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iCreate: 3D Augmented Reality Painting Book for Vocabulary Learning

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Abstract - Mobile technologies are rapidly attracting new users, providing increasing usability, and creating more multimedia communication capacity. Moreover, most primary students have own mobile devices for daily usage. This paper proposed an iCreate project or a digital edutainment application with a digital content which was integrated as 3D augmented reality (AR) painting book for English vocabulary learning and art activities. iCreate is a mobile application using java and vuforia library, develops on Eclipse Integrated Development Environment (IDE) and trials with the primary students. The experimental results show that our proposed application and AR painting book can display 3D animated model real-time and effectively. The usage of the mobile device in this AR project offer two benefits, namely mobility beneficial and ease of use. Besides that, the AR colorful painting book in this project able to attract children's attentions and increase the excitement of this new learning environment.

Index Terms— Augmented Reality; AR; Mobile learning; Mobile application; children's book

I. INTRODUCTION

iCreate is 3-dimensional (3D) augmented reality (AR) painting book to learn English vocabulary on an android smartphone for Thai primary students. iCreate is a mobile learning (m-learning) application which aims to be an edutainment material using Augmented Reality (AR) technology to encourage primary school students or kids to participate more and enjoy study from new multimedia technology. The objective for this application was to expand learning opportunity for primary students in rural areas, Thailand. iCreate was invented to support a better learning approach in English basic vocabulary from anywhere at any time by their own devices.

The research motivation of iCreate was developed to solve one of the significant problems of primary students in Thailand that were a limitation of an English understanding vocabulary and pronunciation [1]. In consequence of traditional books cannot provide the multimedia pronunciation of vocabulary. Traditional simple books cannot make young students feel interested in those contents and cannot attract children attentions. Therefore, most of the students fail to have a good command over the native sounds because they cannot listen or hear the native sounds from their traditional English handbooks.

In order to solve and overcome the above problem, and the fact that most current smartphones are basically able to display multimedia content. Moreover, the current mobile phones have many functions that can support an animated display and multimedia of vocabulary related to a book content. Although traditional books are tangible, easy to read, portable, easy to take notes and their interface is universally known. But those traditional books cannot make child students feel interested and excited in those contents or another word does not motivate the student enough.

Instead of discarding those books, the researchers decided to design and develop a 3D AR painting book for vocabulary learning. The researchers expect that encouragement of iCreate should draw an outstanding outcome in term of education enjoyment while studying English vocabulary. The leverage of AR technology on smartphone provide better probability to expand mobile learning outside the classroom. Educators are looking for the way to integrate mobile phone to the traditional teaching method because mobile technologies provide many advantages flexibility, affordability, and intuitiveness[2]. Although there are some limitations of a smartphone such as small screen size and limited presentation of graphics, a mobile technology shows that those smartphones or mobile devices can be used as an effective tool or learning materials to the students in order to support collaborative practice in the learning environment.

This quasi experimental research was conducted after reviewing the existing or relevant literature which will be provided a brief information in the next section. This article will also detail the research methodology, experimental results and future work that will be detailed in the following sections.

II. RELATED WORKS

A number of papers and articles has been publishing regarding the related subjects of this current research. This literature review presents an extensive coverage of empirical
research, as published in AR application during the period 2009-2015, concerning the use and effectiveness of AR m-learning education[3], [4]. During the last few decades, many teachers and researchers have been developing many applications for the adoption of AR into academic and classroom learning [5], [6]. Those studies, some innovations of AR have been developed and are being used to enhance the English learning efficiency of child students such as TeachAR [7], and ABC3D [8]. One of the first one, introduced by Markus Santoso [9] developed an edutainment tool that combines AR technology with tangram toy. This AR technology was built on the latest mobile device, iPad2. They reported one of the promising digital edutainment that able to increase the excitement of this new learning environment. Finally, following the development of AR application, Poonsri Vate-U-Lan [10] presented an educational research study about AR 3D pop-up book for Grade Three students in Bangkok, Thailand. The story contained in this children's book is “the Seed Shooting Game”. The Augmented Reality 3D pop-up book can be used in both online and off line modes. The developed media is an edutainment in a multimedia format consisting of text, voice, graphics, animation and interaction. This research reported on the major findings which present students' attitudes towards two representations of educational innovation: Augmented Reality and 3D pop-up book.

A number of papers and articles have been published regarding the subjects. However, none of the paper can be employed to incorporate in a mobile application using AR with the painting book for Thai primary students. Besides, all of the books are traditional AR picture books which mean the images was painted. In this research, the author would like to propose the painting book with AR application for basic children users in the developing country. Therefore, this paper focuses on the augmented reality 3D painting book for vocabulary learning, which was used as one of the basic tools for English vocabulary learning in Thailand. The definition of terms in this research is as following:

1) Augmented reality (AR)

Augmented Reality (AR) is a technology presenting live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or Global Positioning System (GPS) data.

2) m-learning

m-learning refers to mobile learning which can be defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices." A form of e-learning distance education, m-learners can use mobile device educational technology in many locations at their time convenience.

3) AR Painting book

Children's books are books for a student that used in the classroom or outside of the classroom. Children's book can teach simple concepts about number, letters, color, language, vocabulary, diversity, love, manners and acceptance. AR painting books display the overlay any video or 3D reconstruction on top of AR children book which allows students to create and draw their own personalized book for the individual.

III RESEARCH METHODOLOGY

In this section, we are presenting a process for usage of the AR painting book. The system is divided into two parts, including 1) an animal painting book for color painting, 2) iCreate: a mobile application which is installed on a mobile device using the vuforia library and unity software, which is a backend as shown in Fig 1 and Fig 2.

AR painting book system contains a picture book and AR application. The AR application can display the overlay any video or 3D object on top of AR painting book via a mobile device, or any other mobile device that can scan with its camera. A student can use AR application in order to display the overlaid 3D animated model. AR painting book is designed for children which could help painting into 3D animation, colorfully and interactively. AR application was developed in order to let students fill in a coloring AR book and see their creations into 3D space. Their creations can display and animate image with sound in real time on a mobile device. It creates a multiple-experience from painting, watching, listening and creative thinking in inspires children. AR application made use of the camera on their smartphone, tablet, or wearable glasses and presented an AR experience on the screen.

1) Usage of AR Application with AR Painting book

The AR application was developed in order to let students fill in a coloring AR book and see their creations or output mapped into 3D space. Their creations can display and animate image and sound in real time on a mobile device. Augmented reality also works on our AR picture book. Students are able to share their own product with their friends in class. The usage of AR book and AR application can be described as 4Ps steps presenting in Fig 1.

- Prepare. Students prepare a painting book, download and then install AR application from google play store.
- Paint. Students fill a coloring in a painting book.
- Point. Students open the application and point a camera of mobile to AR book.
• Plearn (Play and Learn): Students view exclusive content with their application.

Fig 1. Designing of color painting book with AR application

Fig 2. System Diagram of iCreate System

The design process of AR application was started with a workflow architecture in Fig 2. The starting with image acquisition from a camera of the mobile device, then it compares a source image with a target image, and finally, it will render a 3D computer graphics through AR application.

2) Development

Systems analysis and design have planned the development of AR application and picture book through understanding and specifying in detail what an AR application should do, what picture book should do, and how the components of the system should be implemented and worked together. At this stage, the developer should divide a system into smaller parts to make it easier. The developer should design, organize and structure the components of a system, including decisions about the mobile device's hardware, software, and network environment. In this project, the author use java language on android platform in development with the vuforia library for AR and unity for 3D creation. An android project contains all the related files that comprise the source code for AR app. After testing, the developer has released an Android Package Kit (APK) to the google play store.

IV. EXPERIMENTAL RESULTS

The iCreate application has three steps: Paint, Point, and Plearn (Play and Learn) as shown in Fig 1. First, the user paints on a colouring page, then the user turns on an icon shortcut of the iCreate application on mobile device, the device camera will be activated automatically. Second, the user needs to point it to the animal picture template on the painting book. Third, the user should play and learn or ‘plearn’ with software that tracks the marker and visualize the registered virtual 3D model of each marker. There are 3 different 3D models as shown in Fig 3 and Fig 4.

Fig 3. 3D model of each painting paper

Fig 4. Graphic User Interface of System: iCreate Application

To evaluate an efficiency of the system, a pilot testing was conducted. The main target group of this application was the elementary school students (level P3-4), in Sakaeo province, Thailand. One English story about animals along with vocabulary was developed and illustrated for this system. With one topic on vocabulary was created in our system. The result showed that five students spent the time painting three pictures as shown in Fig 5.i.e., a picture of a horse, a picture of a cat and a picture of a rabbit for 25.40 minutes, 24.80 minutes, and 26.60 minutes respectively. The time spending on coloring have been assumed too long since a normal period of primary school for each subject is about 45 minutes. Therefore, the researchers need to solve the problem and develop a new design painting book by reducing a paper size from A4 to A5 in order to reduce a painting time and increase the efficiency of the AR system was shown in Table I.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time Spent (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse</td>
<td>25.40</td>
</tr>
<tr>
<td>Cat</td>
<td>24.80</td>
</tr>
<tr>
<td>Rabbit</td>
<td>26.60</td>
</tr>
</tbody>
</table>

Table I: Time spent on painting different pictures.
Fig 5. Example of a few animal in painting book

**TABLE I. PERIOD TIME OF COLOR PAINTING**

<table>
<thead>
<tr>
<th>No.</th>
<th>Period Time of Color Painting (X Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Old design painting book</strong></td>
</tr>
<tr>
<td></td>
<td>Horse</td>
</tr>
<tr>
<td>S1</td>
<td>26</td>
</tr>
<tr>
<td>S2</td>
<td>28</td>
</tr>
<tr>
<td>S3</td>
<td>28</td>
</tr>
<tr>
<td>S4</td>
<td>24</td>
</tr>
<tr>
<td>S5</td>
<td>25-90</td>
</tr>
<tr>
<td>Total time</td>
<td><strong>76.80 minutes</strong></td>
</tr>
</tbody>
</table>

The efficiency of time signifies a level of performance that describes a process that uses the lowest time to create the greatest amount of outputs.

The efficiency of time is a measurable concept that can be determined by determining the ratio of useful output to total input as shown in (1). It minimizes the waste of usage time.

\[
\text{Efficiency} = \frac{\text{Total time old} - \text{Total time new}}{\text{Total time old}} \times 100
\]

The experiment demonstrates the efficiency of time of a new design of painting book with a 35.42% improvement in speed of our iCreate system.

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**V. CONCLUSIONS**

This research presented an augmented reality-based m-learning add-ons for AR book, namely iCreate, on the mobile device. This application has aimed to be edutainment materials based on AR technology that primary students or kids could read and learn more. The results showed that students perceived the AR book to be more joyful and useful than a traditional book. The application increase the student’s motivation for learning English vocabulary. The result of the pilot experiment showed that a new design of painting book, which reduced the size of paper from A4 to A5 was able to reduce a painting time from 76.80 to 49.60 minutes and increase an efficiency time of iCreate system 35.42%. The AR book and an augmented reality-based m-learning system can work together successfully. The outcome of this research will be used in further steps for the m-learning tools that help and support the collaborative practice in vocabulary learning.

**VI. FUTURE WORK**

Future, the authors will include the quantitative and qualitative method to collect data from students including pre-test, post-test with system and questionnaires with teachers in order to evaluate the effectiveness and usability of this system.

**ACKNOWLEDGMENT**

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REFERENCES