpin the meticulous nature of this research, there were many steps:

1) *Sound effect and voice recording*

The script of each page was proofread and edited before its studio recording. All sound effects were selected from a royalty-free sound-effect database. After recording, all voices, melody and sound were uploaded to the server. This involved special support from the AR creator. Basically, the creator provided only real-time recording through the browser on the Internet, which reduced the quality of sound due to a noisy environment despite the use of a high quality microphone.

2) *Graphic and cartoon creating*

Each graphic and cartoon character was designed and converted to Portable Network Graphics (PNG) which contained the necessary transparency background. In particular, the cartoon characters included all details of face emotion and gesture to make sure that they delivered the precise story nuances. There were approximately 200 images used in this research. They were all uploaded through the browser on the Internet.

3) *Book Assembly*

Each page of the book follows the approved script. Each graphic needed to be linked and synchronised with the text and sound.

4) *Evaluation of the AR 3D pop-up book*

The first draft of the AR 3D pop-up book was evaluated by five educational technologists. The feedback 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 were amended in the revision and other important factors such as quality of sound and quality of graphic, colour of graphic and flow of the story were considered appropriate for the learning objectives. Basically the end product, the AR 3D pop-up book, was developed through comprehensive research to establish a foundation research tool to provide the platform for accurate evaluation. Every step was very carefully planned and implemented throughout this curriculum materials project.

3. *Post-Production Phase*

The post-production phase was conducted with the class in three stages – 1) individual trials, 2) small group trial and 3) real class trial – each is outlined in the following sections.

1) *Individual trials*

The purpose of the individual trials was to examine the differences of the interaction with the developed media of three students who had different competency levels. They were purposely selected in order to represent the general student body from excellent to low competency levels. All three were fascinated with AR. After the experiment, it was found that each was delighted and stimulated by the AR 3D pop-up book and multimedia functions. All three undertook the achievement test and completed it. However, the exercise using the crossword and word finder games were not too difficult for all levels of students but took too long to complete. Thus, the exercise was changed to three-option-multiple choice and fill-in-blank – and this reduced any complexity that may have inhibited the accuracy of the data. It should be noted that the questionnaire was designed to ensure that the “Hawthorne Effect” did not impact by adopting a low key approach to the research when in contact with the students. The Hawthorne Effect is when individual or group behaviour may be impacted upon when subjects are knowingly placed under observation [14]. This circumstance is commonly seen as positive or beneficial, because it is argued that group members when aware they are under observation produce behaviours or perform at a higher level than they might otherwise have [14]. The concept or term is derived from a study which focussed on employee satisfaction at a General Electric manufacturing factory in Hawthorne, Illinois, in 1924-1932 but the term was not coined and the effect was not effectively noted until the 1950s [14]. This may pose a limitation in the research but it is considered minimal due to the simple honesty that children exhibit.

2) *Small group trial*

The small group trial was aimed at investigating the way that students participated with the blended study process using the AR 3D pop-up book and learning package. Three groups of five students were purposely selected at a) excellent, b) average and c) low level of competency. After the trial, it was found that all 15 students were stimulated by the blended learning process. All students understood the directions and the contents of the achievement test and completed it on time. The blank questionnaire exercise was also completed on time. All students were observed to have enjoyed the practical task and actively participated in the learning activities during class.

3) *Real class trial*

The real class trial was conducted to simulate a real classroom situation in Bangkok, the capital city of Thailand, a selected developing country. Basically, the elementary class size in Bangkok is usually about 40+ students. This experiment had 37 students attending the blended learning trial, 20 males and 17 females. To establish what impact on development the AR 3D pop-up book had on student learning, the first step in the classroom-based research

involved a pre-test, testing their knowledge of the material to be learned. The test is 25 items of three-option-multiple choice which was developed at the pre-production stage. The next research step involved students completing an exercise sheet which measured their understanding of the material during the actual class. The exercise sheet consists of 30 items, 26 items of fill-in-blank and four items of three-option-multiple choice. The sum of correct exercise scores equalled 97.84 per cent. After participating in blended learning environment using an AR package of *The Seed Shooting Game*, the next research stage involved students completing a post test which is the same as the pre-test. The sum of achievement scores equalled 87.78 per cent. An added research finding concerning the comparison of achievements between pre-test (34.16 %) and post test (87.78 %) of students using the t-test found that the outcomes such as depth of learning, comprehension and engagement gained from the study were higher than when measured prior to the study. Specifically, the results obviously present that when students studied from the AR 3D pop-up book, their achievements increased (Figure 6). This result confirmed accepting the hypothesis. Additionally, this research finding comparing the achievements of female students (89.4 %) and male students (87.4 %) using the t-test independent found that there was no significant difference though female students earned slightly higher.

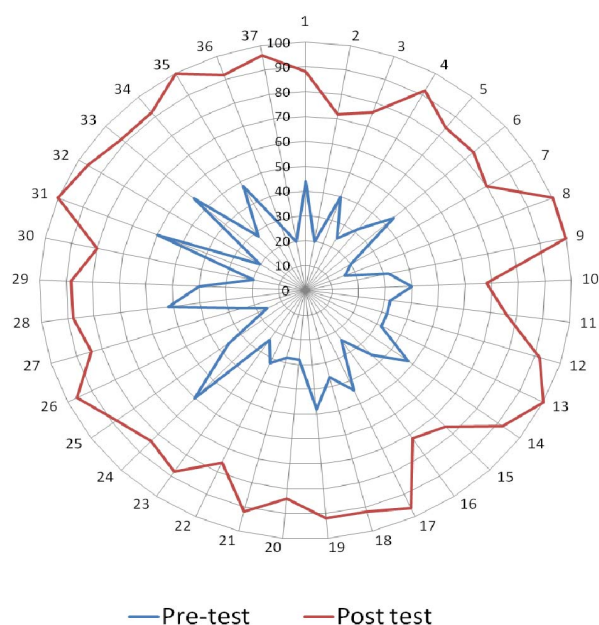


Figure 6. Comparison of pre-test and post test score of 37 participants

IV. DATA ANALYSIS AND RESULTS

This AR 3D pop-up book is a multimedia curriculum material which has been developed based on learning objectives. The media has been designed to assist teachers in elementary schools. The results indicated that the developed

media can be used as a teaching material in blended learning environment and as an edutainment media for individuals. Students involved in this experiment were very excited with the AR environment. The technology became a magnet and aroused a heightened interest in learning. Storytelling and cartoons were suitable for the Grade Three students' age. The participants expressed the desire to study from AR 3D pop-up books in other subjects. Students indicated that the developed media of this research was "a miracle" and increased their attention to learning. The research found that the AR 3D pop-up book played an important role in learning selected aspects of the English language. The AR 3D pop-up book in multimedia mode can be used effectively under the blended learning environment for children. This innovation will be used effectively as a curriculum material for children of both genders. This AR 3D pop-up had its own unique features which differed from other kinds of multimedia or 3D objects and seems very equipped in providing a rich multimedia environment.

V. SUMMARY, DISCUSSION AND RECOMMENDATIONS

This quasi experimental research was conducted with the population of 484 Grade Three students. 99 students were purposively selected for piloting and testing in the research and development process. This curriculum materials research aimed to develop the AR 3D pop-up book for a blended learning environment in a selected developing country, Thailand. The result presents a story of success of AR 3D pop-up book as an academic tool which enhanced the learning of Grade Three students. Best practice of using innovation technology and the appropriate educational theory applied to develop this multimedia educational product resulted in high student achievement. It was revised multiple times based upon the feedback from experts in many fields. Remarkably, this research relied on student centred learning combined with carefully observing individual students to discover and document ways to improve the quality of learning materials.

On the one hand, the developed AR 3D pop-up book has highlighted many benefits that include:

- 1) availability in both online and offline modes which can be used at anytime,
- 2) completion of the necessary steps of AR learning materials development,
- 3) AR multimedia packages can enhance learning activities,
- 4) integration of a variety of learning skills such as listening, reading, comprehension and creativity, and
- 5) functionality depended on teachers' requirements and students' learning capability.

On the other hand, for future research the AR 3D pop-up book should be able to be improved in many ways and these include:

- 1) The acceptability of the various types of graphic objects not only 2D graphic, image and voice but also 3D objects, video and so forth,

2) The function of adding voice and sound to the object which should extend to accepting both the uploading of files and recording voice.

3) The ability to interact with users in terms of rapid feedback to motivate learning outcomes.

4) The capacity to report a log of users on each section of the media which will assist the producer to know about the learning behaviour of each user.

5) The availability of content in AR for educational purposes which is in high demand from teachers who need some 'learning aids' in their class.

The results have confirmed the potential of AR for academic purposes. The AR creator offered a possible option to produce an AR 3D pop-up book without dealing with complicated computer programming. The simple character of a book represented a classical form of delivery of content. The co-operation among the educational technologists, experts in children's storytelling, contents experts and AR creator was a great combination of talented minds that were needed to lead this project to completion. The high involvement of students is also a significant stimulant and motivator for future AR research. Blended learning environments integrating computer technology and face-to-face pedagogy will be a noteworthy educational feature to assist developing countries. AR and other techniques for educational purposes such as gaming and role-playing should be studied in greater depth since the output will definitely enhance modernization of instruction for the future.

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