DEVELOPMENT OF ICREATE: AN AUGMENTED

REALITY APPLICATION ON ENGLISH

VOCABULARY FOR ELEMENTARY

SCHOOL STUDENTS


By

KITTI KOONSANIT


A Dissertation

Submitted in Partial Fulfilment of the Requirements for

the Degree of Doctor of Philosophy

in eLearning Methodology

April 2018

**Assumption University of Thailand**

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# DEVELOPMENT OF ICREATE: AN AUGMENTED REALITY APPLICATION ON ENGLISH VOCABULARY FOR ELEMENTARY SCHOOL STUDENTS

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## ABSTRACT

The main objective of this study was to develop the iCreate application for the elementary students in order (1) to refine a prototype of the iCreate application based upon feedback from experts and users, (2) to compare pre-test and post test scores of students who studied with the iCreate application, (3) to compare post test scores between female and male students who studied with the iCreate application, and (4) to examine students' attitudes toward the iCreate application.

This research and development were studied using mixed methods. The sample population was composed of 50 fourth-grade students from Nangammitraprap School, Sa Kaeo Province, Thailand. The selection method was non-probabilistic sampling that was selected based on characteristics of a population and the objective of the study. The data collecting instruments were a proposed augmented reality iCreate application on a mobile device for learning vocabulary, a pre-test and a post test for the lesson, and an attitude evaluation form. The researcher named this proposed application as the iCreate application. The collected data was analyzed using various statistical calculation methods: mean value, standard deviation, paired sample t-test, and independent samples t-test.

The findings were as follows: (1) The iCreate application was developed and refined based upon feedback by three experts and 50 target users. (2) The post test scores were higher than the pre-test scores by a statistically significant difference by the level of 0.05. (3) No statistically significant difference for post test scores was found between female and male students. (4) Majority of target users were satisfied after using the iCreate application on English vocabulary learning.

**Keywords:** AR; Augmented Reality; Elementary School, English; Mobile Application; Vocabulary

# ACKNOWLEDGEMENT

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| Acronym | Explanation |
|---------|-------------|
| 2D | Two-dimensional |
| 3D | Three-dimensional |
| A4 | The dimensions of the A series paper sizes (210 x 297 mm) |
| A5 | The dimensions of the A series paper sizes (148 x 210 mm) |
| AEC | ASEAN Economic Community |
| API | Application Program Interface |
| APK | Android Package Kit |
| BYOD | Bring Your Own Devices |
| CALL | Computer-Assisted Language Learning |
| IOC | The Index of Item Objective Congruence |
| iOS | A mobile operating system created and developed by Apple Inc. (iPhone OS) |
| MALL | Mobile-Assisted Language Learning |
| RGB | Red Green Blue |
| SDK | Software Development Kit |

# CHAPTER I

# INTRODUCTION

## 1.1    Background of the study

This research study presented the development of the iCreate application using an augmented reality (AR) painting marker to be an English learning tool for edutainment materials based on AR technology for rural elementary school students or children. According to a list of necessary student skills, English is a foundational skill for every Thai student. Communication in English is an essential skill for developing countries. Notably, the countries in Southeast Asia have joined the ASEAN Economic Community (AEC) (Petri, Plummer, & Zhai, 2012). Consequently, English is the universal language used for communicating and influencing the economy, society, and education among those countries. However, the English language is still problematic for the majority of Thai students, especially compared with those from other AEC countries (Kakkar, 2009). Schools in rural areas, however, do not receive equal opportunities that the schools in the urban areas do. Moreover, it found that studying in the English language is offered for only some specific school programs, particularly for private schools that charge relatively high tuition fees (Nitiwong, 2015).

According to the official statistics report from the ministry of education in Thailand, the majority of students lacked fundamental English skills, particularly, vocabulary (Bancha, 2013). Most of them had no knowledge even of basic vocabulary words for everyday use. One of the reasons that caused these phenomena was that English educators themselves were not confident in their English teaching skills (Alqahtani, 2015). They did not efficiently demonstrate a sufficient knowledge of vocabulary. A lack of learning equipment was also an issue. The existing materials for teaching English, particularly to children, was not attractive enough (Berger, 2015).

As mentioned earlier, Thai students who live in rural areas did not have an opportunity to learn the English language with native English speakers because there

1

are not enough English teachers who possess a good command of the language. Consequently, most of the students fail to have a good command over the vocabulary because they had no experience in listening to the sounds pronounced by a native speaker.

Under these circumstances, the researcher wished to invent a tool that could help the students improve learning English vocabulary. When starting this research, most smartphones were capable of displaying multimedia content and had significant features that could support animation and sound effects. Those features are shipped at an affordable price of less than 5,000 Thai Baht. Most of the students already owned a smartphone. For this reason, an opportunity existed to integrate smartphones into the learning system. The researcher was interested in designing and developing the mobile-assisted learning add-ons as shown in Figure 1-1. This add-on was developed on the Android platform for a mobile device without affecting their qualities. The Android platform was a selected since it is a free operating system and is on an open-source platform. No license fee required. Moreover, the Android platform was affordable for those children.



**Figure 1-1: Mobile-assisted learning add-ons**

*Source:* Bobby (2014)

According to many research studies published in 2017, mobile technologies are rapidly attracting new users, providing increased capacity, and allowing more sophisticated uses (Frank & Kapila, 2017; Heflin, Shewmaker, & Nguyen, 2017; Leporini & Palmucci, 2017; Papadakis & Kalogiannakis, 2017). Moreover, most students have their own mobile devices. Therefore, the current studying trends have expanded into the informal mobile learning (mLearning) area. The direction of most current research has focused on integrating a mobile phone into the learning process. This trend is called mLearning. Educators have been exploring how to use mobile technology to support both informal and formal learning. Mobile technologies provide many advantages: flexibility, low cost, just-in-time learning, and user-friendliness (Colorado & Resa, 2014; Huang, Huang, Huang, & Lin, 2012). Although there are also distinct disadvantages, such as small screen size and limited graphics abilities nowadays, mobile technology shows that those smartphones or mobile devices can use be useful tools for learning and supporting collaborative practice in listening and visualization.

The proposal for this application was to enable rural students in Thailand to learn and understand the pronunciation of vocabulary quickly and accurately, anywhere at any time using their own devices. Moreover, this add-on could be used with edutainment materials so that kids read and learn with the cutting-edge AR technology. AR technology was integrated into this proposed learning application in order to motivate and reward learners. An AR application for educational purposes increases young students' motivation to study English (Li, Chen, & Whittinghill, 2014; Li, Chen, Whittinghill, & Vorvoreanu, 2015). Some research about playing games has found that the students appreciated games rather than traditional classes and learned the material more comprehensively by themselves from the game rather than from a textbook. Moreover, boy students enjoyed learning from digital games more than girl students (Hitosugi, Schmidt, & Hayashi, 2014; Vate-U-Lan, 2017). The use of mobile devices to facilitate the use of AR technology allows for both informal and formal learning. Many researchers have reported that AR increased motivation, increased feelings of collaboration, created a more authentic experience with sights, sound, and the ability to see multiple perspectives (Dunleavy, Dede, & Mitchell, 2009; Klopfer, 2008; Squire et al., 2007; Squire & Jan, 2007; Squire & Klopfer, 2007).

### 1.1.1  New knowledge in eLearning

A "new knowledge" extracted from our finding and research development was that the integrated AR technology with marker coloring material could improve a student's vocabulary learning outcome. Combining informal learning (such as with iCreate) with formal learning is able to accelerate the elementary student's learning process as well as retaining the student's attention. The iCreate application was Thailand's first painting AR application for learning English vocabulary, including multimedia content into the color painting art for the English vocabulary lesson. This research revealed that the iCreate application allowed students to actively construct their own new experiences based on painting with an AR marker coloring page and mapping between vocabulary learning and inspiring art.

### 1.1.2  Academic progression in eLearning methodology

The academic progression proves the expertise of a researcher in the field of eLearning Methodology was the iCreate application allows students to actively construct their own new experiences based on painting with an AR marker coloring page and mapping between vocabulary learning and inspiring art.

### 1.2  Statement of the problem

According to the results of some research studies regarding vocabulary levels in the English language among students at elementary schools in the rural area of Thailand (Kirkpatrick, 2012; Prapphal, 2003). There are some problems regarding English vocabulary among the elementary schools in the rural area, Thailand, especially in English vocabulary ability (Noom-ura, 2008; Wiriyachitra, 2002). Similarly, elementary students at Nangammittraphap School which is the elementary school in rural area of Thailand are encountering the same problems (Wiriyachitra, 2002). At Nangammittraphap School, two issues on teaching English vocabulary were identified. The first issue was that most of the student lacked of basic vocabulary knowledge on everyday vocabulary usage that they were supposed to know. The second issue was that the instructional method used in English teaching at Nangammittraphap School still rely on the traditional teaching styles.

Due to the problems mentioned previously, the researcher believed that integrating AR technology into an English vocabulary learning would increase the students' levels of interest, their involvement in the lesson, and help them have a better understanding of English vocabulary while enjoying the learning process.

Therefore, this research aimed to study the results of the iCreate application development, determine gender preferences among the iCreate application, the scores of students between pre-test and post test, and their attitudes toward the iCreate application in contexts for studying English vocabulary.

## 1.3 Research objectives

This research aims to develop "iCreate," an AR application for English vocabulary for elementary school students. In order to fulfill this primary objective, the research has created an AR application to be part of edutainment materials based on AR technology for elementary school students.

Main Objective

> To develop the iCreate application for the elementary students at Nangammittraphap School, Sa Kaeo Province, Thailand

Specific Objectives

(i)  To refine a prototype of the iCreate application based upon feedback from experts and users

(ii)  To compare pre-test and post test scores of students who studied from the iCreate application

(iii)  To compare post test scores between female and male students who studied from the iCreate application

(iv)  To examine students' attitudes toward the iCreate application

## 1.4 Research questions

The research questions for this study:

(i)  What are the feedback and recommendation from experts and users to refine a prototype of the iCreate application?

(ii)  What are the comparison results between pre-test and post test scores of students after studying from the iCreate application?

(iii)     What are the comparison results between post test scores of female and male students after studying from the iCreate application?

(iv)     What are the students' attitude appraisals of the iCreate application?

## 1.5    Research hypothesis

For the research hypothesis that can be tested in this study are:

(i)     There is a statistically significant difference in the students' pre-test and post test scores for those who used the iCreate application.

(ii)     There is a statistically significant difference between the students' post test scores between male and female students who used the iCreate application.

(iii)     There is a statistically significant difference between the scores of attitudes toward the iCreate application between male and female students.

## 1.6    Significance of the research

The invention of AR iCreate application was developed as an optional edutainment tool to motivate students to study English vocabulary. This research is relevant and necessary because it directly supports students at Nangammittraphap School to learn English vocabulary, as well as other young Thai students who are interested in vocabulary learning using the iCreate application.

## 1.7    Definitions of terms

This research uses the following terms as keywords with the following definitions.

**Android:** A mobile platform operating system developed by Google and Open Handset Alliance.

**Attitude appraisal:** Student satisfaction questionnaire that surveys on students who studied with the iCreate application.

**Augmented reality (AR):** Technology integrating the real physical world with digital information and media, such as 3D objects and multimedia, superimposing in real time the camera view of a mobile phone, tablet, PC, or smart glasses. The integration of digital information with the real physical world as communicated by any sensor with a data marker, e.g., a camera and a printed marker under the user's environment in real time. Devices used for AR are commonly those of a computer, a camera, a processor, and a screen. The real physical world was augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics, or GPS data.

**Augmented reality (AR) marker:** A marker or an image printed on many virtual objects or paper, which will superimpose multimedia objects such as video or 3D objects when generated by AR technology

**Augmented reality application toolkit (AR toolkit):** Software building blocks for AR applications that involve the superimposition of virtual imagery in the real world

**Development of iCreate:** The iCreate application was developed by Java code for the Android platform with the Vuforia library for AR and Unity for 3D creation. The researcher followed Brahmawong's seven-step model (R4D3) for R&D prototype development (Vate-U-Lan & Brahmawong, 2009). After testing, the researcher released an Android Package Kit (APK) to the Google Play Store.

**Elementary School Students:** Elementary schools students living in rural areas, children from poor opportunities and children living in families that do not speak the English language. For this research, researcher selected fourth-grade elementary students from two classes of Nangammittraphap School which is small scale school for general children aged between 3 and 16 years in Sa Kaeo Province, Thailand.

**English vocabulary:** The English vocabulary contains simple vocabulary about number, letters, color, animal, vegetables, and parts of the body.

**iCreate:** A name of the proposed augmented reality mobile application which was created and developed by the researcher

**Mobile-learning (mLearning):** A form of eLearning on mobile devices or smartphones which offers more flexible options for anyone to learn from anywhere at any time. The interaction of mLearning can be implemented effectively across multiple contexts, through social media using personal electronic devices.

**Phonics:** A procedure for teaching, reading, and writing in the English language by developing the learner's phonemic awareness

**Plearn:** A portmanteau of the two words "play" and "learn," which means enjoying in English.

**Software development kit (SDK):** A set of software development tools that allow the development of applications for a specific software package, software framework, hardware platform, computer system, video game console, operating system, or similar development platform.

## 1.8 Limitation of the research

The participants of this development were derived from a nonprobability sample that is selected based on characteristics of a population and the main objective of the study. Fifty fourth-grade students from two classes of Nangammittraphap School, Sa Kaeo Province, Thailand were selected by purposive sampling method.

## 1.9 Conceptual framework

Figure 1-2 shows the relationship within the framework between independent variables, intermediate variables which were the seven steps proposed by Brahmawong (Vate-U-Lan & Brahmawong, 2009). The researcher started with studying the concepts, principles, and reading theories about constructivism, constructionism, connectivism, 21$^{st}$ century learning tool, augmented reality, and mobile-assisted language learning. The knowledge gained from this review of the related works was used as guidelines to design and develop the iCreate application. After that, the context of the study, including who, where, and when, was defined in order to specify the scope of the research. In this research, fourth-grade students were used as the sample of the study and the experiment was started in the second semester of 2016 for two weeks at

Nangammittraphap School, Sa Kaeo Province, Thailand. This research was based on the theoretical perspective, such as 3C: constructivism, constructionism, and connectivism and additionally, the 21st century learning tool. Constructivist learning involves students experimentally drawing with AR freely. Based on Jean Piaget's epistemological theory of constructivism, constructionism occurs when experiential learning and creating are connected. Furthermore, connectivism is a learning theory that describes how Internet technologies create new opportunities for people to learn and share information among groups or across the world.

**Concept, principles, and theories**
1. Constructivism   2. Constructionism   3.Connectivism
4. 21$^{st}$ century learning tool
5. Augmented reality   6. Mobile-assisted language learning

| Independent variables | Intermediate variables | Dependent variables |
|---|---|---|

1. The usage of iCreate

2. Genders of the participants

1. Review of literature regarding augmented reality and mLearning

2. Conduct a feasibility study for the iCreate application

3. Develop a conceptual framework for iCreate for vocabulary learning

4. Survey of expert opinions about usability of iCreate

5. Develop a prototype of iCreate

6. Try out and trial run iCreate (pilot experiment)

7. Revise and finalize the prototype of iCreate

Students' post test scores

Students' attitudes toward iCreate

**Context**

Fourth-grade students of Nangammittraphap School, Sa Kaeo Province, Thailand, second semester, 2016

**Figure 1-2: Conceptual framework of research**

In summary, the background of the study on the importance of English vocabulary and the problems of student in the English learning, especially in rural areas of Thailand, were confirmed according to literature. The needs for conducting this study were described in the details which include the research problems and motivations. In order to achieve the research study, the objectives and the research questions were defined. Finally, the significance of the study and the definitions of the terms were clarified, and the conceptual framework of the study was illustrated and explained in this chapter. In the next chapter, a review of the literature and other related work will be described.

# CHAPTER II

# LITERATURE REVIEW

This chapter aims to review the literature on the overall picture of the background of constructivism, constructionism, connectivism, and the 21st century learning tool. It presents a discussion of relevant issues to the study regarding the AR application, augmented reality, mobile assisted language learning, and research hypothesis.

Although there are many different approaches for learning theories in the past decade, those learning theories have been applied to produce positive effects in the classroom for students. In order to create effective learning environments, several learning theories have to study. There are the behaviorism learning theory, cognitivism learning theory, and constructivism learning theory. Behaviorism assumes a learner is essentially passive. Cognitivism focuses on what happens in the mind such as thinking and problem-solving. Constructivism is to make the students active learners.

According to many relevant research (Chang, Wang, & Chao, 2009; Cooper, 1993; Piaget, 1954, 1970; Rogoff, 1991; Vygotsky, 1978), new learning system should contain "elements of constructivism, constructionism, and connectivism especially "constructivism which is the most popular used model of learning in education today" (Hoic-Bozic, Mornar, & Boticki, 2009). By this information, a leaner should actively construct their own knowledge. The role of the teacher moves from one of being the supplier of knowledge to coaches or partners with learners in the learning process. Accordingly, a learning theories of constructivism, constructionism, and connectivism are reviewed in next section.

## 2.1   Constructivism

Constructivism was introduced by Jean Piaget in 1928 (Piaget, 1954, 1970; Vygotsky, 1978). The set of principles clarifies how to get information or to know the nature of information. It is moreover a methodology of the redesign of instruction and

learning as well as instructing hypothesis. The system of ideas claims to exchange center from educates to the learner. The concept of this focuses: (1) knowledge is effectively built by students instead of latently got or ingested; (2) knowledge is in the shape of thinking or practicing, not memorizing; and (3) knowledge is the widespread agreement from interaction and transaction among learners and other individuals. Constructive learning underlines the learning methodology. Constructivism consists of two categories (Chang et al., 2009; Cooper, 1993).

### 2.1.1 Individual constructivism

Individual constructivism states that knowledge is the comprehensive agreement from interaction and arrangement among rationalization. It underlines that individual learning is built under the individual condition (Rogoff, 1991; Vygotsky, 1978). Individual constructivism focuses on self-thinking and permits common reasoning, critical thinking, and logical thinking. Students acquire new information and knowledge from such procedures.

The researcher launched the AR iCreate application to put constructivist learning into practice. The target subject is the elementary school student. In this study, the implementation of the AR iCreate application is based on the concept of constructivism, which allows students to create and draw their personalized paintings individually.

### 2.1.2 Social constructivism

Social constructivism states that knowledge is the all-inclusive agreement from communication and arrangement among individuals. It underlines that individual learning is built under the social condition (Rogoff, 1991; Vygotsky, 1978). Social constructivism emphasizes on intersubjectivity and permits common reasoning, critical thinking, and basic leadership forms. Students acquire new information from such procedures with people.

## 2.2    Constructionism

Constructionism advocates student-centric and revelation realizing where learners utilize the data they definitely know to procure more learning.  Students learn through support in project-based learning where they make associations between various thoughts and zones of information encouraged by the educator through instructing instead of giving lectures or step-by-step direction. Further, constructionism holds that learning can happen considerably more productively when people are dynamic in making unmistakable protests in reality.

Seymour Papert (1980) developed constructionism in a research paper to the National Science Foundation named as "Constructionism: A New Opportunity for Elementary Science Education."

Papert's ideas became well known through the publication of his written book entitled "Mindstorms: Children, Computers, and Powerful Ideas" (Papert, 1980). Papert explained young student implementing programs and software for kids step by step the basic of programming using the Logo educational programming language.

## 2.3    Connectivism

Connectivism is a principal structure for understanding learning. (Siemens, 2005). In connectivism, the beginning stage for learning happens when learning is impelled by the procedure of a student interfacing with and sustaining data into a learning group. Connectivism is a learning theory that describes how Internet technologies have opened new opportunities and channels for people to exchange, learn, communicate and share information between groups or around the world.

Siemens (2005) states, "Community is the clustering of similar areas of interest that allows for interaction, sharing, dialoguing, and thinking together."
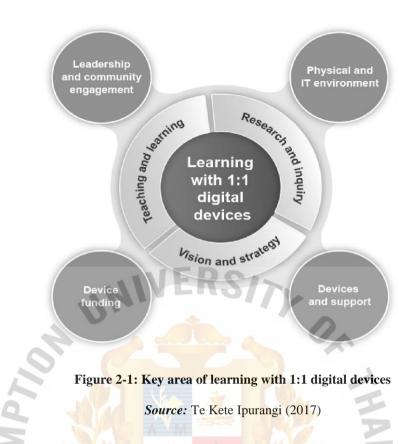
In the connectivist model, a learning community is described as a node, which is always part of a more massive network.  Nodes arise out of the association focuses that are found in a system. A system is included at least two nodes connected keeping in mind the end goal to share assets. Nodes might be of differing sizes and qualities,

contingent upon the convergence of data and the quantity of people who are exploring through a specific node (Goldie, 2016).

Connectivism is a principle of learning for the digital age. Learning has revised over the last several years. The theories of behaviorism, cognitivism, and constructivism provide new useful views into learning in many different environments. They go down short, however, when current learning develops into the informal, networked, information technology and technology-enabled arena.

## 2.4 Twenty-first century learning tool

One of the most renowned $21^{st}$ century learning tools is the one-to-one digital device that allows all students from anywhere access to a digital device at any time. A digital device could be any mobile electronic technologies such as mobile phone, which includes assistive technologies. Indeed, the students have already used those devices in their daily life. Devices could be owned by the student or provided by the teacher (Te Kete Ipurangi, 2017).

The meaning of "1:1" (one-to-one) is that each student has access to a digital mobile device to help their learning. This way may be achieved by students bringing their own mobile devices (bring your own devices: BYOD). At the point when gadget gets to reaches out past the classroom, understudies can utilize their gadget for adapting anyplace whenever. Key areas to consider for school digital devices or a BYOD program are shown in the Figure 2-1.

**Figure 2-1: Key area of learning with 1:1 digital devices**

*Source:* Te Kete Ipurangi (2017)

## 2.5 Mobile-assisted language learning

With the eruption in online activity that followed the emergence of the Internet and the capability of mobile communication devices, computer-assisted language learning (CALL) gave way to mobile-assisted language learning (MALL) and more broadly speaking, mLearning, which is the acquisition of any knowledge or skill through mobile technology anywhere at any time (Geddes, 2004). This sentence describes the change from using static, desktop computers to mobile devices for learning.
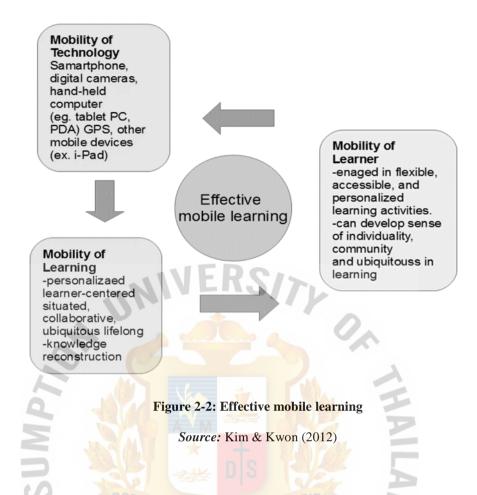
The aim of language learning is to develop communication competency. Using existing communication devices in the classroom is a beneficial way of opening opportunities to practice using the language. The anywhere-and-anytime access to content that mobile devices offer users means that mobile learning can extend the opportunities for informal learning. Since smartphones are part of many students' everyday routines, these smartphones can be used to crossover from the classroom to the outside world.

While this is an emerging technology field of research, researchers seem to agree that mobile devices enhance learners' motivations to engage with content. Moreover, since mobile devices are intended for mobile communication, language content is available everywhere.

## 2.6 Augmented reality

Augmented reality (AR) is a disruptive technology that merges the real physical world with digital content and multimedia, such as 2D/3D objects and clip videos, superimposing in real time the camera view of a smartphone, mobile devices, tablet, PC, or smart glasses.

A direct consequence of using the wrong vocabulary word and incorrect readings in the classroom is a reduced ability to speak English effectively. Some papers and articles have been published regarding this subject. This literature review presents extensive coverage of empirical research, as published in English during the period from 2009 to 2012, concerning the use and effectiveness of mobile learning education.

**Figure 2-2: Effective mobile learning**

*Source:* Kim & Kwon (2012)

From Figure 2-2, mobile learning created flexibility anywhere. There is much valuable content, such as videos, sound, and other multimedia formats, available on its mobile devices. Students can access this content on their devices anywhere at any time without limitations. Their mobile learning experiences can give valuable knowledge and create powerful personalized-centric learning experiences on their mobile devices.

Augmented reality (AR) employments computer-aided design to include a layer of data to help understanding and interaction with the physical world around the client. Currently, there are two categories of AR available to researchers (Klopfer & Sheldon, 2010): 1) location-aware and 2) vision-based. This e-Learning add-on was primarily focused on vision-based AR played with AR markers in the physical environment.

Many AR applications for the classroom have been developed and applied. Most AR iCreate applications have been developed in order to enhance the classical lesson by adding videos, models, animations, and sounds.

Several great basic-level or high-level SDKs were integrated into mobile applications. Table 2-1 shows a comparison of various SDKs for augmented reality.

Table 2-1: Comparison of popular augmented reality SDKs

|   | SDK | License Type | iOS | Android |
|---|---|---|---|---|
| 1 | Vuforia | Commercial SDK option | ✓ | ✓ |
| 2 | Wikitude | Commercial SDK option | ✓ | ✓ |
| 3 | ARToolKit | Open-source | ✓ | ✓ |
| 4 | Aurasma | Commercial SDK option | ✓ | ✓ |
| 5 | Daqri | Commercial SDK option | ✓ | ✓ |
| 6 | Metario | Commercial SDK option | ✓ | ✓ |
| 7 | Layar | Commercial SDK option | ✓ | ✓ |
| 8 | Zappar | Commercial SDK option | ✓ | ✓ |

Augmented reality (AR) is a disruptive technology which is the procedure of superimposing computer-generated objects, such as clip video, voice, animation, or 2D/3D models, over the live preview of physical world surroundings. AR has accomplished exceptional development and advances over the past years (Azuma et al., 2001; Krevelen & Poelman, 2010). Moreover, the researcher compared the free version

of five SDKs (Vuforia, Daqri, Metaio, Wikitude, Layar) for targeting the Android platform. The following five are described below.

### 2.6.1 Daqri

DAQRI is augmented reality developer API (Application Program Interface) for providing custom software and creative solutions to the customer through their mobile application.

### 2.6.2 Layar

Layar is a mobile application and platform for accessing digital information about the physical world around a person. Using augmented reality technology, Layar displays layers of digital information to the user's mobile phone. This platform can contain digital information related for both geolocation as well as images.

### 2.6.3 Metaio

Metaio is an SDK and tool for developing and providing augmented reality solutions.

### 2.6.4 Vuforia

Vuforia is an augmented reality package and software development toolkit (SDK) for mobile devices that enables the development of augmented reality. It helps image processing and computer vision technology to identify and track images (marker targets) and general 2D/3D objects, such as animation, instantly.

### 2.6.5 Wikitude

Wikitude is a mobile augmented reality application which is developed by the Austrian company Wikitude GmbH.

First, the analysis results found that Vuforia is a good SDK for flexibility in implementation as shown in Figure 6. Most mobile developers like it (Qiao & Chen, 2014). It provides APIs for both Java and C/C++. Then, Daqri is the most exciting application. It is convenient for implementations with many images in books or posters. Finally, Metaio has the most ways for real-world registration and 3D modeling. All the

SDKs surveyed are useful, but only those SDKs mentioned above were selected for this work. Moreover, for regular users, there is a useful mobile application called Aurasma, which provides an augmented reality platform. Aurasma's image recognition technology uses the camera from a smartphone or tablet to recognize real-world images and overlay multimedia on top of them in the form of animations, videos, 3D models, and web pages.

Regarding AR as learning helps over the later a long time, numerous classroom-level AR applications have been created and used in formal learning. The direction in modern education found that combination of entertainment and playing into learning activities in the classroom could increase the learning motivation of students. It boosts their initial attention to study the subjects. Moreover, games focus their concentration on content for long continuous periods of time (Garris, Ahlers, & Driskell, 2002). Following this direction, the primary goal of this research was to create and develop an AR mobile application for learning aids.

Moreover, many current case studies have demonstrated AR's prospects of entering classrooms as formal learning in the type of AR markers, AR vocabulary, AR entertainment, and information representation gadgets (Qiao & Chen, 2014). The researcher discusses three of the many types: AR picture markers, AR edutainment, and AR information representation gadgets for AR formal learning in the classroom.

Because of the AR features, AR markers can show information that plaintext and traditional pictures cannot. Therefore, AR improves and enhances the courses for getting to substance and provide a kind of creative learning experience (Qiao & Chen, 2014). One example is the 3D augmented reality 3D marker that teaches the student about the layers of the earth, history of the earth and its functions, sun waves, relative sizes with another planet, and more as shown in Figure 2-3.

**Figure 2-3: Example of 3D augmented reality marker**

*Source*: Larngear Technology (2015)

AR features try to offer developers and game creators boundless assets to make associations and connections between the virtual world and physical objects. AR features are not obliged by model, dimensions, animation, computer-generated objects or other physical natures. They also enable AR players to immerse themselves in the game storyline better and communicate with real or virtual objects (Qiao & Chen, 2014). Formally known as the Quiver App, Quiver allows the student to print out the pre-designed coloring pages. Then, students can point the camera at their coloring page and watch the 2D characters come to life in 3D. This exciting activity is shown in Figure 2-4.



**Figure 2-4: Example of Quiver application**

*Source:* Quivervision (2016)

AR knowledge representation apparatuses have the acquired AR features to upgrade the expressiveness of the classroom environment, making it conceivable to represent phenomena that happen in a vacuum, sea, the small world, and numerous other customarily inaccessible places, or indeed show extra information aligned with the physical object (Qiao & Chen, 2014).

AR was brought by educators on instructional design and learning materials preparation. In its yearly published Horizon Report, the New Media Consortium, an international community of experts on educational technology, had two times in 2010 and 2011 explained that AR would see worldwide use in learning shortly thereafter (Qiao & Chen, 2014). In Thailand, the researcher reviewed the literature review of expert opinions of AR in education, for instance, (Srifa & Pookeamkam, 2017). The literature suggested that augmented reality brings new dimensions to self-learning (Srifa & Pookeamkam, 2017).

## 2.7   Phonics

Phonics is the basic reading instruction. It explains young children about the relationships between letters and sounds. It is one of the first building blocks of reading. The connection between sound and letter is a principal component of an English instructional program for spelling and reading because it provides readers with tools for creating new written words. For example, if a child takes the word "boy," although it consists of a single syllable, it contains three different phonemes: /b/ /o/ /y/. Phonics helps elementary students learn to read words. For students to be able to read new vocabulary words, they need to have an understanding of the relationship between letters and the sounds of letters. For example, children are taught to read the letters in a word like "b-o-y" and then merge them to pronounce the word boy. Nowadays, there are five steps to learn phonics sounds as shown in the Figure 2-5.

# 5 Steps in learning Phonics

C = consonant
V = vowel
e.g of CVC words : box, six, bed, etc
e.g of CVCV words : rare, cape, etc

**Step 1**
Learning a-z

**Step 2**
CVC words
with
one vowel

**Step 3**
CVCV words
with
two vowels

**Step 4**
Words with
double/triple
consonant
blends

**Step 5**
Advance
phonics
diphthongs/
diagraph
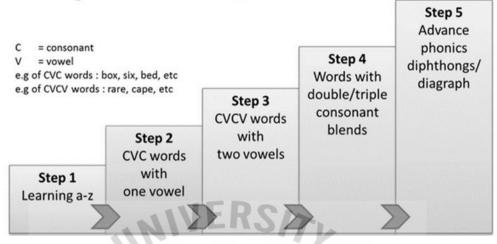
**Figure 2-5: Five steps in learning phonics**

*Source:* Aki Kaka (2017)

## 2.8 Related Works

Chang (2009) presented the usage of constructivism to investigate learning styles and impacts in a blog framework condition. A blog framework condition enables clients to outline their customized online content for people, gatherings, working, and organizations. The blog framework is a stage for clients to share their thoughts and improve the learning impacts of the understudies. A fourteen-week experiment was directed to investigate whether the communication of a showing system and learning style in view of the constructivism and framework would improve an understudy's learning impacts. The research results of the two-way multivariate analysis of covariance (MANCOVA) analysis revealed: (1) the student's learning method has no significant affectation on their learning impacts; (2) the teaching plan based on the constructivism can enhance the student's learning impacts; and (3) under the environment of the teaching plan and learning method, the experimental group showed better results in learning.

Saekhow (2010) presented the interactive multimedia virtual reality courseware in computer lessons about "Introduction Personal Computer Hardware." In this study, the researcher found that the efficiency of an assisted-instruction interactive

multimedia virtual courseware program in teaching "Introduction Hardware for Personal Computer" was 87.92/84.44. Comparison of the learning achievements of the students' lessons before and after viewing showed that the post test scores were higher than those of pre-test. Most of the students satisfied the lesson well with an average score of 61.7 per cent.

Vate-U-Lan (2011) presented an educational research study about an AR 3D pop-up book in the two modes of learning for third grade students in Bangkok, Thailand. The title in this children's book was "The Seed Shooting Game." The augmented reality 3D pop-up book can be used in either online or offline mode. The developed tool is an edutainment in a multimedia format consisting of text, sound, graphics, 2D/3D animation, and two-way communication. This research results reported on the major findings which present students' attitudes toward two representations of educational innovation tool: augmented reality and a 3D pop-up book.

Santoso (2012) developed an edutainment tool that combines AR technology with a tangram toy. This AR technology was built on an iPad device, one of the latest mobile devices. His summary described one of the promising digital content increases the excitement of this new learning environment. The utilization of the mobile device in this AR application offers two benefits, namely mobility and ease of use. Besides that, the colorful markers in this project attract children attentions.

Meesuwan (2013) presented the instructional package together with the augmented reality technology. The researcher studied the design of instructional packages and concepts and the augmented reality technology from documents and research papers. Moreover, the researcher studied various concepts using augmented reality technology, such as the theory of learning for developing a guideline for consistent processes to influence changes in student behavior, thinking, and learning. It is found that the form of the augmented reality technology consists of: 1) the teacher's manual, 2) the student's manual, 3) the lesson's content, 4) the test, 5) the media of the augmented reality technology, 6) the presentation of 3D pictures, 7) the form of markers, and 8) are other qualifications of the instructional package where forms can be developed and used in the instruction. This is consistent with the concept of Kapfer & Kapfer stating that the instructional package is the form of communication between the teacher and

the students, consisting of suggestions for the students to perform learning activities, resulting from learning by instructional packages.

Wojciechowski (2013) presented the evaluation of the attitudes of students toward learning in his augmented reality environments. The attitude questionnaire was created based on technology acceptance model, enhanced with distinguished enjoyment and interface style constructs. For empirical research, a storyline of an experimental chemistry lesson was developed. The study involved second grade students. As follows from this result, seen convenience and delight had a comparable impact on the attitude toward utilizing increased reality environments.

Su Cai (2014) presented an augmented reality learning tool for a secondary school chemistry class in Shenzhen, China. According to data analysis and summary, we concluded that (a) the AR tool had a significant supplemental learning effect as a computer-assisted learning tool, (b) the AR tool was more efficient for typical students, (c) students generally had positive thoughts about this software, and (d) students' learning attitudes were positively correlated with their assessment of the software.

Zarzycki (2014) presented the teaching and design for augmented reality. This research looked into the ways that emerging interactive technologies are being adopted by designers and expanded into the areas of advertising, training, entertainment, and marketing. It discussed in detail the project development stages and methodologies used to engage design-focused students into often-complex technological issues. The discussion is contextualized through some case studies of mobile and marker-based AR applications developed by students.

Meesuwan (2015) presented the development of tangrams with augmented reality. This research included three objectives: 1) to develop tangrams with AR (augmented reality technology), 2) to compare the students' achievements before learning and after learning by using the tangrams with AR, and 3) to study the opinions of the students toward tangrams with AR. In this study, the tangrams with AR developed by the researcher were evaluated by the experts and tested by 15 fifth-grade elementary school students at Wang Itog School, Phitsanulok. The results of this research are 1) the result of the tangrams assessment by experts was at an appropriate level ($X = 4.18$, $SD = 0.32$) and 2) by comparing the learning achievements of the samples before learning and after

learning using the tangrams with AR, the students' achievements after learning are higher than before learning with a statistical significance of 0.05 level.

Vate-U-Lan (2017) presented the oxymoron of serious games in eLearning: gender differences from an internet-based survey in Thailand. The results of research found that almost half the participants who chose only an entertaining computer game preferred to play educational computer games at 49.2 per cent and 15.1 per cent, respectively. The research findings confirmed that females thought differently about playing computer games compared to their male counterparts.

A number of papers and articles have been published regarding these AR subjects. This literature review presented an extensive coverage of empirical research, as published about AR during the period from 2009 to 2017, concerning the use and effectiveness of AR mobile learning education.

However, none of the research papers incorporated an in-field prototype integrated constructivism, constructionism, and connectivism theory using the AR iCreate application for learning vocabulary on mobile devices for Thai students.

In summary, constructivism shows learning as an active process in which learner actively construct knowledge and skill based on what they already knew and experienced. The theory emphasizes the participation of the leaner and deemphasizes the involvement of teacher.

According to the constructivism point of view, the role of the teachers are being coaches or mentors to learners in the learning process. In order to effectively transform learners from a passive recipient of information to active constructors of knowledge, the teacher needs to provide learners with the motivative environment. One of many ways to create a motivative environment is to use modern gadgets.

With AR mobile application, constructivism can be applied to learning by allowing individuals to construct own vocabulary. Students viewed superimposed vocabulary content through the iCreate application. Their creations displayed an animated image and made sounds in real time on a mobile device. A student can use the iCreate application in order to display the overlain image or video. Students shared

their products with their friends in class. In order to gain a better understanding of how learning theories evolved in AR mobile application, some research processes related to the research methodology of this study will be described in the next chapter.

# CHAPTER III

# RESEARCH METHODOLOGY

The previous chapter has presented and reviewed about the background of constructivism, constructionism, connectivism, and the 21st century learning tool. Moreover, it presented a discussion of relevant issues to the study regarding the AR application, augmented reality, mobile assisted language learning, and research hypothesis.

This chapter presents the research design and methodological approaches, and the data collection is explained. The mixed method is used for this research. In brief, this chapter is organized on the following sections: (i) Using an AR application with informal learning (ii) Prototype development (iii) Development of the iCreate application (iv) Target population and sample (v) Variables (vi) Research methodology (vii) Research design including research instruments and data collection (viii) Rating scale and (ix) Reliability analysis of the attitude appraisal.

## 3.1  Using an AR application with informal learning

The iCreate application contains an AR application and English vocabulary. An augmented reality application displayed an overlay of any video or 3D reconstruction on top of AR marker using a tablet device or any other mobile device that was captured by the camera. A student can use the iCreate application in order to display the overlain image or video. Students perceived the AR application to increase motivation levels and found it more rewarding than traditional learning methods. All the students liked the mLearning add-ons with the iCreate application. The painting activity and the iCreate application for learning English vocabulary worked well together (Koonsanit & Vate-U-Lan, 2017).

The iCreate application was developed to let students fill in an AR marker coloring page and see their creations mapped into 3D space. Their creations displayed an animated image and made sounds in real time on a mobile device.

The iCreate application utilized the camera on the smartphone, tablet, or AR wearable glasses and presented an augmented reality experience on the screen. The iCreate application worked on an AR marker coloring page. Students shared their products with their friends in class as shown in Figure 3-1.



**Figure 3-1: Usage of an AR application**
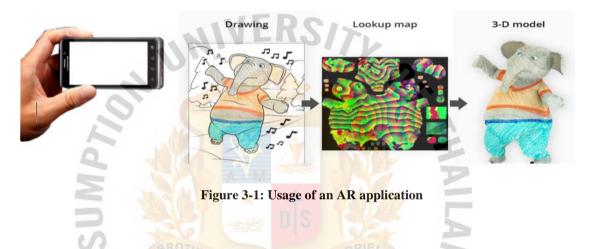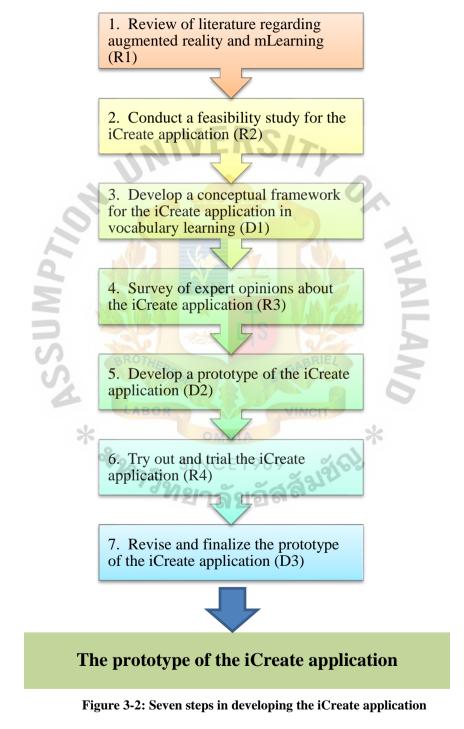
Figure 3-1 demonstrates an interaction between the iCreate application and an AR marker coloring page.

1. Students filled an AR marker coloring page.
2. Students downloaded and installed the AR application from the Google Play Store.
3. Students opened the application and pointed the smartphone camera at the AR marker coloring page.
4. Students viewed superimposed vocabulary content through the iCreate application.

## 3.2 Prototype development

### 3.2.1 The seven steps for a prototype development

For a prototype in this project, the researcher followed Brahmawong's seven-step model (R4D3) for R&D prototype development (Vate-U-Lan & Brahmawong, 2009):

1. Review of literature regarding augmented reality and mLearning (R1)

2. Conduct a feasibility study for the iCreate application (R2)

3. Develop a conceptual framework for the iCreate application in vocabulary learning (D1)

4. Survey of expert opinions about the iCreate application (R3)

5. Develop a prototype of the iCreate application (D2)

6. Try out and trial the iCreate application (R4)

7. Revise and finalize the prototype of the iCreate application (D3)

**The prototype of the iCreate application**

**Figure 3-2: Seven steps in developing the iCreate application**

*Source:* Vate-U-Lan & Brahmawong (2009)

1) Review of a related body of knowledge through documentary research (DR), interviews, field visits, and Internet searches on the R&D prototype (R1 – First research)

2) Conduct a survey of need assessment on the R&D prototype (R2 – Second research)

3) Develop the conceptual framework of the R&D prototype (D1 – First design)

4) Survey of experts' opinions (3) through questionnaires, Delphi technique, or a focus group (R3 – Third research)

5) Develop the first draft of the R&D prototype making use of the knowledge and information crystallized from steps I, II, and III (D2 – Second design)

6) Seek experts' verification of the prototype or conduct developmental testing of the R&D prototype: try out and trial run (R4 – Experimental research). For this research, the researcher tried out the iCreate application with a sample group of students.

7) Revise and finalize the R&D prototype (D3 – Third design)

At the first step, knowledge of augmented reality and mLearning in mobile application were reviewed. Next step, the researcher conducted a need assessment for the prototype of the iCreate application. Based on the information obtained from the first step and the second step, at the third step, the researcher developed the conceptual framework for the prototype of the iCreate application. Next step, at the fourth step, the researcher elicited expert opinion to find out any weakness that might be on the prototype of the iCreate application. At the fifth step, the first prototype of the iCreate application was drafted. Next, the first prototype of the iCreate application was tried out at the sixth step. After collecting the feedback, the researcher revised and finalized the prototype of the iCreate application.

## 3.3    Development of the iCreate application

The flow of the iCreate application development was the typical process for creating a standard application. There was a number of models for development such as waterfall model as shown in Figure 3-3.
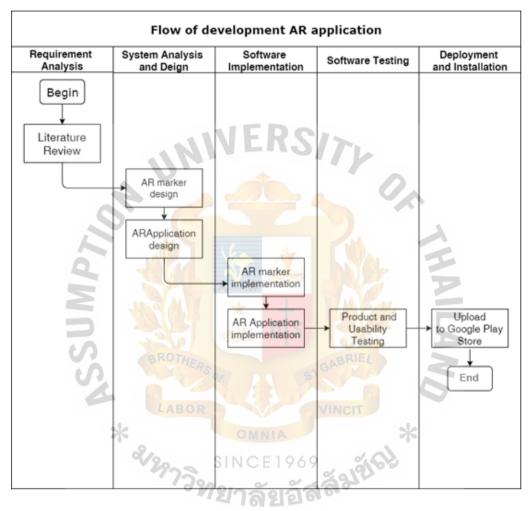


**Figure 3-3: Flow of the iCreate application development**

The target purpose of this research was to develop the prototype of the iCreate application to enhance English vocabulary for students. However, the researcher designed a sequential development approach, which was the flow of application development for this project. There were complete five steps as described below.

### 3.3.1 Requirement analysis

The requirement for review and analysis was the first and essential stage in order to ensure that the product and ideas were possible to develop and implement.

### 3.3.2 System analysis and design

At this stage, the researcher divided the system into smaller parts to make it easier to manage. The organization and structure of the components of a system are shown in Figure 3-4.

Camera → Marker → Recognition → Interpretation → Rendering

**Figure 3-4: System design**

From Figure 3-4, an AR overlaid the computer-generated video and 3D object onto the camera-captured video. This was accomplished through five components: 1) camera, 2) marker, 3) recognition, 4) interpretation, and 5) rendering.

1) The camera scanned an AR marker coloring page in real time. Then the device screen was augmented by building one layer of reality on top of another in order to create an augmented reality experience with pictures and videos directly viewable by the person in a real-time environment.

2) The AR used markers (i.e., a physical element, commonly an image marker, that would trigger AR animations). Augmented programming software was used to deliver animation or virtual records to those AR markers.

3) When an AR marker coloring page is in front of the camera, the software saw the page and captured the information and pattern encoded on it and sent this information to the iCreate application. The application recognized the information from the marker and searched for the marker in an existing database.

4) The application interpreted an AR marker coloring page and determined how to integrate virtual objects. Some AR was just relative placement over a registration mark,

while more advanced algorithms created shadows, occlusion (i.e., things in front of the virtual items).

5) The AR iCreate application was developed to render 3D models to overlay the marker. The researcher used several software programs to create 3D models such as Unity3D and Blender software. When the 3D model creation was completed, it was rendered in order to be compatible with an augmented reality experience.

### 3.3.3 Software implementation/coding

The software was implemented using computer programming and deployment with software development tools. In this project, the researcher used the Java language on the Android platform with the Vuforia library. An Android project contained all the related files that comprise the source code for AR application.

### 3.3.4 Software trial

Software trial was performed by an evaluation of the software against requirements gathered from stakeholders and software specifications. The testing phase was conducted after finishing of the implementation phase. Software testing comprised of validation and verification. Software verification was testing in order to prove that "you built it right." Software validation was testing in order to prove that "you built the right thing."

### 3.3.5 Deployment and installation

After the testing phase, the researcher had a release version APK ready for the Google Play Store. Once the APK was ready, the researcher uploaded the APK files to the Google Play Store. This step was done by logging into the Google Play Android Developer Console.
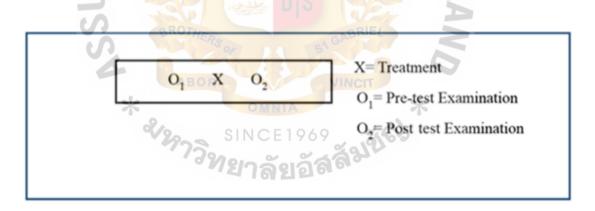
### 3.4 Target population and sample

### 3.4.1 Target group

The target population of this research was a group of students from an elementary school in the rural area of Thailand. Fifty fourth-grade students from Nangammittraphap School, Sa Kaeo Province, Thailand were purposefully selected to

represent and participate in this current research project. The iCreate application contained one complete English vocabulary lesson which improved and strengthened English reading and comprehension skills. The researcher decided to divide activities into three activities:

1) Pre-test: The first step in the research involved a pre-test, testing knowledge before informal learning. After that, 50 fourth-grade elementary school students in a rural school in Sa Kaeo Province tried out this system for two weeks using mobile devices.

2) Post test: After informal learning using the iCreate AR application, all students completed the post test which is equivalent to the pre-test as shown in Figure 3-5.

3) Analysis: From Figure 3-5, pre-test and post test scores were used in this research. X, O1, and O2 represented the treatment condition, the pre-test examination, and the post test assessment of the dependent variable, respectively.



$O_1 \quad X \quad O_2$

X= Treatment
$O_1$= Pre-test Examination
$O_2$= Post test Examination

**Figure 3-5: Pre-test and post test research design**

*Source:* Adopted from Edmonds & Kennedy (2012)

### 3.4.2 Variables

According to the purposes and the research questions of the study, there were variables including independent variables, an intermediate variable, and dependent variables.

The independent variables were the fourth-grade students and the iCreate application. The intermediate variable in this research was the seven-steps (Vate-U-Lan & Brahmawong, 2009).

The dependent variables were the prototype of the iCreate application, the students' post test scores, and the students' attitude appraisals of iCreate.

## 3.5 Research methodology

This research was designed to use both a pre-test and post test. The population included 50 students from Nangammittraphap School in the Sa Kaeo Province in the east of Thailand during the 2016 academic year. The participants of this development were derived as a nonprobability sample that were selected based on characteristics of a population and the main objective of the study. They were selected by purposive sampling method by their necessary information by the qualities of different gender, age, same academic level (fourth grade), and the same school.

In research stage, the researcher used the mixed method because it was a logical and appropriate option as a way of collecting information from the students. The data collection, including the pre-test, post test, and attitude appraisal from the student, was considered to be the main purpose of the data. It can help to investigate the design and development of iCreate by enabling stakeholders, including students, to make decisions that either accept or reject this work.

### 3.5.1 Research instruments

The research instruments were 1) the prototype of the AR iCreate application with an English lesson entitled "Vocabulary for Kids," and 2) a set of pre-test and post test examinations including 30 items of four multiple-choice questions, and 3) an attitude appraisal of the iCreate application. Moreover, the development toolkits for an iCreate application were the following:

1) Vuforia – augmented reality toolkit

2) Unity3D for 3D object creation

3) Java language version 7.0
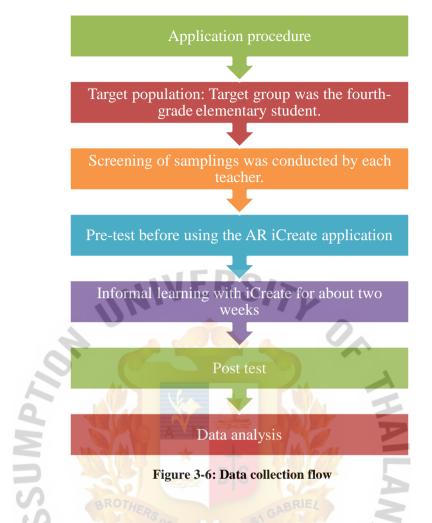
4) Android 4.3

5) Smartphone (screen size 5.5 inches or bigger)


### 3.5.2  Proposed data collection, data analysis

In this research, there were five main steps for data collection as shown in Figure 3-6.

1) Select a group of students and introduce the iCreate application to them and demonstrate how to use it.

2) Let the selected group do the pre-test examination to measure their background knowledge. The pre-test was a set of 30 items of four multiple-choice questions about English vocabulary.

3) Let the selected group study English vocabulary using the iCreate application. Each student was required to practice and participate for 60 minutes per week.

4) Give the post test examination to the selected group in order to measure any improvement of English vocabulary skills studied from the iCreate application. The post test was a set of 30 items of four multiple-choice questions about English vocabulary. This was the same as the pre=test.

5) The student filled in the questionnaire regarding his or her attitude toward the iCreate application. (50 students)

The ability of this application was evaluated by the post test and the attitude appraisal of the AR iCreate application. The researcher chose and used software to help analyze the raw data. After that, the software created a report to visualize the data for the different variables. The information from the questionnaires was analyzed by statistical methods, such as the mean, standard deviation, and paired sample t-test. The results of pre-test and post test were analyzed by paired sample t-test at the 0.05 level of significance.

**Figure 3-6: Data collection flow**

From Figure 3-6, the 30 questions of pre-test and post test scores were analyzed by statistical methods, such as the mean, standard deviation, and paired sample t-test.

## 3.6   Research design

This research design was mixed method divided into two parts: the first part of this study consisted of the development stage, which was the development of the iCreate application. The second part consisted of the data collection with pre-test and post test which was collected by distributing the test as shown in Figure 3-6. The questionnaires were analyzed for different two genders (female and male) and different examinations (pre-test and post test).

**Figure 3-7: Research design**

## 3.7 Likert's five-rating scale

The level of attitude based a Likert's scale ranged by five different levels. A grading scale from one to five, with one being strongly disagree and five, strongly disagree, as shown in Table 3-1. They were grouped into different classes to get an idea of the distribution, and the range of such class of data is called the class interval (Vagias, 2006).

To evaluate the evaluation form of the iCreate application for "vocabulary learning," the students filled in the form. This research used Likert's five-rating scale which best measured the attitudes toward the iCreate application (Vagias, 2006).

Level 5 = Strongly agree

Level 4 = Agree

Level 3 = Fair/Uncertain

Level 2 = Disagree

Level 1 = Strongly disagree

The following criteria were designed so that the researchers could interpret the meaning of the scores.

Table 3-1: Definition of class interval

| Class Interval | Mean |
| --- | --- |
| Score of 4.51 – 5.00 | Strongly agree |
| Score of 3.51 – 4.50 | Agree |
| Score of 2.51 – 3.50 | Fair/Uncertain |
| Score of 1.51 – 2.50 | Disagree |
| Score of 1.00 – 1.50 | Strongly disagree |

*Source:* Vagias (2006)

The research was divided into two parts. The first part of this study consisted of a quiz for the pre-test and post test, which was collected by distributing paper tests to 50 students. The second part consisted of the attitude appraisal of the iCreate application which was collected by distributing tests to 50 students only after treatment.

Part 1: A quiz for the pre-test and post test using four multiple-choice questions (a, b, c, d) for 30 items. Examples of question numbers nine and ten are shown in Figure 3-8.
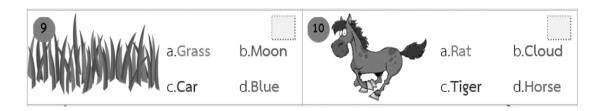


**Figure 3-8: Examples of quiz questions for the pre-test and post test**

Part 2: The score of attitude appraisal from 50 students toward the iCreate application (only after treatment) is shown in Table 3-2.

**Table 3-2: Attitude appraisal of the iCreate application questionnaire**

| No. | Attitude appraisal | Score | | | | |
|-----|-------------------|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| Q1 | I like the iCreate application. | | | | | |
| Q2 | I feel excited using the iCreate application. | | | | | |
| Q3 | I feel happy using the iCreate application. | | | | | |
| Q4 | I understand the vocabulary from the iCreate application. | | | | | |
| Q5 | I want to study with the iCreate application. | | | | | |
| *Note | Q1 where "1" means very unsatisfied, and "5" means very satisfied | | | | | |
| | Q2-Q5 where "1" means strongly disagree, and "5" means strongly agree | | | | | |

## 3.8 Reliability analysis of the attitude appraisal

For this research, the Cronbach's alpha was used to measure the reliability of the attitude appraisal. Cronbach's alpha is commonly used as an estimate of the reliability of a psychometric test for a sample of examinees. The researcher used a Cronbach's alpha to determine the reliability of attitude appraisal of the iCreate Application. A result value of ten sample examinees from the treatment group was compared with the acceptable Cronbach's alpha value (acceptable level > 0.6) (DeVellis, 2016; George & Mallery, 2003; Kline, 2013). The result of Cronbach's alpha on this attitude appraisal

(five questions) was calculated to be 0.909. The following criteria were designed in order to interpret the meaning of Cronbach's alpha value.

**Table 3-3: Definition of Cronbach's alpha**

| Cronbach's alpha Interval | Meaning |
|---|---|
| $\alpha \geq 0.9$ | Excellent (high-stakes testing) |
| $0.7 \leq \alpha < 0.9$ | Good (low-stakes testing) |
| $0.6 \leq \alpha < 0.7$ | Acceptable |
| $0.5 \leq \alpha < 0.6$ | Poor |
| $\alpha < 0.5$ | Unacceptable |

*Source:* Devellis (2016)

The Cronbach's alpha of this attitude appraisal was calculated to be 0.909. The Cronbach alpha should be greater than 0.6 (DeVellis, 2016; George & Mallery, 2003; Kline, 2013). In our result, the Cronbach's alpha was calculated as 0.909. Therefore, it was acceptable for this attitude appraisal.

In summary, this chapter described the overall research procedure of the study. It started with a description of the research design, and the mixed method was best fit for this research. After that, the target population and sample used in the study were clearly identified. According to the objective and research hypothesis of the study, three types of variables and research design including research instruments and data collection were defined previously. Moreover, the Cronbach's alpha was applied to measure the reliability of the attitude appraisal. Finally, to illustrate how the data were collected and analyzed, a section on the procedure for the data collection and the data analysis were described. In order to gain a better understanding of how to develop AR iCreate

mobile application, some topics related to the development of iCreate application will be described in the next chapter.

# CHAPTER IV

# DEVELOPMENT OF ICREATE APPLICATION

In this chapter, the researcher presents the development of the augmented reality-based e-Learning for vocabulary on the mobile device. In brief, this chapter is organized on the following sections: (i) The prototype of the iCreate application (ii) Usage of the iCreate application with the AR marker coloring page (iii) Implementation of the iCreate application (iv) Feedback from experts (v) Product testing and small group trial and (vi) Field Testing.

The development of iCreate application aimed to be edutainment material based on AR technology for elementary students or children to read and learn more. The results expected that students perceived the vocabulary to be more fun and useful. Students surely benefited from the AR iCreate application. The advantages of the application were to increase interest in reading English vocabulary. The students that learned with the AR iCreate application are enhanced their reading abilities and English pronunciation better.

## 4.1    The prototype of the iCreate application

The iCreate application is 3-dimensional (3D) augmented reality (AR) application for learning English vocabulary for Thai elementary students using an Android smartphone. The iCreate application is a mobile learning (mLearning) application which aims to be an edutainment material using augmented reality (AR) technology to encourage elementary school students or children to participate more and enjoy studying from new multimedia technology. The objective of this application was to expand learning opportunities for elementary students in rural areas. The iCreate application was invented to support better ways to approach learning basic English vocabulary from any location at any time by their own devices as shown in Figure 4-1.
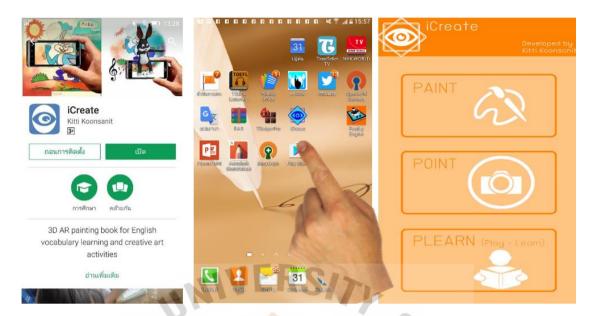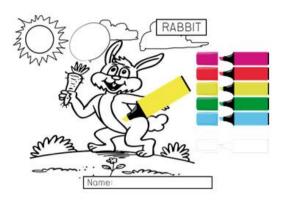
**Figure 4-1: The screen capture of iCreate application**

This section describes a typical process for using the iCreate application. The iCreate application was divided into two parts: 1) the iCreate application is a mobile application which was installed on a mobile device using the Vuforia library and Unity3D software and 2) an AR marker coloring page. This framework is the backend as shown in Figures 4-2 and 4-3.

According to Figure 4-2, the iCreate application overlays the 2D motion picture or 3D static object on the marker for the physical paper. As a result, the mobile phone screen would show an augmented form of the AR marker coloring page.

A student can use the iCreate application for displaying the overlain 3D animated model. AR painting marker was designed for children who could improve their painting experiences to be more colorful and rewarding. The iCreate application was developed in order to let students color an AR marker coloring page and see their creations popup vividly in 3D space. Their creations can be viewed and animated with sound in real time on a mobile device. This adds a new active experience to regular painting. With this application, students can watch and listen, possibly improving their motivation. AR application utilizes the camera on their smartphone, tablet, or wearable glasses to present an AR experience on the screen.

(a) Prepare             (b) Paint



(c) Point             (d) "Plearn"

**Figure 4-2: Designing of the iCreate application**

## 4.2 Usage of the iCreate application with the AR marker coloring page

The iCreate application was developed in order to let students color in an AR marker coloring page and see their creations mapped into 3D space. Their creations displayed animated images and sounds in real time on a mobile device. AR also worked on the AR marker coloring page. Students shared their results with their friends in class. The usage of the iCreate application can be described with the 4-Ps steps.

### 4.2.1 Prepare

Students prepared an AR marker coloring page. The application was installed via the Google Play Store as any other typical mobile application.

### 4.2.2 Paint
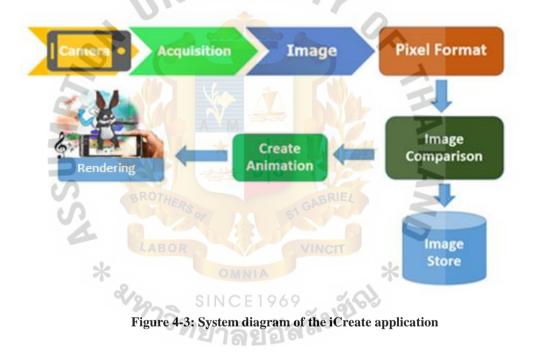
Students colored an AR marker coloring page.

### 4.2.3 Point

Then, students opened the application and moved the mobile phone in the way that its camera area covered an AR marker coloring page.

### 4.2.4 "Plearn"

"Plearn," a portmanteau from play and learn, can be literally translated to Thai as getting pleasure from learning by performing. Students viewed superimposed vocabulary content through the iCreate application.



**Figure 4-3: System diagram of the iCreate application**

The design process of the iCreate application was described with a workflow architecture in Figure 4-3. It started with the image acquisition from the camera on the mobile device. The acquired images were converted to specific image format where the color of each pixel was stored in a specific format. The pixel format was defined through the type of color channels (RGB: red color code / green color code / blue color code) where the color value ranges from zero to 255, e.g., pixel format values are RGB-008-008-008 and RGB-005-126-255. Then, it compared the source image with a target

image. Finally, it rendered 3D computer graphics through the screen of the iCreate application.

The steps of the construction and determination of the efficiency of iCreate application were illustrated in Figure 4-4.



1. Design the prototype of the iCreate application for learning vocabulary

2. Create the prototype of the iCreate application for learning vocabulary

3. Test and trial the prototype with experts

4. Modify the prototype

5. Conduct a small group testing

6. Revise for improvement

7. Conduct a field testing

8. Evaluate the iCreate application
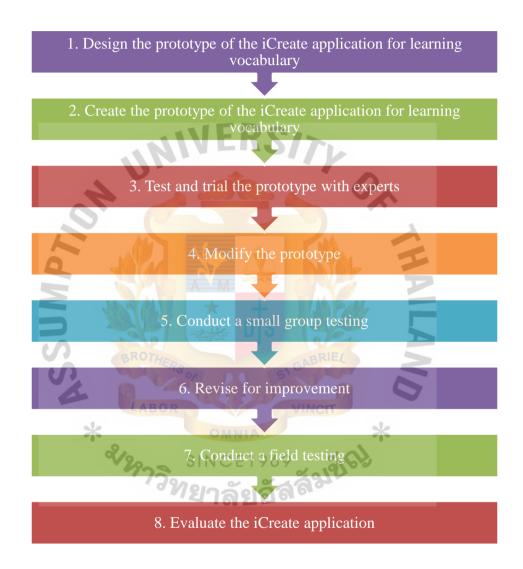
**Figure 4-4: Steps of conducting and evaluating the iCreate application**

From Figure 4-4, in order to determine whether the steps of conducting and evaluating of the iCreate followed its objectives as designed, the prototype testing by the selected experts was defined in the third step of the figure before the step of small group testing and the step of field testing.

## 4.3    Implementation of the iCreate application

At this stage, the researcher divided an application into smaller parts to make it easier for implementation. The researcher designed, organized, and structured the components of the application, including the decisions about the mobile device's hardware, software, and network environment. In this project, the researcher wrote Java code for the Android platform 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 the AR application. After testing, the researcher released an Android Package Kit (APK) to the Google Play Store.

The iCreate application contained four steps: prepare, paint, point, and "plearn" (a portmanteau of play and learn). First, the students prepared an AR marker coloring page and installed the application via the Google Play Store. Second, the user painted the coloring page. Then, the user pressed an icon shortcut of the iCreate application on mobile device, automatically initializing the device camera. Third, the user pointed the camera toward the animal picture template on the painting marker. Fourth, the user played and learned or "plearned" with the software that tracks the marker and visualizes the registered virtual 3D model. There are three different 3D models and AR marker coloring pages as shown in Figures 4-5, 4-6, 4-7, 4-8, and 4-9.

**Figure 4-5: 3D model of each painted paper**

**Figure 4-6: Graphic user interface (GUI) of the iCreate application**

**Figure 4-7: An example of an AR marker coloring page (zebra)**
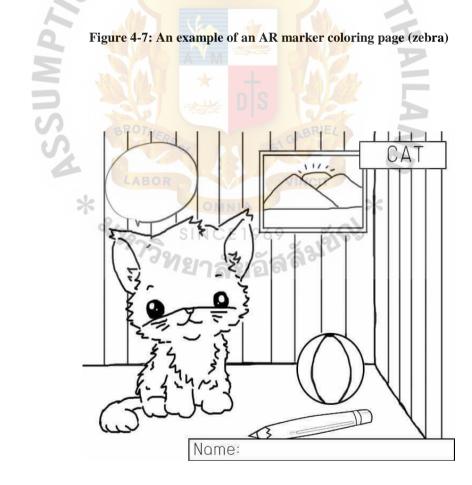


**Figure 4-8: An example of an AR marker coloring page (cat)**
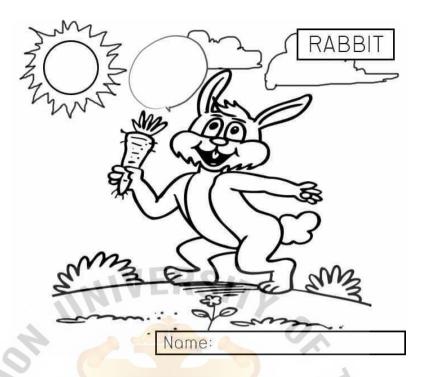
**Figure 4-9: An example of an AR marker coloring page (rabbit)**

## 4.4 Feedback from experts

After finishing the iCreate application implementation, we inquired individual experts' opinions on this application by questionnaire form. Those experts are researchers in computing or in the AR field. Our survey questionnaire form for evaluation was developed and based on Wilaiporn Chaiyaist's publication (Chaiyasit, Yananan, & Janu, 2015). The form in her publication was focused on a mobile learning application which was used as a guideline for the survey questionnaire. The questionnaire covered four aspects: (i) capability, (ii) system design, (iii) usability, and (iv) overall quality. The application evaluation process consisted of the three following sections.

### 4.4.1 Criteria of expert selection

Experts were defined as a new generation of those who graduated with a Ph.D. in the field of computers or other related areas. The experts need to meet a minimum strength qualification including a minimum of three years of full-time work experience

about application development. Moreover, the experts should have the specific knowledge about AR and user experience design.

### 4.4.2 Create a questionnaire

A questionnaire was created using the five Likert scale rating system (Vagias, 2006) in order to determine the appropriateness of the iCreate application. There were four questions in the questionnaire which aimed to grade the appropriateness of the capability, the design of the application, the usability, and the overall of application. A questionnaire form toward iCreate application for experts was shown in Appendix 4.

### 4.4.3 Explain the iCreate application to the experts

The iCreate application was presented to the experts. The individual experts rated each area of interest. Results of all aspects are shown in Table 4-1.

**Table 4-1: Result of evaluation by experts**

| Feature Lists | Evaluated by three experts | | | | | Meaning |
|---|---|---|---|---|---|---|
| | 1st Expert | 2nd Expert | 3rd Expert | $\bar{X}$ | SD | |
| (i) Capability | 5 | 4 | 5 | 4.67 | 0.47 | Excellent |
| (ii) System Design | 5 | 4 | 5 | 4.67 | 0.47 | Excellent |
| (iii) Usability | 5 | 5 | 5 | 5 | 0 | Excellent |
| (iv) Overall | 5 | 4 | 5 | 4.67 | 0.47 | Excellent |

Likert scale data where "1" means poor and "5" means excellent

The scale part of the Likert's five-rating scale (Vagias, 2006) comes from applying values to each of the answers: poor = 1.00 to 1.50, fair = 1.51 to 2.50, average = 2.51 to 3.50, good = 3.51 to 4.50, and excellent = 4.51 to 5.00.

Three experts are researchers in computing or in the AR field. The following experts were surveyed: Dr. Tanakorn Wichaiwong whose expertise is in the computer

technology field, Dr. Jartuwat Rajruangrabin from National Electronic Computer Technology Center, and finally, Dr. Wongyos Keardsri whose expertise is also in the computer technology field.

According to the results of the evaluation by the three experts, all aspects containing the capability, the design of the system, usability, and overall quality came out at an excellent level. The result of the overall experts' satisfaction levels reached an excellent level at 4.67 (SD = 0.47) with the developed iCreate application.


## 4.5 Product testing and small group trial

After finishing the evaluation by three experts, the researchers primarily evaluated the efficiency of the application by conducting a pilot testing prior to the statistical research on this application. The pilot testers of this application (1:5) were five fourth-grade elementary school students in the Sa Kaeo Province of Thailand. An English story about animals along with the vocabulary was written and illustrated for this application. The result showed that the five students spent time painting three pictures as shown in Figures 4-7, 4-8, and 4-9. It took 25.40 minutes, 25.20 minutes, and 27.00 minutes to paint a zebra, cat, and rabbit pictures, respectively.

The majority of time was spent on coloring the picture. The average time consumed by painting was approximately 77.40 minutes.

The researcher needed to solve the problem of an AR marker coloring page by downsizing a paper size from A4 to A5 in order to reduce a painting time and increase the efficiency of the application in order to improve the iCreate application performance as shown in Table 4-2.

**Table 4-2: Time of color painting**

| No. | Initial design for AR marker coloring page | | | Redesign of AR marker coloring page | | |
| | A4 (210 X 297 mm) | | | A5 (148 X 210 mm) | | |
| | Zebra | Cat | Rabbit | Zebra | Cat | Rabbit |
|---|---|---|---|---|---|---|
| 1st Student | 26 | 31 | 29 | 13 | 18 | 19 |
| 2nd Student | 23 | 20 | 23 | 17 | 15 | 15 |
| 3rd Student | 28 | 25 | 27 | 19 | 18 | 16 |
| 4th Student | 26 | 29 | 29 | 18 | 16 | 18 |
| 5th Student | 24 | 19 | 25 | 15 | 12 | 19 |
| x̄ | 25.40 | 25.20 | 26.40 | 16.40 | 16.20 | 17.40 |
| Total time | 77.40 minutes | | | 50.40 minutes | | |

From Table 4-2, the efficiency of time signifies a level of performance that describes a process that spends less time to create the most significant 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 Equation (1). It minimizes time spent.

$$Effciency \ of \ time \ ratio = \frac{\text{Total time\_old} - \text{Total time\_new}}{\text{Total time\_old}} * 100$$

(1)

$$Effciency \ of \ time \ ratio = \frac{77.40 - 50.40}{77.40} * 100 = 34.88\%$$

The experiment demonstrated the efficiency of time of the redesigned AR marker coloring page with a 34.88 per cent improvement in speed for our iCreate application.



(a) Zebra       (b) Cat       (c) Rabbit

**Figure 4-10: Actual painting result of pilot students**

## 4.6 Field Testing

The statistical research was conducted. The primary target group of this application was fourth-grade elementary school students in the Sa Kaeo Province of Thailand.

The population in this research is the fourth-grade students of Nangammittraphap School during the second semester of 2016. The samples are the aggregate of 50 students from rooms 4/1 and 4/2 who were purposefully selected as shown in Figure 4-10 and Figure 4-11. Our data collection procedure was followed as Figure 4-12.

**Figure 4-11: Target group of this application was fourth-grade students**



Target population

Selection of a sample group

Sample group

Pre-test

Informal learning with the iCreate application

Post test

Attitude appraisal of the iCreate application
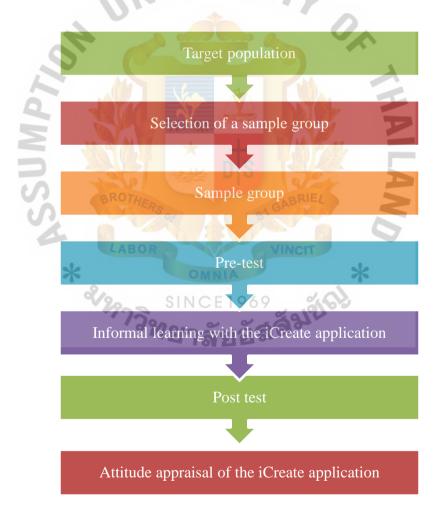
**Figure 4-12: Data collection procedure**

In summary, this research developed the augmented reality-based e-Learning for vocabulary on the mobile device. The researcher named this proposed application as the iCreate application. The researcher followed the Seven-Step Model for Prototype Development developed by Brahmawong (Vate-U-Lan & Brahmawong, 2009). This research and development were studied using a mixed method. The sample population was composed of 50 fourth-grade students from Nangammitraprap School, Sa Kaeo Province, Thailand. The selection method was non-probabilistic sampling that was selected based on characteristics of a population and the objective of the study. The data collecting instruments were a proposed augmented reality iCreate application on a mobile device for learning vocabulary, a pre-test and a post test for the lesson, and an attitude evaluation form. The collected data was analyzed using various statistical calculation methods: mean value, standard deviation, paired sample t-test, and independent samples t-test. The results of statistical analyses can indicate the effectiveness of the application.

In order to gain a better understanding of the effectiveness of AR iCreate mobile application, the statistical results from the evaluating the iCreate application will be described in the next chapter.

# CHAPTER V

# DATA ANALYSIS AND RESULTS

This chapter explains the results from the iCreate application for Thai rural students which followed the research questions: the feedback and recommendations from experts and users to refine a prototype of the iCreate application, the comparison results between pre-test and post test scores of students, the comparison results of post test scores between female and male the usage of the iCreate application, and the students' attitude appraisals of the iCreate application, respectively.

## 5.1   List of symbols and meanings of symbols

The symbols written in this research follows the statistical convention. Below describe the symbols and their meanings.

| | |
|---|---|
| $\bar{x}$ | Mean value |
| SD | Standard deviation |
| P-value | Significant difference in means |
| Sig. | Significances |
| * | There is significant difference in means at 0.05 (P<=0.05). |
| df | The number of independent sample of information that went into calculating the estimate (n-1) |
| N | Number of sample |

## 5.2    Descriptive data analysis of field testing

Demographic information of 50 students (eight- to eleven-year-old children) (28 males, 22 females) from Nangammittraphap School, an elementary school in Sa Kaeo Province, as shown in Table 5-1.

**Table 5-1: Classification based on different variables**

|  | Classification | n | Per cent |
|---|---|---|---|
| | Male | 28 | 56.0 |
| Gender | Female | 22 | 44.0 |
| | Total | 50 | 100.0 |
| | 8-9 years old | 26 | 52.0 |
| Age | 10-11 years old | 24 | 48.0 |
| | Total | 50 | 100.0 |
| | Room 4/1 | 24 | 48.0 |
| Class No. | Room 4/2 | 26 | 52.0 |
| | Total | 50 | 100.0 |

Table 5-1 shows that there were 28 males (56 per cent) and 22 females (44 per cent) among the students.  Table 4-3 also shows that about half of the students who participated in the study were ages 8-9 years old (52 per cent), followed by ages 10-11 years old (48 per cent).  Table 5-1 shows that about half of the students who participated in the study were a student of room 4/1 (48 per cent), followed by a student of room 4/2 (52 per cent).

## 5.3    Results of the hypotheses testing

According to section 2.10 of chapter II,  the research hypothesis of this study that can be tested are as follows:

(i)    There is a statistically significant difference in the students' pre-test and post test scores of students who studied with the iCreate application.

(ii)    There is a statistically significant difference of the students' post test scores between male and female students by the iCreate application.

(iii)    There is a statistically significant difference between the scores of attitudes toward the iCreate application by male and female students.

This research consisted of a pre-test and post test, which was collected by 50 students in order to study the test scores of those who studied with the iCreate application.  There are three hypothesis results found that:

(i)    There were significant differences between the students' scores on achievement tests before and after the treatment by the iCreate application.

(ii)    There were no significant differences of the students' scores on post tests between male and female students by iCreate application.

(iii)    There were no significant differences between the scores of attitude appraisals of the iCreate application by male and female students.

The results of three hypotheses tested are explained in sections 5.4, 5.5, and 5.6, respectively.

## 5.4   Comparison of pre-test and post test scores of students

The researcher wanted to test if the performance of a student had changed after treatment with the iCreate application by a paired sample t-test which compared the mean scores before and after the treatment as shown in Table 5-2.

**Table 5-2: Comparison of pre-test and post test scores**

| Testing Score | Treatment | n | $\bar{x}$ | SD | t | df | Sig. |
|---|---|---|---|---|---|---|---|
| 30 items to test | Pre-test (before) | 50 | 22.84 | 1.621 | -15.76 | 49 | *0.000** |
| | Post test (after) | 50 | 27.04 | 1.873 | | | |

\* Differed at a statistically significant level of 0.05 (P < 0.05)

The results found that the levels of students' scores on tests before and after treatment differed at a statistically significant level of 0.05 (P < 0.05).  Moreover, the levels of students' scores on achievement post test were significantly high.   As revealed, pre-test scores of all students $\bar{x} = 22.84$, SD = 1.621 and post test scores of all students $\bar{x} = 27.04$, SD = 1.873.

## 5.5　Comparison of post test scores between male and female students

**Table 5-3: Comparison of post test scores between male and female students**

| Gender | n | x̄ | SD | t | df | Sig |
|--------|-----|-------|-------|-------|-----|-------|
| Male | 28 | 27.29 | 1.487 | 1.047 | 48 | 0.300 |
| Female | 22 | 26.73 | 2.273 | | | |

* Differed at a statistically significant level of 0.05 (P < 0.05)

From Table 5-3, in response to post test scores between male and female students when using iCreate application indicated that:

Post test examination part, the level of students' scores on the post test between male and female student did not have a statistically significant difference. There were no significant differences between the students' scores on post tests between male and female students. Post test of male x̄ = 27.29, SD = 1.487 and post test of female x̄ = 26.73, SD = 2.273.

## 5.6 Scores of attitude appraisals of the iCreate application by students

There were five questions of attitude appraisal of iCreate application. Students who studied from this augmented application reported their attitudes as shown in Table 5-4.

Table 5-4: Mean score of attitude appraisals of the iCreate Application

| No. | Question of attitude | N | Min | Max | Mean | SD | Meaning |
|---|---|---|---|---|---|---|---|
| | Feedback findings | | | | | | |
| Q1 | I like the iCreate application. | 50 | 3 | 5 | 4.14 | 0.756 | Satisfied |
| Q2 | I feel exciting using the iCreate application. | 50 | 3 | 5 | 4.36 | 0.749 | Agree |
| Q3 | I feel happy using the iCreate application. | 50 | 3 | 5 | 4.14 | 0.756 | Agree |
| Q4 | I understand vocabulary from the iCreate application. | 50 | 3 | 5 | 4.28 | 0.701 | Agree |
| Q5 | I want to study with the iCreate application. | 50 | 3 | 5 | 4.12 | 0.746 | Agree |
| | Summary | 50 | 3 | 5 | 4.21 | 0.742 | Agree |

*Note   Q1      where "1" means very unsatisfied, and "5" means very satisfied

         Q2-Q5    where "1" means strongly disagree, and "5" means strongly agree

Table 5-4 summarizes the students' responses in the form of their opinions about the iCreate application. In response to the first question regarding the preference of the iCreate application when using it, a mean of 4.14 and SD of 0.756 indicated that almost

all users had a high level of satisfaction.

In response to the question of the excitement of the iCreate application when using it, a mean of 4.36 and SD of 0.749 indicated that the most users were excited to use it.

In response to the question of their happiness when using the iCreate app, a mean of 4.14 and SD of 0.756 indicated that the most users were happy to use it.

In response to the question of the vocabulary understanding when using the iCreate app, a mean of 4.28 and SD of 0.701 indicated that the most users saw an improvement of vocabulary understanding.

In response to the question of the need of the iCreate application, a mean of 4.12 and SD of 0.748 indicated that the most users were satisfied.

Overall respondents "plearned," or played while learned, from the iCreate application and had a high level of satisfaction.

Moreover, the researcher wanted to test if male and female groups differ in the scores of attitudes toward the iCreate application by independent sample t-test which calculates the means of the two groups separately (male and female) and compares them as shown in Table 5-5.

**Table 5-5: Comparison of attitudes toward the iCreate application between male and female students**

| Satisfaction questions | Gender | n | x̄ | SD | t | Sig (2 -tailed) |
|---|---|---|---|---|---|---|
| Q1: I like the iCreate application. | Male | 28 | 4.18 | 0.670 | 0.403 | 0.688 |
| | Female | 22 | 4.09 | 0.868 | | |
| Q2: I feel excited when using the iCreate application. | Male | 28 | 4.36 | 0.731 | -0.030 | 0.976 |
| | Female | 22 | 4.36 | 0.790 | | |
| Q3: I feel happy when using the iCreate application. | Male | 28 | 4.18 | 0.772 | 0.403 | 0.688 |
| | Female | 22 | 4.09 | 0.750 | | |
| Q4: I understand vocabulary when using the iCreate application. | Male | 28 | 4.25 | 0.645 | -0.338 | 0.737 |
| | Female | 22 | 4.32 | 0.780 | | |
| Q5: I want to study with the iCreate application. | Male | 28 | 4.07 | 0.663 | -0.500 | 0.620 |
| | Female | 22 | 4.18 | 0.853 | | |
| Total Q1-Q5 | Male | 28 | 4.20 | 0.589 | -0.011 | 0.992 |
| | Female | 22 | 4.21 | 0.707 | | |

* Differed at a statistically significant level of 0.05 (P < 0.05)

In response to the scores of attitude appraisals concerning the preferences of the iCreate application when using it, the results from male and female students did not differ. There were no significant differences between the scores of attitude appraisals of the iCreate application between male and female students. Attitude appraisal of male students $\bar{x} = 4.18$, SD = 0.670 and attitude appraisal of female students $\bar{x} = 4.09$, SD = 0.868.

In response to the scores of attitude appraisals of the excitement when using the iCreate application, the results between male and female students did not differ. There were no significant differences between the scores of attitude appraisals of the iCreate application between male and female students. Attitude appraisal of male students $\bar{x} = 4.36$, SD = 0.731 and attitude appraisal of female students $\bar{x} = 4.36$, SD = 0.790.

In response to the scores of attitude appraisals of the happiness when using the iCreate application, the results between male and female students did not differ. There were no significant differences between the scores of attitude appraisals of the iCreate application between male and female students. Attitude appraisal of male students $\bar{x} = 4.18$, SD = 0.772 and Attitude appraisal of female students $\bar{x} = 4.09$, SD = 0.750.

In response to the scores of attitude appraisals of the vocabulary understanding when using the iCreate application, the results of male and female students did not differ. There were no significant differences between the scores of attitude appraisals of the iCreate application between male and female students. Attitude appraisal of male students $\bar{x} = 4.25$, SD = 0.645 and attitude appraisal of female students $\bar{x} = 4.32$, SD = 0.780.

In response to the scores of attitude appraisals of the need to use the iCreate application, the results between male and female students did not differ. There were no

significant differences between the scores of attitude appraisals of the iCreate application between male and female students. Attitude appraisal of male students $\bar{x}$ = 4.07, SD = 0.663 and attitude appraisal of female students $\bar{x}$ = 4.18, SD = 0.853.

# CHAPTER VI

# CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

This chapter consists of four sections. The first section presents the summary of the study. The second section presents the major findings of the study, which are organized according to the three hypotheses proposed in Chapter II. In the third section, the discussions about the results are explained. Finally, the recommendations for future research to serve other demands of eLearning are proposed.

## 6.1    Summary of the study

This current research has fulfilled the main purpose of the study as to develop the iCreate application for the elementary students at Nangammittraphap School. This study had the following purposes:

Main Objective

    To develop the iCreate application for the elementary students at Nangammittraphap School, Sa Kaeo Province, Thailand

Specific Objectives

    (i)    To refine a prototype of the iCreate application based upon the feedback from experts and users

    (ii)    To compare pre-test and post test scores of students who studied with the iCreate application

    (iii)    To compare post test scores between female and male students who studied with iCreate application

    (iv)    To examine students' attitudes toward the iCreate application

This research presented an augmented reality-based mLearning, namely the iCreate application, on the mobile device. This application has aimed to be an edutainment material based on AR technology that elementary students or children could use for reading and learning English vocabulary better.

After finishing a prototype of the iCreate application, the researcher inquired for the experts' opinions on this application by a questionnaire form. It revealed that all aspects containing the capability, the design of the system, usability, and the overall score came out at an excellent level. The result of experts' satisfaction overall reached an excellent level at 4.67 (SD = 0.47).

Moreover, the result of the pilot experiment with five students before the trial run showed that a redesign of AR marker coloring page, which was scaled down from a paper size of A4 to A5, reduced the painting time from 77.40 minutes to 50.40 and increased the efficiency time spent with the iCreate application by 34.88 per cent.

After that, 50 students from the trial run were tested and evaluated in this research. This trial run of the developed application was divided into three parts. The first part of this trial run consisted of a pre-test which was collected by distributing the tests to 50 fourth-grade students at Nangammittraphap School. The second part consisted of a post test which was collected by distributing tests to the same 50 students who studied from this application. The result showed that the students' scores on tests before and after treatment differed at a statistically significant level of 0.05. The students' average score on pre-tests before studying was 22.84, SD = 1.621. The students' average score after treatment was 27.04, SD = 1.870. Moreover, the results from a post test found that there was no difference between the two genders. Finally, the third part consisted of the attitude appraisals of the iCreate application. (The average attitude of male students was 4.20, SD = 0.589, and the average attitude of female students was 4.21, SD = 0.707.) The analysis of attitude appraisals of indicated that there is no significant difference between the scores of attitudes toward the iCreate application between male and female students.

## 6.2 Major finding

This research proposed an iCreate project or a digital edutainment application with a digital content which was integrated as a 3D AR painting maker for English vocabulary learning and art activities. The iCreate is a mobile application using Java and the Vuforia library, developed using the Eclipse Integrated Development Environment (IDE) and trials performed with the elementary students. The treatment

results show that our proposed application as the iCreate application can display 3D animated models effectively in real time.

The research has been tested on one group of students. The treatment results were evaluated in terms of the paired sample t-test and independent t-test. The results of testing of the hypotheses showed that:

(i) There is a significant difference between the students' scores on achievement tests before and after treatment by the iCreate application.

(ii) There is no significant difference between the students' scores on post tests between male and female students by the iCreate application.

(iii) There is no significant difference between the scores of attitudes toward the iCreate application by male and female students.

The "new knowledge" reflected from the research results and these findings implied that the AR iCreate application enhanced the ability to learn English for the elementary students at Nangammitraprap School. The application improves students' ability to learn vocabulary. Combining informal learning (such as iCreate) with formal learning accelerates the elementary student's learning process as well as retaining his or her attention. The iCreate application is Thailand's first painting AR application for English vocabulary learning, which includes multimedia content into the color painting art for English vocabulary lessons.

"Academic progression" which proves the expertise of a researcher in the field of eLearning Methodology was that the iCreate application allows students to actively construct their own new experience based on painting with an AR marker coloring page and mapping between learning vocabulary and inspiring art. Responses from the participants in this research agreed that the iCreate application helped them to improve learning English vocabulary. In addition, they strongly preferred using iCreate alongside their English course in school. Participants expressed a desire for more iCreate integration with their English classes.

## 6.3 Discussion

### 6.3.1 To refine a prototype of the iCreate application

Refinement of iCreate greatly improved all aspects, including its capability, system design, and usability. The average scores for all aspects were excellent, and the application is fit for practical use. AR experts also reviewed this application as well. Results from the evaluation by three experts graded the overall appropriateness at 4.67 (SD = 0.47) on a 5.0 scale, which proves this iCreate application successfully achieved its development goals. Moreover, the feedback from users showed that students perceived the iCreate application to be more fun and useful. The iCreate application increased the students' motivations for learning English vocabulary. Our result corresponded with Wojciechowski and Cellary's research, which suggested that participants are most satisfied when studying informal learning with an AR mobile application (Wojciechowski & Cellary, 2013). Moreover, this current result corresponded with Cai's research, which suggested that AR was exciting and it could motivate students to learn (Cai et al., 2014).

### 6.3.2 To compare pre-test and post test scores of students

The results found that the levels of students' scores on tests before and after treatment differed at a statistically significant level of 0.05 (P < 0.05). Moreover, the levels of students' scores on achievement tests of post test were very high. The students' average score on pre-tests before the study was 22.84 with SD = 1.621. The students' average score after treatment was 27.04 with SD = 1.87. The mean difference of scores between pre-test and post test showed a clear improvement. The result indicated that the students did acquire new vocabulary after using iCreate. Analysis revealed that the performance of students increased significantly after informal learning with the iCreate application. This conclusion is in line with the research of Saekhow (2010). She said that students earned higher scores on the post tests when their interest is held by an excellent instructional media.

In addition, mLearning is affordable for schools in rural areas. The device can be used as a replacement for personal computers which are scarce in rural areas.

### 6.3.3 To compare post test scores between female and male students

Regarding the post test examination part, the levels of students' scores for the post test between male and female students did not differ. This could imply that the iCreate application is suitable for any gender because the coloring activity is universally enjoyed. Students can participate with the AR application and study the vocabulary at the same time on their own.

### 6.3.4 To examine students' attitude appraisals of the iCreate

Regarding students' attitude appraisals of iCreate for the learning activities, the students were excited, enthusiastic, attentive, positive, active, happy with the learning activities, and free to choose the content of learning. They also found it easy to use after studying. They can feel that the iCreate application is a flexible and encouraging edutainment tool for learning English vocabulary.

By observing the behavior of students, the researcher found that the students were eager to learn with graphics and multimedia. By allowing students to choose their own cartoons, colors, and music, they are more likely to enjoy learning with the iCreate application. iCreate supports personal learning preferences via a personal device. This educational tool understands the difference between students. Teachers were able to give advice to each student according to their competency. Students can learn by themselves anytime at any place, based on their preferences. This follows the constructivism idea. Human learns through the five senses of perception, including sight, hearing, smell, touch, and taste. Learning from the iCreate application engages the senses of perception through touch (painting by hand) as well as the ears and eyes via the screen of the mobile device and AR marker coloring page. The activities connected new knowledge and existing knowledge together. This connection led students to memorize and understand new vocabulary, corresponding to the constructivism theory.

### 6.4    Recommendation

### 6.4.1    Suggestions for improving research methodology

(i)    Due to this school is in a rural area, the researcher needs to prepare and provide more research instruments including smartphone device, color pencils for students.

(ii)    Small screens impair 3D visualization. The screen size should be larger than 5.5 inches in order to improve the learning experience.

(iii)    Students might lose their attention if their coloring time takes too much time. Therefore, the size of paper should not be too large. The researcher recommends the A5 paper size for this mLearning application.

(iv)    A variety of cartoon characters could improve a learner's satisfaction. The characters should include animals or modern cartoons characters, such as Doraemon, Sailor Moon, and Pikachu. The attractiveness of the cartoon also improves the involvement of the students.

### 6.4.2    Recommendations for future research

(i)    This study was conducted in one school in Sa Kaeo Province, Thailand. The future research should have tested the iCreate application with other schools or other provinces.

(ii)    In the future, the iCreate application should expand its functionality to cover online testing so that the student could do the test immediately after complete learning task within a certain amount of time.  The results should be reported with a grade or by a number of stars or badges.  There should be a pre-test and post test comparison feature.  For teachers, there should be a central system for reporting results, some optional configuration, and real-time usage monitoring.

(iii)    The iCreate application should support the iOS platform for those users who do not own an Android device.

(iv)    A future researcher should include both the quantitative and qualitative methods used to collect data from students, including pre-test and post test with the application as well as questionnaires for the teachers to evaluate the application's various aspects.

(v)　　The outcome of this research should be used to further the mLearning approach in helping and supporting the collaborative practice of English learning.

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**APPENDICES**

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# APPENDIX 1: Results statistics

1. Reliability analysis of the attitude appraisal (ten sample examinees)

**Case Processing Summary**

|       |                        | N  | %     |
|-------|------------------------|----|-------|
| Cases | Valid                  | 10 | 100.0 |
|       | Excluded[a]            | 0  | .0    |
|       | Total                  | 10 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | N of Question |
|------------------|---------------|
| .909             | 5             |

2. Attitude appraisals of iCreate (questions one through five)

**Statistics**

|      |         | Q1   | Q2   | Q3   | Q4   | Q5   | Sum     |
|------|---------|------|------|------|------|------|---------|
| N    | Valid   | 50   | 50   | 50   | 50   | 50   | 50      |
|      | Missing | 0    | 0    | 0    | 0    | 0    | 0       |
| Mean |         | 4.14 | 4.36 | 4.14 | 4.28 | 4.12 | 4.20800 |

## 3. Descriptive statistics

**Gender**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Male | 28 | 56.0 | 56.0 | 56.0 |
| | Female | 22 | 44.0 | 44.0 | 100.0 |
| | Total | 50 | 100.0 | 100.0 | |

**Age**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 8-9 Year old | 26 | 52.0 | 52.0 | 52.0 |
| | 10-11 Year old | 24 | 48.0 | 48.0 | 100.0 |
| | Total | 50 | 100.0 | 100.0 | |

**Classroom**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Room 4/1 | 24 | 48.0 | 48.0 | 48.0 |
| | Room 4/2 | 26 | 52.0 | 52.0 | 100.0 |
| | Total | 50 | 100.0 | 100.0 | |

## 4. Paired sample t-test (pre-test and post test)

‣ **T-Test**

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Before_Test | 22.84 | 50 | 1.621 | .229 |
| | After_Test | 27.04 | 50 | 1.873 | .265 |

**Paired Samples Correlations**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Before_Test & After_Test | 50 | .426 | .002 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | Before_Test - After_Test | -4.200 | 1.884 | .266 | -4.736 | -3.664 | -15.760 | 49 | .000 |

## 5. Independent sample t-test (post test scores between female and male subjects)

**T-Test**

**Group Statistics**

| | เพศ | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| After_Test | ชาย | 28 | 27.29 | 1.487 | .281 |
| | หญิง | 22 | 26.73 | 2.272 | .484 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| After_Test | Equal variances assumed | 8.311 | .006 | 1.047 | 48 | .300 | .558 | .533 | -.513 | 1.630 |
| | Equal variances not assumed | | | .997 | 34.484 | .326 | .558 | .560 | -.579 | 1.696 |
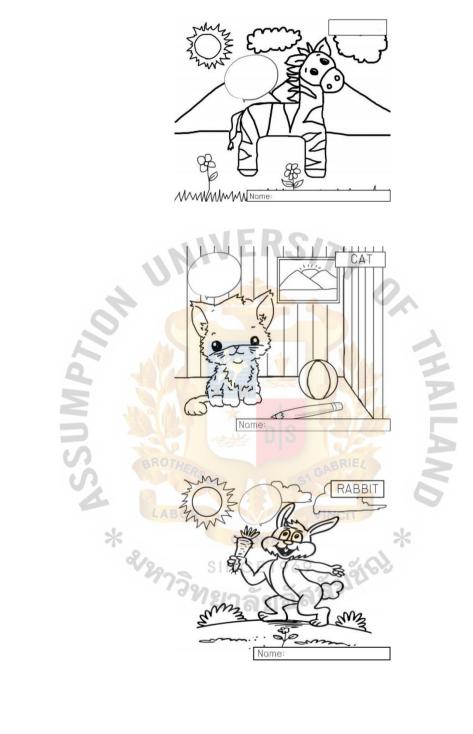
# APPENDIX 2: Pictures collection

1. Pictures
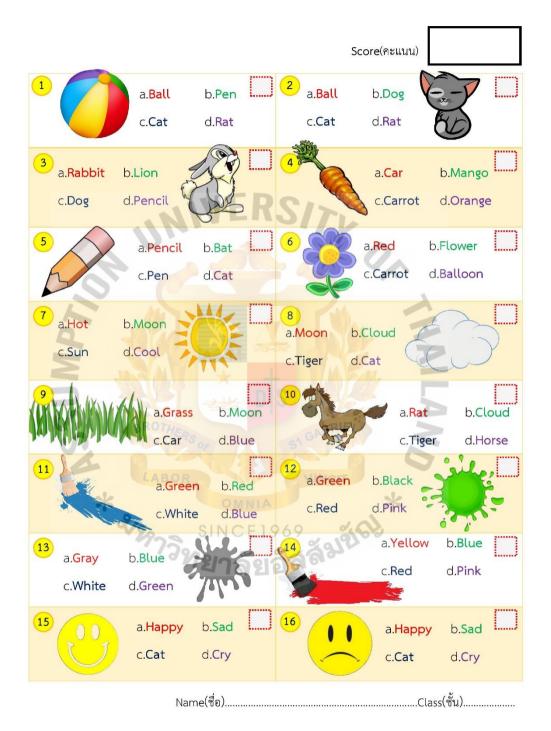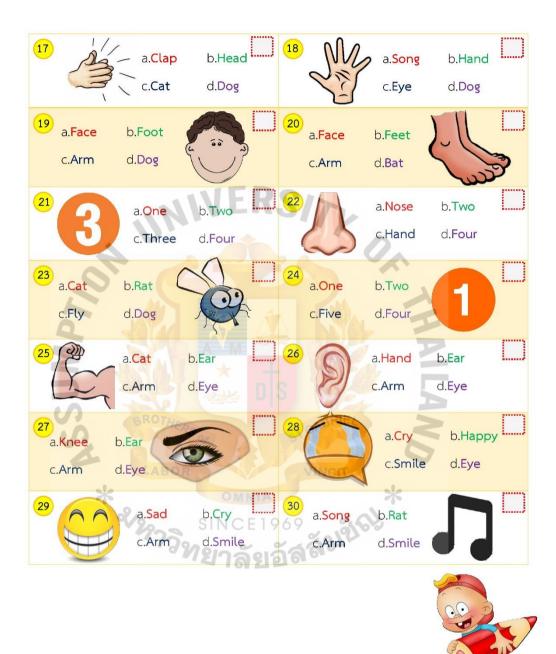
2. AR marker coloring pages

# APPENDIX 3: Pre-test and post test

1. Pre-test and post test

Score(คะแนน)

| 1 | a.Ball | b.Pen |
| c.Cat | d.Rat |

| 2 | a.Ball | b.Dog |
| c.Cat | d.Rat |

| 3 | a.Rabbit | b.Lion |
| c.Dog | d.Pencil |

| 4 | a.Car | b.Mango |
| c.Carrot | d.Orange |

| 5 | a.Pencil | b.Bat |
| c.Pen | d.Cat |

| 6 | a.Red | b.Flower |
| c.Carrot | d.Balloon |

| 7 | a.Hot | b.Moon |
| c.Sun | d.Cool |

| 8 | a.Moon | b.Cloud |
| c.Tiger | d.Cat |

| 9 | a.Grass | b.Moon |
| c.Car | d.Blue |

| 10 | a.Rat | b.Cloud |
| c.Tiger | d.Horse |

| 11 | a.Green | b.Red |
| c.White | d.Blue |

| 12 | a.Green | b.Black |
| c.Red | d.Pink |

| 13 | a.Gray | b.Blue |
| c.White | d.Green |

| 14 | a.Yellow | b.Blue |
| c.Red | d.Pink |

| 15 | a.Happy | b.Sad |
| c.Cat | d.Cry |

| 16 | a.Happy | b.Sad |
| c.Cat | d.Cry |

Name(ชื่อ)......................................................................Class(ชั้น)....................

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| 17 | a.Clap | b.Head | |
| | c.Cat | d.Dog | |

| 18 | a.Song | b.Hand | |
| | c.Eye | d.Dog | |

| 19 | a.Face | b.Foot | |
| | c.Arm | d.Dog | |

| 20 | a.Face | b.Feet | |
| | c.Arm | d.Bat | |

| 21 | a.One | b.Two | |
| | c.Three | d.Four | |

| 22 | a.Nose | b.Two | |
| | c.Hand | d.Four | |

| 23 | a.Cat | b.Rat | |
| | c.Fly | d.Dog | |

| 24 | a.One | b.Two | |
| | c.Five | d.Four | |

| 25 | a.Cat | b.Ear | |
| | c.Arm | d.Eye | |

| 26 | a.Hand | b.Ear | |
| | c.Arm | d.Eye | |

| 27 | a.Knee | b.Ear | |
| | c.Arm | d.Eye | |

| 28 | a.Cry | b.Happy | |
| | c.Smile | d.Eye | |

| 29 | a.Sad | b.Cry | |
| | c.Arm | d.Smile | |

| 30 | a.Song | b.Rat | |
| | c.Arm | d.Smile | |

# APPENDIX 4: Questionnaire toward iCreate application for experts

1. Questionnaire toward iCreate application for experts

   The iCreate application was presented to the experts. The individual experts rated each area of interest. Questionnaire for experts of all aspects are designed and shown in below form.

Experts' opinions toward the iCreate Application

Instruction: Please Check ✓ the number that the best represents your opinions or satisfaction towards iCreate application

| Feature Lists | Likert's five-rating scale | | | | | Recommendation |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| (v)  Capability | | | | | | |
| (vi) System Design | | | | | | |
| (vii) Usability | | | | | | |
| (viii)  Overall | | | | | | |

Likert scale data where "1" means poor and "5" means excellent

   The scale part of the Likert's five-rating scale (Vagias, 2006) comes from applying values to each of the answers: poor = 1.00 to 1.50, fair = 1.51 to 2.50, average = 2.51 to 3.50, good = 3.51 to 4.50, and excellent = 4.51 to 5.00.

# APPENDIX 5: Questionnaire toward iCreate application for students

1. Questionnaire toward iCreate application for students

Students' opinions toward the iCreate Application

Instruction: Please Check ✓ the number that the best represents your opinions or satisfaction towards iCreate application

| No. | Attitude appraisal | Score | | | | |
|-----|-------------------|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| Q1 | I like the iCreate application. | | | | | |
| Q2 | I feel excited using the iCreate application. | | | | | |
| Q3 | I feel happy using the iCreate application. | | | | | |
| Q4 | I understand the vocabulary from the iCreate application. | | | | | |
| Q5 | I want to study with the iCreate application. | | | | | |
| *Note | Q1 where "1" means very unsatisfied and "5" means very satisfied | | | | | |
| | Q2-Q5 where "1" means strongly disagree and "5" means strongly agree | | | | | |

# Doctor of Philosophy: Major in eLearning Methodology



## KITTI KOONSANIT

**Dissertation Title:**

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**Advisor**

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