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BOSTON UNIVERSITY

WHEELOCK COLLEGE OF EDUCATION & HUMAN DEVELOPMENT

Dissertation

EXAMINING THAI STUDENTS' EXPERIENCES OF AUGMENTED REALITY TECHNOLOGY IN A UNIVERSITY LANGUAGE EDUCATION CLASSROOM

by

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Doctor of Education

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For my parents and teachers

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EXAMINING THAI STUDENTS' EXPERIENCES OF AUGMENTED REALITY TECHNOLOGY IN A UNIVERSITY LANGUAGE EDUCATION CLASSROOM

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ABSTRACT

Descriptive mixed-methods were employed to investigate the experiences and perceptions of English as a Foreign Language (EFL) Thai students in higher education in integrating Augmented Reality technology (AR) in their reading classroom. Participants were queried on their habitual use of computers and the Internet, their perceptions of the advantages and disadvantages of AR, their experiences in using AR, and their reflective reports of self-efficacy in using AR in creating English vocabulary flashcards as supplemental learning resources. A questionnaire on their use of computers and the Internet was employed with 48 EFL, English-major undergraduates. Subsequently, the participants underwent the Classroom Activity Treatment which comprised 1) the Teacher Showcase, 2) the AR Computer Tutorial, and 3) the Student Showcase, respectively. Classroom observation notes were taken during the three phases. Besides, at the end of each of these three phases, a questionnaire on the acceptance and self-efficacy of AR was administered. Subsequently, 24 students participated in semi-structured interviews to elicit further insights into their perceptions of the effectiveness of AR in EFL instruction and learning. The Technology Acceptance Model 3 (Vankatesh & Bala, 2008) was employed for theoretical perspective on the data. Findings revealed most participants had no prior knowledge or understanding about AR before the study. Participants reported AR as advantageous for stimulating student engagement and motivation, and for enhancing memory and memorization. AR was reported to promote learning and practicing digital literacy skills. Participants reported relatively high levels of self-efficacy in using AR, which were primarily driven by their self-satisfaction, creativity and enthusiasm, peer and teacher assistance, as well as technological training and infrastructure. Participants also reported that they would continue using AR in the future when necessary resources, time, and access were secured, for the purposes of professional productivity and development. Analysis suggested that English education curricula be improved and re-designed to integrate the implementation of AR technology to tailor the learning experiences to the students' needs and learning styles. Professional development and training should also be provided for teachers and students to educate them in using AR in language education teaching and learning.

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CHAPTER ONE

INTRODUCTION

Introduction

This chapter presents an overview of the study, including the background and personal motivation for proposing it, the rationale for and purpose of the proposal, the problem statement and research questions, the potential significance of the study, and a brief description of the plan of inquiry for this dissertation proposal.

Background and Personal Motivation for the Study

Technologies have played an increasingly significant role in reshaping the current world across geographical, socio-economic and socio-cultural contexts in the globalized 21st century. In the realm of higher education, in particular, existing technologies and emerging innovations have had a major influence on both multimodal teaching and learning, as well as curricula modifications despite long-standing challenges. These challenges include, for example, the high cost of hardware and software and inconsistent empirical evidence of improved performances from the adoption of new technologies. In recent years, Augmented Reality (AR), one of the latest emerging technological advances, has entered the scholarly research domain and classrooms. At present, AR is gaining increased attention in both national and international contexts. The novel uses of AR can provide learners with a new channel for perceiving the real world in order to support and enhance ubiquitous learning in either formal or informal settings (Azuma, 1997).

The New Media Consortium's (NMC) Emerging Technology Initiative annually produces a Horizon Report to present educational technology possibilities that promise to have positive impacts in education. In 2010 and 2011, Horizon Report predicted that AR would be increasingly implemented in classrooms within five years: 2010-2016 (The New Media Consortium (NMC), 2015). More recently, the 2015 Horizon Report in Higher Education confirms that AR would come into widespread pedagogical use as one of the visualization technologies in the upcoming 2 to 5 years (The New Media Consortium (NMC), 2015).

This dissertation was also inspired by my personal experience working as a teaching assistant in an Education Lab (ED101), a required technology lab for education undergraduates in the School of Education at Boston University (prior to being renamed Wheelock College of Education and Human Development). In the course, students learned about how to integrate several emerging educational technologies into various K-12 (kindergarten to Grade 12) subjects and at different levels of student proficiency. Students also had the opportunity to discuss advantages and disadvantages of the tools, and to investigate how to align the benefits of the tools with ISTE Standards for Teachers and Students (ISTE Standards for Teachers, 2016; ISTE Standards for Students, 2016). Among other contemporary technological innovations in education, AR attracted my attention in particular because it harnesses and integrates the power of computing and Internet resources into real life experiences to attempt combine the best of both worlds, and it is being increasingly experimented with in both K-12 schools and universities. However, the body of research in the field of AR is still limited, and my research can contribute to better understanding the field of AR in language education classroom settings. In the 21st century it is important for students and teachers to be equipped with technological and pedagogical knowledge so that they can incorporate technologies for enhancing their digital literacy skills appropriately and effectively. Therefore, I have proposed to conduct a study investigating how learners in higher education in Thailand, my home country, perceive the use and usefulness of AR technology and what their levels of self-efficacy are realized in utilizing it. Contributing to a better understanding of how AR may benefit education can improve instructional design and redesign so as to incorporate this emerging platform more effectively.

Purpose of the Study

The key aims of this study are twofold: (1) to examine the learners' perceptions and acceptance of the use of AR technology in language classrooms. This includes how they perceived its usefulness in regard to affordances or advantages and constraints or disadvantages, and with regard to its perceived ease of use. Moreover, this research explored the learners' surrounding self-efficacy in participating in AR-enhanced language learning activities; and discovered how and to what extent the AR technology was pedagogically integrated into language learning in a formal higher education setting. This study shed light on promising areas for materials development and instructional design and redesign in which the AR technology was used as supplementary teaching and/or learning resources. Overall, the empirical data on learners' experiences in using the AR technology could contribute to an understanding of how language education may be enhanced through the implementation of the technology.

Statement of the Problem

AR technology can be said to still be in its infancy, yet it has already been experimented with in the education domain. Its future in education seems promising; its classroom integration is advancing so rapidly that more educational research studies have begun to shift attention to investigate its educational usefulness, effectiveness, and applicability for instructional design and pedagogical practices for improving learning performances.

The problem investigated in this dissertation centers on the learners' experiences and perceptions of the use of AR technology in a Thai higher-education environment. Specifically, the questions of how and to what extent Thai learners perceive such technology as supplementary learning materials were examined in depth. It was advantageous to understand how learners perceive the benefits and the drawbacks of integrating this emerging technology, and to gain understanding of students' attitudes and related self-efficacy toward the technology. The results provided insights into the learners' reported affordances and constraints in the integration of AR for their learning purposes.

Ultimately, we hoped that understanding the learners' successful practices and emerging struggles in technology adoption will contribute to the field of educational technology. This could be accomplished by creating more effective technology-mediated classrooms, enriched teaching and learning materials and resources, as well as improved AR-enhanced curriculum redesign.

Research Questions

The research questions were:

1. What were participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities as implemented in their classrooms?

2. After completing the activities, what level of self-efficacy did participating Thai undergraduates experience in using augmented reality technology?

3. After completing the activities, what were participating Thai undergraduates' intentions for using augmented reality technology in their future learning?

Significance of the Study

This study examined higher education Thai learners' perceptions about and acceptance of AR technology in a classroom setting, as well as their self-efficacy in the use of the technology. In-depth understanding of the participants' experiences in which they have hands-on use will help teachers and educators to gain better understanding of the educational affordances and constraints of the AR technology in higher education settings in particular and to plan for the future based on the insights of this dissertation. The potential implications of this study are:

• Participating Thai learners' self-reports of their experiences in using the AR-enhanced, classroom-based learning activities, demonstrate to what extent such technology was generally perceived as useful in a higher education context of English as a Foreign Language in Thailand.

• Participant reports of affordances and constraints as well as the ease of use of

AR technology while participating in AR-enhanced learning activities can be useful in tailoring appropriate needs-based teaching and learning environments, in promoting a new range of ideas for materials development and instructional design to improve their use of technologies for pedagogical purposes.

• Participating Thai learners' self-reported perceptions of and self-efficacy of the use of the AR technology could inform policy decisions on redesigning the curriculum and support staff to more effectively integrate technology for the purposes of instruction and classroom management.

• Participating Thai learners may learn from their peers who, as one part of their participation in this research, reflected and reported their experiences of success or failure at using the AR technology in the classrooms. They may find collaboration with peers as part of a healthy learning experience in which technologies are integrated in classroom activities.

Plan of Inquiry

The research questions were investigated through a mixed-methods descriptive study. This approach provided an inquiry method to obtain in-depth understanding of Thai learners' experiences in a specific context (Creswell, 2014). In particular, the aim was to investigate participants' self-perceived usefulness of the AR technology in a classroom setting, how they actually participated in AR-enhanced learning activities in the language classroom, and what their levels of self-efficacy were when using such technology.

Participants were recruited purposefully to obtain a group of 48 undergraduates at the Faculty of Liberal Arts, Mahidol University, Thailand, who were enrolled in the course Analytical Reading, one of the required English as a Foreign Language (EFL) courses for English-major students. The Analytical Reading course took place in Fall 2017 in August, 2017. At the beginning of the course, the consenting participants attended an orientation in which they learned about the fundamentals of AR technology in education, and in which they were informed about this research scope and procedures. After that, they were asked to provide written consent whether to participate in the study.

In the following weeks, a questionnaire on computer and the Internet use were administered with the consented participants. This questionnaire sought personal information about demographics and habitual use of computers and the Internet of the participants. Also, it allowed the participants to provide a brief account of their pre-existing knowledge/understanding about AR technology, if any. Later, a classroom AR activities treatment was implemented in a classroom. This treatment consisted of three different phases: 1) a teacher showcase, 2) an AR tutorial class, and 3) a student showcase. The participants took part in completing the activities in the treatment either in pairs or in groups. These activities had been pre-designed and pre-made through a continuing collaboration between the researcher and the designated teacher of the course. Classroom observation was also conducted to investigate the participants' behaviors and any classroom circumstances surrounding the AR activities. After each phase of the activities, a questionnaire on AR acceptance and self-efficacy was distributed to ask participants about their direct experiences in using the AR technology in a language classroom. Questions requested their reports of their overall perceptions of the usefulness and ease of use of the technology, what their intentions to use it were, and how they rated their self-efficacy toward the integration of the AR technology in language classrooms.

Subsequently, at the end of Phase 3 (a student showcase) 24 consented interview volunteers agreed to participate in a follow-up interview. In a Skype-based semi-structured interview, the interviewees were asked further questions regarding their practical AR experience participation and specifically, what they individually perceived as advantages and disadvantages of AR technology, and their level of self-efficacy in using it.

In addition, three months after the interview, 18 out of 48 participants provided retrospective insights on an online questionnaire on their existing knowledge/ understanding about AR technology. This questionnaire was the part of the questionnaire on computer and the Internet use that had been previously administered at the beginning of the research. The data obtained from the classroom observations, questionnaires, and interviews were triangulated and analyzed for useful findings and discussion.

CHAPTER TWO

LITERATURE REVIEW

Introduction

To convey the potential of Augmented Reality (AR) in higher education, this chapter provides an overview of AR in the higher education system. The chapter also presents current definitions of AR, alongside types of AR applications that are currently being used in classroom settings. Arguments for and against the potential uses and efficiencies of AR are presented, in addition to an explanation of how this new technology aligns with some existing learning theories and approaches. These ideas are analyzed and discussed to shed light on both the instructional and learning applicability of AR in higher education. Finally, a review of a conceptual framework for studying users' technology acceptance is provided.

Overview of Augmented Reality

Definitions

Definitions of AR vary across computer sciences and educational technology domains vary from the conceptual to practical, how-to implementation. To gain a better understanding of AR in education, viewing AR conceptually rather than as a particular type of technological tool or device was adopted because it offered a more comprehensive perspective for educators and researchers alike to gain a better understanding of AR in education. This is because AR could be applied to and implemented on a wide range of devices, such as desktop computers, smartphones, tablets (e.g. iPads), and other head-mounted displays/devices (Liu, 2009). Ludwig and Reimann (2005) defined AR as "human-computer interaction, which adds virtual objects to real senses" (p. 4). In a simpler sense, AR could be described as a situation or an experience in which a wide range of technologies project digital sensory input such as texts, images, videos, audios or three-dimensional components onto real-world environments. This augmented experience gives users immersive perceptions through various types of technological devices (Yuen, Yaoyuneyong, & Johnson, 2011; Billinghurst, Kato, & Poupyrev, 2001; Milgram & Kishino, 1994; Azuma, 1997). AR technology superimposes interactive, computer-generated visuals and other multimedia elements onto real-life surroundings, allowing simultaneous viewing and interacting between the virtual and real objects in attempt to enhance users' perceptive experiences (Dunleavy, Dede, & Mitchell, 2009). This process of seamlessly overlaying and combining virtual data with real-world, context-sensitive, and simulated data maximizes users' access to richer and more meaningful learning content that is contextually relevant (Billinghurst et al., 2001; Klopfer & Squire, 2008). Azuma (1997) also proposes three major defining characteristics of AR. Firstly, AR should have a combination of both real-world and virtual elements. Secondly, AR is interactive and processed in real time. Lastly, AR should exist in a three-dimensional format.

Differences between Augmented Reality (AR) and Virtual Reality (VR)

Milgram and Kishino's (1994) continuum of Mixed Reality is useful to better understand the differences between AR and VR (See Figure 1). Mixed Reality (MR) refers to the convergence of real and virtual worlds. The resulting products are four types of new environment visualizations in which physical and digital components co-exist and interact in real time (Milgram & Kishino, 1994). That is, on one extreme, it is the real environment and at the other end of the continuum, it is an entirely virtual environment. The grey area in between is reserved for two other types of augmented environments: Augmented Reality (AR), described as a real world environment with superimposed digital input, and Augmented Virtuality (AV), described as a virtual world with superimposed real world input.

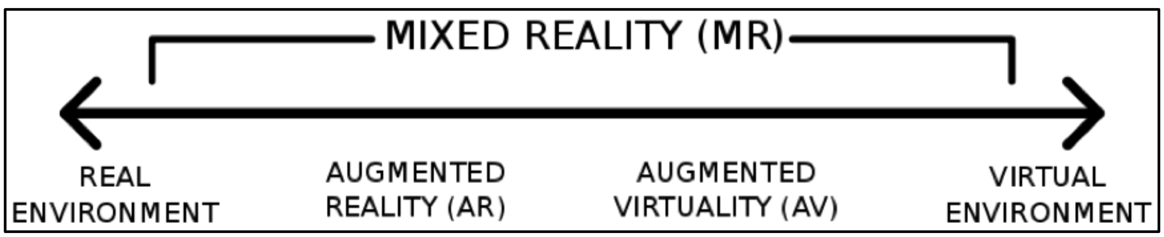


Figure 1.1 Mixed Reality (MR) continuum (Milgram and Kishino, 1994)

As illustrated in Figure 1.1 above, AR is closer to the Real Environment (RE) than to the virtual environment or VR. While VR technologies "completely immerse a user inside a synthetic environment" (Kipper & Rampolla, 2013, p. 1), AR environments are real yet enhanced by virtual input and imagery. That is, AR allows users to see the real world with virtual elements composited with or superimposed upon it, bridging the gap between the two worlds (Chang, Morreale, & Medicherla, 2010).

One of the best-known examples of VR is Second Life, a three-dimensional virtual world developed by Linden Lab. The technical architecture of Second Life is purely digital, whereas commercial gaming consoles, such as Nintendo Wii, PlayStation, and Xbox360 are well known examples of AR because the users' movements control computer-created avatars in the virtual environment (Yuen et al., 2011).

Technical Components and Types of Augmented Reality

AR systems could be enabled and viewed through several kinds of technological devices across different operating system platforms. Nevertheless, fundamental hardware requirements of an AR operational system include at least a video camera and a computer display (Azuma, 1997; Billinghurst et al., 2001). Johnson et al. (2011) added that more efficient AR experiences could be achieved by the implementation of GPS technology, image recognition software, computer speakers and sound systems, Internet access, and intuitive computer interfaces. Thus, there are many options for bringing computing resources to real experiences in an AR configuration.

Another important element for AR implementation is a marker. Markers are "physical objects or places where the real and virtual environments are fused together" (Kipper and Rambolla, 2003, p. 5). It is what the computer or device identifies as a location on which digital input is to be superimposed. Also, with advanced mobile technologies in the present day, AR utilization has become even more efficient and easier as the aforementioned components are usually features included on newly launched models of smartphones, wearables, and tablets.

In regard to types of AR, especially for education, Dunleavy and Dede (2014) and Johnson et al. (2011) similarly specified two predominant modes of gathering information in AR systems that are widely used among teachers and educators. These modes are 1) position-based or 'Markerless AR', and 2) vision-based or 'Marker-based

AR.’ Marker-based AR utilizes some type of images, such as a Quick Response (QR) or two-dimensional codes as markers to produce a resulting visualization when sensed or scanned by cameras or smartphones. These visual codes would then be interpreted by software or a mobile application that brings up information in response. Markerless AR, in contrast, uses location-based data from, for example, a mobile device’s Global Positioning System (GPS) to interpret AR data (Dartmouth College Library Research Guides, n.d.). In Markerless AR, the technology responds to the actual environmental location whereas in markered AR, codes or images are placed in a real environment and trigger a prepared response when seen by the technology.

Nonetheless, both Marker-based and Markerless AR require specific AR software or applications to function. While Marker-based AR has been well received by some early AR users because it does not require too many and too expensive resources, at present, Markerless AR has become widely adopted significantly due to improved GPS accuracy and Internet bandwidth capacity in modern mobile devices.

Applications of Augmented Reality in Various Fields

Juniper Research (2014) calculated that by 2015 the annual revenues from mobile AR services and applications would reach $1.2 billion. Moreover, they reported that mobile games, which accounted for more than 40% of AR downloads in 2013, would continue to earn the largest market revenue in the future, while AR has been increasingly used within mainstream lifestyles and entertainment (Juniper Research, 2014). An increasing number of researchers have pursued and adopted AR because it allows not only users’ enhancement of visualization and perceptions of the world, but also the productivity in disparate daily-life tasks (Billinghurst & Henrysson, 2009). Benefits of AR are emerging in several fields including advertising and marketing, architecture, medical science, manufacturing, healthcare, and education, for example. The next section describes some of these applications to present a more detailed picture of how early adopters of AR are implementing it.

Advertising and Marketing

Companies seeking engaging marketing solutions to attract customers' attention would find AR very useful in that it could manipulate customers' viewing experience of particular products in an unprecedented way. For instance, automotive campaigns have already displayed full-size AR-enhanced virtual cars on top of an advertising brochure (Yuen et al., 2011). In 2014, L'Oreal Paris also developed and launched a smartphone and tablet application called Makeup Genius that allowed users to have virtual makeup and beauty-style trials by using the front-facing camera of their computers to launch an AR experience (TechAcute, 2014)

Architecture

In architecture, AR applications also allow users to be immersed in a walk-through virtual experience of under-construction facilities or three-dimensional models of planned buildings. Computer-generated visual representations of a structure could be projected onto or superimposed on real-life local views of a property even before actual construction takes place (Yuen et al., 2011; Behzadan, 2008). An AR sample mobile application, Trimble SketchUp Scan, is a software that enables users to create three-dimensional models of rooms by using a scanning process (Engineering.com, 2016). This mobile application makes it possible to construct dimensionally correct computer models of existing offices or apartment interiors by scanning the real spaces.

Medical Science and Healthcare

Samset, et al. (2008) stated that AR technology enhances medical surgical and clinical procedures by improving cost effectiveness, increasing health safety, and advancing overall medical efficiency. AR-mediated technology has potential to support physicians and surgeons in the holographical visualization of patients' internal anatomy and in streaming data to create superimposed images for further diagnosis. A recent research study at Worcester Polytechnic Institute experimented with AR technology by using a two-dimensional AR image overlay device to guide needle insertion procedures during a joint arthrography (Worcester Polytechnic Institute Automation and Interventional Medicine Laboratory, 2015). Another example for a personal healthcare benefit is the mobile application called EyeDecide developed by OrcaMD. EyeDecide initially enables patients to use the camera display for simulating the impact of specific eye conditions, such as dry eyes, floaters, and cataracts, on their vision. The application would describe each eye condition from which a patient is suffering, and initial symptom diagnosis would be provided alongside treatment recommendations and even further medical appointment suggestions with specialists (MedicalFuturist.com, 2016)

Education

AR technology and applications have potential for all fields where information technology and rapid information exchange are indispensable. Apart from the aforementioned examples, cutting-edge AR progress has also been increasingly employed in other prominent domains such as the military, tourism, entertainment, sports, and particularly, education (Yuen et al., 2011; Azuma, 1997; Johnson et al., 2011).

Although AR research and development has been driven by the needs in business-related enterprises rather than sectors involving in education, and no particular agenda for AR technology has yet been made for educational purposes, academics and researchers have continued to seek applicable ways to use such technology in education and professional training. Given the functionality of AR that makes user interfaces more intuitive and that makes the teaching of abstract concepts, such as those in science education, become easier, researchers are quite positive that AR has potential implications for the augmentation of many teaching and learning environments (Billinghurst et al., 2001).

Two examples of AR applications in education are AR books and Element4D by DAQRI. AR books could be said to be an early “stepping stone helping the public bridge the gap between the digital and physical world” by the use of AR (Yuen et al., 2011, p. 127). In 2012, Tokyo Shoseki, a Japanese publish company, for example, launched textbooks with AR-enhanced content to the market. The textbooks were part of an English course called New Horizon and intended for adult learners. The users could download a mobile application and scan the AR content in the textbooks to access interactive, cartoonish presentations that aid English conversational proficiency (ZDNet, 2012). Similarly, the Institute for the Promotion of Teaching Science and Technology in Thailand developed a 3D AR geology textbook that helps to teach students about the earth's layers and basic geology (Yuen et al., 2011; LearnGearTech, n.d.).

With the AR interface technology, abstract or difficult concepts that are not easily conveyed in classrooms could be brought to life with interactive, multimedia content that may be more engaging for learners.

Element4D developed by DAQRI is another example of AR in education. Element4D is an educational AR application that offers a new, fun way for students to learn about chemistry (DAQRI, n.d.). Teachers can download and print paper blocks of chemical elements to create several paper cubes. Each face on a cube depicts a different chemical symbol representing the chemical elements of the Periodic Table. Students then use an Element4D mobile application to scan the cubes to see virtual representations of chemical reactions which will appear on the different faces of the cube. They could also predict the formula and appearances of compounds made by combining different chemical elements. This allows students to have a hands-on learning opportunity to conduct a virtual lab experiment that might be difficult or inconvenient in real classrooms with limited resources.

Tools/Programs for Augmented Reality Applications

The uses of AR technology are promising and various applications in diverse fields are made possible by revolutionized capabilities of software and hardware. Currently, there are a number of tools, devices, and mobile applications as well as freeware software options that are available for educators who wish to experiment with AR in order to create a new array of AR-enhanced materials and learning environments. Therefore, it is useful to describe some of the tools or companies that have already had an impact on AR evolution. These developers include Aurasma, Layar, Wikitude, and Plickers.

Aurasma (www.aurasma.com)

Aurasma is now Hewlett Packard's AR visual browsing platform. Generally, Aurasma's AR image recognition technology uses smartphones or tablets' camera to recognize printed images and then overlay virtual media on top in the forms of 2D and 3D animations and models, videos, and webpages. Aurasma empowers mobile devices to recognize over 500,000 real objects, including print, product packaging, and physical places by using cameras, GPS, Bluetooth, or WiFi Internet (PRNewswire, 2015). In his video, Paul Hamilton (Hamilton, 2012) gave an example in which he discussed the use of Aurasma in teaching mathematics, particularly in calculating areas of squares, rectangles, and triangles. He created printed, teaching materials along with Aurasma AR content. Then the students were taught fundamental concepts of area calculations and were asked to use Aurasma application to access the AR content that allowed them to find math solutions. This example depicts an applied pedagogical practice in classrooms that matches the learning goals and objectives. Another interesting educational example by Aurasma is the activity called "*Then & Now—We've Always Read*" by Carol Thompson (Thompson, 2015). In the activity, she made a library exhibit board on which several school teachers' pictures of their childhood were posted. The students then were asked to use the Arusma App to scan those pictures to know who that teacher actually was and what his/her favorite book was. The premise behind this activity was twofold. First, it engaged students with technology. Second, it encouraged students' reading as after the activity, some of the "antiquated books were checked out after being suggested by one of the teachers on the wall" (Thompson, 2015, p. 39).

Layar (www.layar.com)

Layar is another early AR company established in Netherlands in the summer of 2009. It quickly gained international reputation as one of the very first mobile AR browsers in the market, attracting a number of software developers and end users to create millions of AR content that is viewable via the Layar App for iOS and Android operating systems. Layar's AR platforms in producing interactive print has changed the ways people discover and interact with useful and educational information. Users could create AR content with a variety of easy-to-use drag-and-drop features of the web-based Layar Creator. They can also use the free Layar App to scan the pages of the Layar-enhanced printed text to immerse themselves in AR content that include videos, social media links, texts, and other digitally customized elements. Recently, the Reading & Writing Foundation (RWF), an organization based in the Netherlands, has used Layar Creator to make use of AR in its communications with the public in order to "raise awareness of the importance of public libraries as modern learning hubs" (Layar, 2015). Layar's Sponsored Pages Program also provides Layar Creator credits to educators, students, charities and other groups as it is aimed at helping foster the AR implementation growth in the global community including the educational community.

Wikitude (www.wikitude.com)

Wikitude Studio is an AR web-based content creating tool designed for users without prior computer programming skills. Wikitude Studio allows technology enthusiasts to produce their own AR projects and publish them in the Wikitude App within minutes. Basic features of Wikitude are multimedia drag-and-drop functions, cloud recognition (a service allowing users to work with thousands of marker images hosted in the cloud), and extensive multi-platform functions that allow Wikitude content to be accessible across operating systems, such as iOS and Android. Furthermore, Wikitude founded Wikitude Academy, an online dedicated space for sharing and exhancing knowledge about AR among academics and researchers. They are welcome to attend free webinars, apply for an educational license, and see what universities and students around the world are creating with Wikitude Studio in an academic context. Wikitude Studio is frequently used in tourism and language education by encouraging users to practice their language skills outside classrooms and to share information with other learners and the community. An example to suggest that this is effectively employed is LearnAR, an AR travel talking phrasebook. It was developed by Wikitude in collaboration with BBC Active and Pearson (Wikitude, 2012). It allowed traveler users to scan specific locations to reveal hidden AR content, such as suggested dining places and tourist attractions in the area. It also provided a resource for important phrases in a local language.

Plickers (www.plickers.com)

Plickers is QR-based, in other words a “marker-based” AR, student response system that “collects real-time formative assessment data without the need for student devices” (Plickers, 2016). Plickers uses a teacher's mobile devices or tablets, either iOS or Android, in conjunction with a series of QR markers to create a student response system to use in classrooms in which students do not have laptops or tablets. Teachers could utilize Plickers to poll students or to allow them to answer multiple-choice or true-false questions for instant feedback. Each student is given a unique and individually assigned QR marker card, each of which has 4 sides that are lettered A, B, C, and D. Once asked a question, a student holds the card so that the letter he/she chooses to answer the question is at the top of the card. Teachers then use the iOS or Android Plickers application on their devices to slowly scan the room where all students raise their cards. AR triggers on each particular QR marker card would be captured, and the students’ answers would be recorded and shown on the teachers’ devices.

One of the major affordances of Plickers is that it is simple to use and intuitive. Students do not have to own any technological device to use Plickers. A teacher, however, will have to have one device to scan QR markers to collect assessment data. This low requirement of resources enables increasing use of Plickers in classrooms, compared to other electronic student response systems. Plickers is also a good example to show that the AR technology does not only support learning but also classroom assessment.

Arguments for the Uses of Augmented Reality in Higher Education

Although AR technologies are considered an emerging technological trend that has had limited use in higher education to date, some proponents have examined its uses and influence in teaching and learning (for example Yuen et al., 2011; Azuma, 1997; Johnson et al., 2011; Billinghurst et al., 2011). The next section presents an analysis of AR educational affordances drawn from these authors that include AR effectiveness to promote various learning approaches, to promote authenticity of learning, to promote the 21st Century Skills and Digital Literacy, and to promote motivation and engagement among learners.

Promoting Different Approaches of Learning and Training

Situated Learning. Dunleavy et al. (2009) discussed the possible connection between situated learning theory and augmented reality in the activity called Alien Contact!. The activity, whose learning goals were based on Massachusetts State Standards to foster multiple higher order thinking skills, was a location-based, AR-enhanced game that required several players with different roles in the same team to accomplish the assigned tasks. The roles were a chemist, a cryptologist, a computer hacker, and an FBI agent. The students had to use handheld devices to play the game. The objective of the game was to discover the reasons why aliens had come to earth and landed in a particular site. The students were facilitated and guided by the teacher and AR content to form hypotheses by collecting evidence from various designated locations. In completing the task, they used the knowledge of mathematics, science, language arts skills coupled with interactions with avatar characters in the game (Yuen et al., 2011;

Dunleavy et al., 2009).

Based on situated learning (Lave & Wenger, 1991; Brown, Collins, & Duguid, 1989), learning usually takes place in a well-designed, particular contextual environment in which learners and their peers interact and exchange ideas in engaging, constructive and collaborative ways, with facilitation by the teachers. That is, an authentic context is crucial for learning to occur, and successful communication takes place in a socially meaningful context. Vygotsky's socio-constructivism (Vygotsky, 1978) claimed that humans interact with each other in a social context and build knowledge based upon scaffolding their pre-existing knowledge, while task-based and problem-based approaches (Ellis, 2003) emphasizes the role of a teacher to provide a contextually meaningful task set with clear objectives for the students to complete as a group. Knowledge in this view is constructed based on the real-life context and culture, drawn by case analysis. The learning context consists of various conditions or circumstances in the learning activity, such as instructions, common themes, and the setting of interaction, all of which are formed around a particular subject that needs problem-solving skills.

In addition, the assignment of different roles aligns with Johnson & Johnson's (1999) proposed cooperative learning model that constitutes five criteria: 1) positive interdependence, 2) individual accountability, 3) promotive interaction, 4) group processing and 5) development of small group interpersonal skills. In combining or integrating these elements, AR environments could render enriched cooperative learning experiences where learners have opportunities to think critically, synthesize independently, collaborative actively and make choices or decisions as a group.

Constructivist Learning. AR learning activities could be considered educationally useful by a study carried out by Lakarnchua and Reineders (2014). They investigated how a group of Thai university students improved English skills and motivation after completing a campus tour task that was created with Wikitude's AR content. In this discover-based learning task, 34 students from the Faculty of Engineering were assigned to create a virtual interactive map of their faculty facilities for future visitors, conference attendees, or visiting lecturers. Prior to the beginning of the task, the students attended an introductory session to learn about Wikitude Studio. Then they were assigned to complete two activities. First, they created an AR-enhanced campus tour using prompts about five pre-determined sites around their faculty, some familiar and some relatively unknown to them. This was to encourage them to draw their personal background knowledge and stimulate curiosity and use of information-gathering strategies. Second, they had to take a tour created by their classmates and answer AR-generated questions about the sites. The results were that the students were reported to show high enthusiasm and the activity was "highly encouraging" (Lakarnchua & Reinders, 2014, p. 45). Student-centeredness was also reported in that each student worked independently and individually and also worked collaboratively as a team where they discussed each other's suggestions. They had several decision-making sessions to come to the team's agreements on the task.

Lakarnchua and Reinders' (2014) exploratory study to examine the effectiveness of AR technology in promoting an inquiry-based learning seems to align very well with a notion of constructivist learning that promotes learners' self-regulation and collaboration.

Dunleavy et al. (2009) suggested that the engagement of the student as well as their identity as a learner is formed by participating in collaborative groups and communities. Constructivism has also changed the role of the teacher to become a facilitator, where the responsibilities to organize, synthesize, and analyze content information are in the hands of the learners. By using augmented reality to encourage students to engage on a deeper level with the tasks, concepts and resources being studied through the use of information overlays, students could exercise their deep connections within their existing and newly constructed knowledge and use their critical thinking skills more effectively (Kerawalla, Luckin, Seljeflot, & Woolard, 2006).

Creating AR learning environments for learners also theoretically conjoins Jonassen's (2013) stance Constructivist Learning Environments (CLEs) as educational environments that were created for the purposes of independent learning through constructivism. In these situations, the teacher becomes the facilitator, guiding the learners through their cognitive and constructive knowledge construction while the learner takes charge their learning. Jonassen (2013) also suggested adding conversation or collaboration tools, so that learners can work together as a so-called "community of learners" (p. 229), collaborating on a common solution. The final and outermost layer of the CLE model is of the contextual support in forms of coaching, modeling or scaffolding by the instructional facilitator where necessary.

Skills Training. AR has not only suggested its usefulness and effectiveness in education, it has also shown benefits for skills training and development programs across diverse fields. The aforementioned AR technologies have brought about substantial applications in medical science, tourism, architecture, entertainment, and skill trainings (TechAcute, 2014; Yuen et al., 2011; Behzadan, 2008; Worcester Polytechnic Institute Automation and Interventional Medicine Laboratory, 2015; MedicalFuturist.com, 2016). AR could be said to have potential to provide powerful contextual "*in situ* learning" (Yuen et al, 2011, p. 130) experience and exploration. Simultaneously, AR also promotes the learner's self-discovery of information in the real-world settings where virtual representations enhance the tasks that could not physically demonstrated on site. These benefits could be realized concretely in military uses. The military also finds AR technologies very effective and useful for army missions and training. Head-Up Displays (HUDs) and Helmet-Mounted Sights (HMSs) have been used by arm forces for many years. Surrounding data or objects could be projected onto transparent helmet-mounted displays for use in troop training and simulations, which "allow soldiers to carry out exercises in real landscapes augmented with depictions of enemy troops or tanks" (Kipper & Rampolla, 2013, p. 101). With this convenience, the soldiers could undergo relatively realistic, virtual battlefield trainings through a wider range of scenarios than would normally be possible in the physical training site. Also, there is less requirement for extra equipment and manpower, and there is likely to increase physical safety and reduce possible risks from training among the newly trained soldiers.

In areas of life safety and decreased risks of physical harms, AR also supports medical training in several medical schools where the medical students use AR head-mounted displays or glasses to see and conceptualize parts of human anatomy. Also, a group of medical scientists at Worcester Polytechnic Institute also experimented with AR technology to use virtually superimposed 2D images to guide needle insertion procedures during joint arthrography procedures (Worcester Polytechnic Institute Automation and Interventional Medicine Laboratory, 2015). Another application for AR in the medical domain is in ultrasound imaging (State, et al., 1994) in which an optical see-through display is used by the ultrasound technician to view 3D-rendered images of the fetus overlaid in real time on the abdomen of the pregnant woman. The images appeared as though they were actually inside of the abdomen and were correctly rendered as the pregnant woman moved (Kipper & Rampolla, 2013; State et al., 1994). Other medical treatments also could benefit from AR through, for example, an exposure therapy program in which patients suffering from cockroach phobia receive on-going AR-mediated treatments over a certain period of time. The results were satisfactory because the patients were reported to recover significantly after treatment.

Promoting Authenticity of Tasks and Learners

Tatsuki (2006, no pagination) noted, “authenticity is taken as being synonymous with genuineness, realness, truthfulness, validity, reliability, undisputed credibility, and legitimacy of materials or practices.” Interestingly, he emphasized both materials and the interaction with them. Morrow (1977) and Rogers and Medley (1988) agreed that authenticity can be rendered from materials, in any form, that are based on cultural and situational contexts. Thus, it is possible to conceive of authenticity that results from the uses of augmented reality in education as a multidimensional concept that may be categorized into two major types: task authenticity and teacher/learner authenticity (Taylor, 1994; Breen, 1985; Lee, 1995).

In AR environments, the center is on the design of authentic learning tasks that are usually identified as gamed-based, problem-based, or task-based (Ellis, 2003; Wu, Lee, Chang, & Liang, 2013). Squire and Jan (2007, p. 6) defined AR games as "games played in the real world with the support of digital devices that create a fictional layer on top of the real world context." Characteristics and features of gamed-based learning usually include roles, challenging tasks, sites or spaces for group work, and authentic resources (Squire & Jan, 2007). In addition to gamed-based learning, educators have employed AR environments to promote problem-based learning that links to self-motivation and problem-solving skills, proficiencies often deemed necessary in the 21st century (Liu, 2009). However, even though educators may view game-based and problem-based learning differently, one approach could complement or embed the other in the design of learning tasks or activities.

Since AR began to emerge, developers have emphasized teacher/learner authenticity as important in AR learning environments. Lee (1995) suggested that the nature of interaction between teacher and learner might also affect the production of authentic learning materials. Thorp (1991, p. 117) recommends accommodating students' interactional styles while making learning expectations "as explicit as possible." Lee (1995, p. 326) builds on this idea by stressing the need for contextualizing tasks so that students can learn in more natural, meaningful, and relevant ways. The requirements for advanced resource preparation in implementing AR means that the roles of teachers typically shift from being authoritative to being facilitative, while students demonstrate greater self-regulation in learning and yet simultaneously may participate in collaborative group work with peers. These attributes describe some of the potential of AR.

Nevertheless, using authentic materials can be a double-edged sword. Guariento and Morley (2001) cautioned that authentic materials might confuse or frustrate some students and undermine their intrinsic motivation because of resource and/or task complexity. Given the potential complexity of interacting with real world experiences enhanced with the superimposition of digital resources, teachers designing such tasks need to pay special attention to simplifying them and equipping students with carefully written instructions or guidelines that would facilitate their effective completion of the tasks.

Promoting Digital Literacy in the 21st Century

Digital Literacy is 1), a person's ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills, and 2), a person's ability to perform tasks effectively and appropriately in digitally mediated environments (Cornell University Digital Literacy Resource, 2016). A digitally literate learner should be able to use diverse technological software and hardware appropriately and effectively to retrieve, evaluate, and interpret perceived information to render ethical and appropriate judgments of the quality of such information.

AR technologies could create learning environments, both inside and outside classrooms, where virtually interactive formats could enable students to handle a vast pool of available information in engaging ways to facilitate knowledge building. Klopfer (2008) asserted that AR mobile games allowed learners to organize, search, and evaluate data at hand in real-life sites; improving their skills in navigating, analyzing, and evaluating primary and secondary sources of information.

Digital Literacy, which encompasses information, media and technology skills, is one of the critical components in the Partnership for 21st Century Learning's (2016) Framework. The Framework for 21st Century Learning defines and illustrates skills and knowledge students need to succeed in work, life and citizenship necessary for 21st century learning outcomes. Thousands of educators and hundreds of schools in the U.S. and abroad have adopted these descriptions of 21st century skills and placed them as goals at the center of learning (Partnership for 21st Century Learning, 2016).

Students exposed to AR technology in their learning have the potential to reap benefits from it as they could learn to improve their interpersonal communication with peers and community and to develop collaborative and cooperative learning skills. Moreover, AR affords abundant possibilities for learners to demonstrate creative thinking and construct knowledge by using innovative technological devices and tools merged with authentic, real world experiences. More importantly, learners are able to apply digital tools to plan and guide inquiry or discovery of new knowledge while also using critical thinking skills to manage projects, solve assigned problems, and make informal decisions using digital resources. These are parts of necessary skills deemed critical for learners in this century as stated in the Student Standards by the International Society for Technology in Education (ISTE) (2016).

Promoting Increased Motivation and Engagement

While AR environments have shown some empirical evidence in boosting student learning outcomes, several preliminary exploratory studies also pointed out that the integration of AR into pedagogical practices could add excitement and heighten students' motivation, positive attitudes and engagement with the tasks (Jerry & Aaron, 2010; Azuma, 1997; Klopfer, 2008; Squire & Jan, 2007; Johnson et al., 2011; Billinghurst et al., 2001). Because the students were unfamiliar with the novelty of AR learning tasks that incorporated mobile devices in game-based or problem-based tasks, they felt very eager to explore and immerse themselves with the AR learning environments.

AR integration can be linked to some cognitive motivation theories proposed in psychology research which, for example, include two influential approaches: self-determination theory (Rigby & Przybylski, 2009) and attribution theory. Self-determination theory focuses on intrinsic motivation (engagement in activities for enjoyment and satisfaction) and extrinsic motivation (engagement in activities for achieving instrumental ends, such as earning rewards) (Dörnyei, 2003, p.7). In addition to self-determination theory, attribution theory is also influential as it proposes that what a person perceives to be the causes for their past failures or successes will have a major impact on their expectations and hence their achievements in the future (Dörnyei, 2003, p.8). Attribution links between the past and future achievement or failure contribute to shaping motivational disposition. An important insight is that attribution and how a person perceives it or explains it can create new attitudes and motivational effects that subsequently lead to achievement (or failure) results.

Applying motivation theories to the integration of AR into learning and teaching, it can be inferred that students would be likely to maintain positive attitudes and motivation if they feel that they are able to tackle learning activities with and by processes of collaboration and guidance from more experienced others.
Moreover, their engagement in the learning tasks could lead them to be continuously motivated when assigned further challenging tasks in the future even though the degree of excitement may decrease with repeated exposures. This could be regarded as one of the challenges for instructional design and pedagogical practices in which the teacher has to be able to evolve learning tasks to sustain engagement with the AR technology.

Critiques of Augmented Reality in Higher Education

Along with educational benefits analyzed and discussed above, research has also reported a number of trade-offs and drawbacks that can be categorized into three major challenges: technological and technical challenges; institutional, teacher and pedagogical challenges; and learner challenges.

Technological and Technical Challenges

Access to Equipment and Maintenance Cost. Cuban (1986, 2001) and Saettler (1990) found that accessibility is one of the most common flaws contributing to the failure or under performance of technology integration in education. The term accessibility, especially for AR use, refers to access to appropriate technological devices and to the Internet infrastructure. Current iterations of AR technologies often adopt mobile devices, such as smartphones and tablets to enhance a sense of virtual immersion through linking to advanced GPS systems and through intuitive user interfaces. However, this means that successful and effective AR systems are likely to require expensive and sophisticated hardware and software that are not affordable to all users. Even though mobile devices have become cheaper and more accessible to the public and individual students, it is still a challenge for some school districts to invest in these devices and have them available in classrooms for routine use.

Another accessibility challenge is that implementing AR learning experiences among students requires well-established wireless Internet infrastructure that includes high-performance Internet servers and high-speed WiFi bandwidth and connection throughout school or university geographical footprints. The necessity also may include yearly subscriptions, sustainable updates for hardware and software, and on-going maintenance services. Even though in the present time the cost of mobile devices has declined compared to the past, the wireless networks infrastructure may not have kept up with new technologies requiring more bandwidth. This is especially relevant to AR as high-speed wireless connections are often necessary to make AR work effectively. Interruptions in or loss of Internet connections or inconvenient access to the Internet could mean that AR learning tasks fail while in process.

Technical Training and Professional Development. Both academics and students need training to understand the fundamental concepts, potential, functionality and utilization of a vast variety of AR programs/ applications for educational purposes. Dunleavy et al. (2009) found that during the implementation of an Alien Contact! AR lesson, participating teachers expressed a concern for more technical and skills support. They reported that they did not have full confidence when left to set up and implement the program by themselves. In addition, teachers whose teaching approaches were more lecture focused often had a difficulty dealing with technical glitches and allowing students to explore the learning environment on their own. This is because they did not have a complete picture of what was on the students' mobile devices and because they relatively lost authority over the AR learning tasks where students were generally directing and controlling their learning.

This evidence suggests that the lack of teacher professional training and development programs on the integration of technological innovations may hinder the future uses of AR for teaching and learning. This challenge also resonates one of the most common drawbacks asserted by Cuban (1986, 2001), and it yields complicated dimensions in departmental, managerial, and practical levels for teachers. Training and/or workshops are necessary for teachers to effectively implement AR, just as they were for nearly every other computer-based technology. Researchers have found repeatedly that these workshops should accentuate both technological and pedagogical skills and knowledge (UNESCO, 2011; Shuler, 2009) or the integration of these skills with content as described by TPACK (Mishra & Koehler, 2006). In sum, training for teachers and other educators such as educational technologists or instructional designers is necessary if continued use of the AR technology is expected to be implemented and to contribute to improving education and training.

Institutional, Teacher and Pedagogical Challenges

Resistance. The integration of AR technologies into higher education may conflict with the traditional instruction beliefs and systems. Cuban (1986, 2001) defined a key socio-economic and socio-cultural phenomenon related to effective technology use in education as “situationally constraint choice.” He explained that a situationally constrained choice is a historical, political, economic, cultural and organizational influence that may restrain teachers from integrating technology into their instruction due to unique managerial and structural characteristics of those institutions. These characteristics may include teachers’ long-held teaching practices that do not change rapidly, and the inflexibility of tight schedules, and the overwhelming number of obligations imposed on teachers. When emerging AR technologies enter the status quo of the higher education system, necessary changes to the system usually result in some degree of resistance.

Teachers may feel concerned that AR would overtake their classrooms and reduce their importance to the educational practice. AR learning activities, as an emerging, advanced technology form, may necessarily involve innovative approaches, such as participatory simulations (Squire & Jan, 2007). However, the resulting new instructional approaches are quite different from teacher-centered, delivery-based focus in conventional teaching methods. Teachers worry that once students experience this type of technology-mediated learning, they would not be inclined to appreciate their previous approaches of learning that learners may then view as less engaging and less exciting. Moreover, teacher roles that shift from authoritative instructor to facilitative coaches may cause resistance among academics. That is, technology acceptance among higher education teachers is a critical issue that innovators must take seriously when introducing emerging technologies. Teo (2011) described technology acceptance as users’ willingness to use technologies designed to facilitate achieving tasks or assignments. From many perspectives and much research (e.g. Cochran-Smith, et al., 2015), teacher education and professional development play a vital role in ensuring that teachers are capable of using technologies in school settings.

AR Resources and Content. As an emerging innovation under the umbrella of mobile technologies, AR has posed two major constraints due to its insufficient and/or inflexible content and resources. Despite a growing number of mobile devices and software that enable general users to create AR content without any computer programming knowledge (see Layar, 2015; Wikitude, 2016; Plickers, 2016), the continuing developments of AR resources are still limited to willing AR enthusiasts. Moreover, most AR development to date has been for business-related enterprises, not particularly for educational purposes. Annetta, Burton, Frazier, Cheng and Chmiel (2012) asserted that even though there are many free resources available for teachers use, they are not likely to reap fullest benefits from them because, they are not properly trained both pedagogically and technologically to use these tools.

Another drawback, related to pedagogical implementation, is the inflexibility of the content in AR environments. As some of the AR contents are made and digitally superimposed over certain objects and places in real world surroundings, such as artifacts in museums, it is quite difficult for educators to make changes to these AR contents when they want to adjust their lesson plans to accommodate curricular requirements, instructional objectives and specific student needs. Moreover, students might find other resources they find online more accessible than the AR contents. Additionally, to adapt or change the AR contents, teachers are required to have access to AR authoring tools that are often web-based. Consequently, immediate decisions for content changes are difficult to implement because it takes time and requires hands-on skills to make changes.

Poor Integration into Curriculum and Instructional Design. Poor integration of AR systems into curriculum and instructional design may result from the aforementioned resistance from teachers and institutions, the lack of available resources and educational contents, and the lack of professional develop to develop teachers' technological and pedagogical integration skills. All these are contributing factors to prevent the more effective and widespread use of AR in higher education. Cuban (1986, 2001) pinpointed that to effectively utilize educational technologies in classrooms, teacher participation in planning, designing, developing and evaluating technology integration plans are tremendously important. Given the complexity of technologies in contemporary education, these activities also may require close collaboration with educational technologists and instructional designers. Saettler (1990) cited that the lack of collaborative work between a triad of media producers, instructional designers, and teachers, who possessed diverse mindsets and skills of expertise, as powerful explanations for failures in the past. Thus, it is predictable that AR learning environments and accompanying materials would benefit from collaborative development by educators in these roles to best serve pedagogical practices in each particular contextual setting and for each particular subject matter.

Learner Challenge

The most frequently reported limitation of AR in its current state of development is student cognitive overload. Across studies, researchers report that students are often overwhelmed with the complexity of the activities (Dunleavy et al., 2009; Dunleavy & Dede, 2004), the scientific inquiry process and navigation or making decisions as a team (Klopfer & Squire, 2008; Klopfer, 2008). Some AR simulation games, for example, require a significant amount of complex processes and materials the students have to manage. These processes may include operating a mobile device, using the AR software, following the navigation instructions, completing all the required tasks for the activity, and collaborating with peers about the information, all of which could be quite frustrating and intimidating tasks, even for technology-savvy students. Teachers are therefore worried that AR simulations may cause students to have cognitive overload. Careful tailoring and managing the level of complexity is then a critical instructional issue. In response, AR content designers for educational purposes have attempted to decrease the cognitive load by: 1) creating a simplified experience structure for initial contact and increasing complexity as the experience progresses; 2) scaffolding each experience explicitly at every step to achieve the desired experience/learning behavior; and 3) replacing text with subtitled audio (Dunleavy & Dede, 2004; Klopfer & Squire, 2008).

Conceptual Frameworks for Technology Acceptance

This section presents previous theoretical/conceptual models that attempted to measure users' technology acceptance. Firstly, Davis, Bagozzi, and Warshaw's (1989)

Technology Acceptance Model (TAM), an empirically-based and widely used model to measure users' acceptance of a given technology, is reviewed briefly to provide background for its inclusion in this proposed research. Next is a review of some previous studies in which TAM and its extended versions were adopted for determining users' levels of acceptance in using emerging technological innovations, such as AR and mixed reality (MR). These empirical studies proposed and introduced determinants, such as enjoyment and self-efficacy into TAM. The third sub-section presents an overview of the Technology Acceptance Model 3 (TAM3), another version of extended, re-constructed TAM, by Venkatesh and Bala (2008) in terms of its relevance to previous research. The final section presents a rationale for the use of the TAM3 model as a main conceptual framework for use in data analysis for the proposed dissertation research.

Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989)

Technology acceptance refers to an individual's willingness to use or to incorporate any form of technology into their working tasks or activities to achieve their productivity goals (Teo, 2011). Originally proposed by Davis (1989), TAM is a highly influential socio-technical model extended from the Theory of Reasoned Action model proposed by Ajzen and Fishbein (1980). TAM helps to predict users' intentions and future behaviors in utilizing information technology (Legris, Ingham, & Collerette, 2003). Figure 2.1 presents the first modified version of the TAM (Davis, Bagozzi, & Warshaw, 1989) which provided a theoretical basis for understanding how a user of technology is influenced by "External Variables" and how these variables affect their beliefs, attitudes, and intentions to use technology in any given circumstance. The external variables would yield changes in users' initial two constructs of cognitive beliefs: Perceived Usefulness and Perceived Ease of Use.

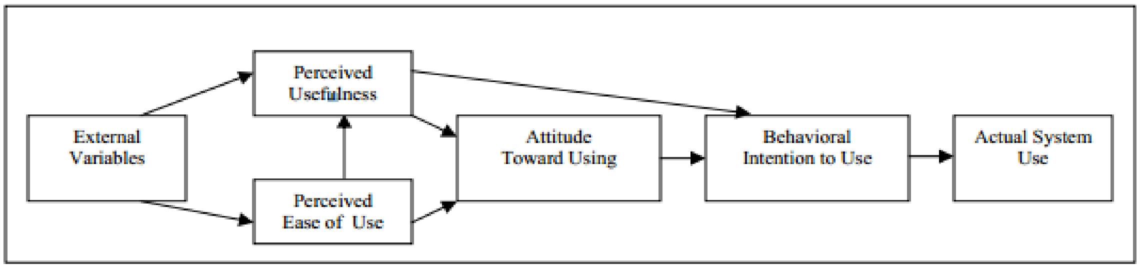


Figure 2.1 Technology Acceptance Model by Davis, Bagozzi, and Warshaw (1989)

Davis defined *Perceived Usefulness* as, "the degree to which a person believes that using a particular system would enhance his or her job performance" (1989, p. 320). That is, it is critical for technology users to have a firm belief that such technological tools would be effective and that they are capable of being used to the fullest advantage. Davis (1989) also asserted that any technologies perceived as highly useful are viewed as offering positive use-performance and user-friendliness.

Perceived Ease of Use refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Effort in this respect is a finite resource each user has and he or she may allocate such to a number of activities or tasks he or she is carrying out. That is, any technology that is viewed as easier than another is likely to be preferable for adoption in terms of it being perceived as more efficient and easier to use.

Attitude Toward Using is a subsequent construct in TAM defined as "an individual's positive or negative feelings about performing the target behavior (e.g., using a system)" (Fishbein & Ajzen, 1975, p. 216). Users' attitudes toward any technology or system is postulated to mediate the effects of Perceived Ease of Use and Perceived Usefulness on users' behavioral intention which eventually affects how and whether or not users would incorporate technology in their actual use. However, in later studies (for example Davis, Bagozzi, & Warshaw, 1992; Szajna, 1996; Venkatesh & Davis, 2000), a mediator of Attitude Toward Using was dropped from the TAM model because it was found to be a weak construct mediator.

Extended Technology Acceptance Model (TAM) with a Mediator of Computer Self-Efficacy

According to the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989), Bandura's (1982) concept of self-efficacy strongly influences the construct of Perceived Ease of Use. Bandura (1982) defined self-efficacy as "judgments of how well one can execute courses of action required to deal with prospective situations" (p. 122). Simply put, self-efficacy judgments are likely to help determine expected outcomes. However, it is important to note that Bandura distinguished self-efficacy judgments from outcome judgments. Self-efficacy judgments help predict the tendency of outcomes; that is, they can determine behavioral actions (Bandura, 1982, p.321). For instance, a teacher with high self-efficacy in technology integration may be likely to anticipate its successful implementation into his or her pedagogy. The opposite is also true with the less confident teachers. However, it is not necessarily true that self-efficacy and outcome judgments are consistent because outcome expectations—the perceived results of self-efficacy judgments—may not always contribute to accurate predictions of subsequent behaviors in some occasions. For instance, a teacher with high self-efficacy of technology use may demonstrate poor technology integration in his or her classrooms due to some misconception or other unintentional reasons. Likewise, a teacher with low self-efficacy may turn out to outperform those with high self-efficacy in pedagogical practices. For this reason, Bandura (1982, p.321) asserted that outcome judgments are more “concerned with the extent to which a behavior, once successfully executed, is believed to be linked to valued outcomes”, and therefore the outcome judgments are a construct that act similarly to Perceived Usefulness. Thus, in order to predict users’ actual behaviors with better reliability, it is safer to consider both self-efficacy and outcome beliefs or judgments simultaneously.

Compeau and Higgins (1995, 1999) also suggested that self-efficacy shows a strong effect on users’ intention to adopt technologies as well as their behaviors in using them. Compeau and Higgins (1995) developed and tested a measurement of computer self-efficacy. They investigated the relationships between users’ computer self-efficacy, their computer technology usage, and the environment in which the use occurred. The results showed that self-efficacy was an influential mediator among environmental variables, outcome expectations, and actual computer usage. Figure 2.2 presents an extended TAM with a mediator of self-efficacy (Igbaria & Iivari, 1995)

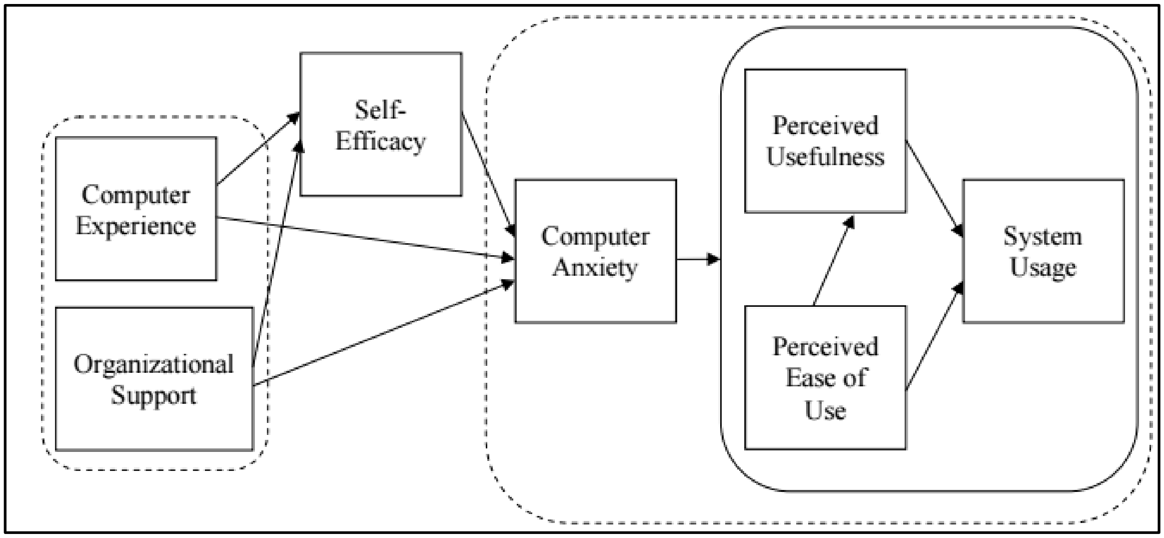


Figure 2.2 Extended Technology Acceptance Model by Igbaria & Iivari (1995)

Igbaria and Iivari (1995) studied 450 Finnish computer users who were working professionals. Their aim was to examine the determinants and the outcomes of self-efficacy in a computing behavior context among their participants. They proposed a modified TAM that incorporated a self-efficacy mediator. Their model proposal introduced self-efficacy, users' computer anxiety, users' computer experience and proficiency as well as organizational support in terms of technical and technological skills and infrastructure to address the influence of self-efficacy on users' adoption and/or integration of technology. Igbaria and Livari (1995) stated that these additional constructs affect the basic constructs of Perceived Ease of Use, Perceived Usefulness, and Actual System Use in the TAM (Davis F. D., 1989; Davis, Bagozzi, & Warshaw, 1989).

Yun (2015) conducted an empirical study of users' self-efficacy regarding virtual reality (VR) and AR technology that investigated the effect of motion graphics in the user interface of the mobile AR and what features could improve users' AR visual experiences. Yun surveyed participants to gather data about how they developed their self-efficacy and cognitive attitude toward mobile AR. The results showed that the motion graphic elements on the user interface of the mobile AR applications could have positive effects on the users' visual experience. An improved visual experience, in turn, "had a positive effect on the users' self-efficacy" and their favorable attitudes (Yun, 2015, p. 6).

Chen (2014) also conducted a months-long case study the primary objective of which was to investigate students' levels of self-efficacy in participating in a course where VR and AR were pedagogically integrated. The participants were 154 freshmen and sophomore students from a university in Taiwan, who enrolled in an occupational English course. Initially, the participating students were given an orientation regarding the scope of the study. They were then introduced to and trained how to use certain devices and tools necessary for a VR-AR courseware designed with three major themes involving three main tasks. After completing the thematic lesson tasks in the courseware, the participants completed a survey in which they determined the effectiveness of the courseware and elicited their self-efficacy about it. The survey employed the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) with an added section on self-efficacy that comprised items asking about users' confidence levels in completing the tasks. The results suggested that the participants found the VR-AR courseware "quite easy to use" (Chen, 2014, p. 39) and that they moderately accepted the technology. Nevertheless, it was reported that external factors, such as the Internet speed and capability and users' ability to operate technological devices, were related to the participants' Perceived Ease of Use as the users felt that more technical and technological convenience and ability facilitated a smoother, easier, and more effective practice of technology use.

Extended Technology Acceptance Model (TAM) with a Mediator of Perceived Enjoyment

In the context of TAM, Venkatesh (2000) referred to enjoyment as "the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology" (p. 351). Several studies of technology acceptance of emerging technologies (Davis, Bagozzi, & Warshaw, 1992; Venkatesh, Speier, & Morris, 2002; van der Heijden, 2003; and Venkatesh, 2000), have proposed that enjoyment is a direct determinant of Behavioral Intention to Use and Perceived Ease of Use, and considered that enjoyment is an intrinsic motivation factor. Figure 2.3 below graphically presents this relationship.

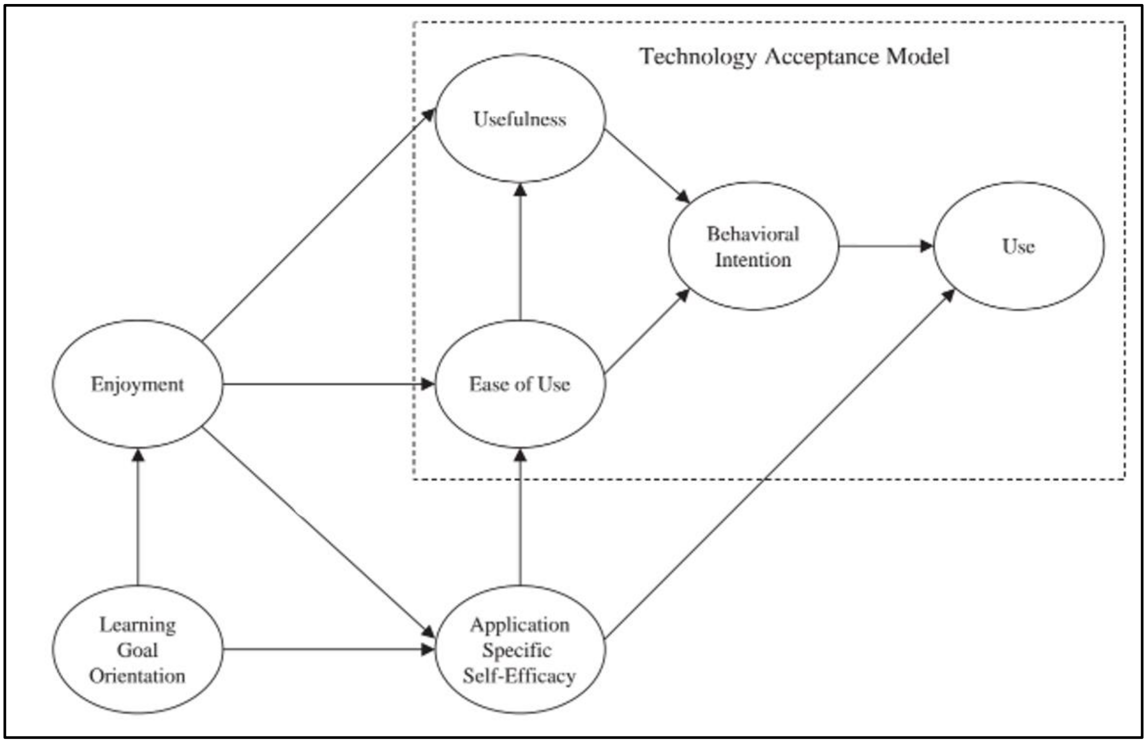


Figure 2.3 Extended Technology Acceptance Model by Mun & Hwang (2003)

Enjoyment is a mediator added to the Technology Acceptance Model in some recent research studies in various fields. For instance, Haugstvedt and Krogstie (2012) conducted a study in the field of tourism in which they investigated the construct of enjoyment within a cultural heritage context as an extension of the TAM proposed by Davis, Bagozzi, and Warshaw (1989). Jung, Dieck, and Dieck (2014) also conducted a qualitative research in which they attempted to propose an AR technology acceptance model particularly for tourism. In their theoretical model proposal, they extended the TAM by including the constructs of enjoyment, perceived benefits, personal innovativeness, information quality, and costs of use, all of which are accounted for external variables.

Mun and Hwang (2003) also conducted a study on an extended TAM with a certain emphasis on enjoyment as a mediator. They investigated users' technology acceptance levels of Web-based systems by incorporating some motivational variables of self-efficacy, perceived enjoyment, and an orientation of learning goals, into the TAM. Figure 2.3 presents Mun and Hwang's proposed research model of an extended TAM. In their study, 109 user participants who used Blackboard as a learning management system completed a questionnaire after a 2-week trial period in which they learned and actually used the system. Subsequently, their online usage and activities over eight weeks were recorded by the internal Blackboard system for further analysis. The results showed that a mediator of enjoyment had a significant effect on how users perceived their levels of self-efficacy, and how they perceived usefulness of a given technology. That is, enjoyment was found to "positively influence usefulness, ease of use, and application-specific self-efficacy" (Mun & Hwang, 2003, p. 446). The study's implications also highlighted that it is critical that organizational and/or training interventions that facilitate application-specific self-efficacy and enjoyment of the users might be able to promote increased levels of technology usage which may be prone to increased levels of perceived ease of use. Consequently, with heightened ease of use of technology, users may find such technology useful for improving their learning. Therefore, from this study, it can be said that enjoyment is a crucial determinant and factor in enhancing perceived self-efficacy and ease of use in integrating a given technological tool or application. Therefore, based on the discussion of enjoyment as another variable, it is proposed that such variable be added in this study to find out if it has any effect on users' perceived usefulness and ease of use of the AR technology.

In regard of the variable of enjoyment in research studies on the AR technology acceptance, Yusoff, Zaman, and Ahmad (2011) conducted an evaluation study of mixed reality technology (Milgram & Kishino, 1994). The study investigated users' perceptions and acceptance of mixed reality (MR) technology in an attempt to improve design and examine users' preferences in utilizing the technology. They designed and implemented a MR technology prototype as a supplementary situated-learning-based resource for 63 Biomedical Science students in two higher education settings in Malaysia, who were studying regenerative concepts and tissue engineering processes. They employed the TAM (Davis, Bagozzi, & Warshaw, 1989) as a theoretical model with added constructs of Perceived Enjoyment and Perceived Innovativeness. The Perceived Innovativeness construct referred to the willingness of a user to have a trail of their use of a given technological tool or application. They divided their study into three phases: a demonstration, a hands-on activity, and task-oriented sessions. After all these three phases, the participants completed a questionnaire about their MR experience. The results suggested that all participants, except three, expressed that they had fun with the MR prototype, the majority (93%) agreed that the prototype "was pleasant to use" and that they "enjoyed using" the prototype (Yusoff, Zaman, & Ahmad, 2011, p. 1380). In addition, the participants positively reported high levels of Perceived Usefulness and Perceived Ease of Use. The results from correlation analyses showed strong positive relationships between Perceived Ease of Use and Perceived Usefulness. To sum up, Yusoff, Zaman, and Ahmad (2011) stated that the participants found the system easy to use and they spent less effort to operate it, which heightened their enjoyment. For this reason, they considered the system useful for their academic performance. These implications are in line with a study by Venkatesh, Speier, and Morris (2002) that enjoyment has an effect on users' perceived usefulness and perceived ease of use.

Wojciechowski and Cellary (2013) conducted a study on AR to evaluate learners' attitudes towards learning in AR-enhanced, three-dimensional learning environments. The researchers adopted the TAM (Davis, Bagozzi, & Warshaw, 1989) to investigate and explain determinants that encouraged learners' increased system usage. However, a determinant of enjoyment was added to the model as suggested by Davis, Bagozzi, and Warshaw (1992) in which they proposed that enjoyment is an influential intrinsic motivation factor among users. The AR architecture system called ARIES was implemented as an AR learning environment and 42 secondary school students engaged in learning through scenario-based AR tasks that were similar to scientific experiments. Each AR installation was composed of a desktop PC with a monitor, a webcam, and square cardboard AR markers. The participants placed the cardboard markers in front of the webcam to launch AR and then two- and three-dimensional objects were digitally superimposed on that particular cardboard marker. Those two- and three-dimensional objects appeared on the monitor that also had an image of the cardboard marker on it. Through each task, they could freely manipulate the cardboard markers so that they saw AR images or objects mirroring on the computer screen. That is, the participants could view the virtual objects and directly interact with them intuitively and naturally as if they were real objects. After the completion of the experiment, the participants completed a questionnaire with items asking about the ARIES system, their attitudes towards using it in improving learning performance. The results showed that Perceived Usefulness and Perceivned Enjoyment "had a similar effect on attitude toward using image-based AR environments", and more importantly Perceived Enjoyment was regarded a more significant facor than Perceived Usefulness (Wojciechowski & Cellary, 2013, p. 583). This finding suggested that the use of AR-enhanced learning materials could encourage increased motivation among young learners. However, the findings were not only attributed to the AR technology but the researchers also concluded that in order to maintain high level of motivation and participation, there should be a continuing process of materials development and provision of engaging learning content fit to students' interest and course objectives. The studies' implications included the conclusion that effective and successful implementation or dissemination of AR technology in education relies, at least in part, on the availability and quality of AR-mediated content and learning environments for a diverse group of learners.

Technology Acceptance Model 3 (Venkatesh & Bala, 2008)

Even though the Technology Acceptance Model (TAM) by Davis, Bagozzi, and Warshaw (1989) has been widely used in education research since it was introduced, it has also been re-constructioned and extended to increase its effectiveness and accuracy in measuring users' technology acceptance and behavioral usage. The extended TAM models with new determinants such as self-efficacy (Igbaria & Iivari, 1995; Yun, 2015; and Chen, 2014) and enjoyment (van der Heijden, 2003; Venkatesh, 2000; Mun & Hwang, 2003; Yusoff, Zaman, & Ahmad, 2011; Wojciechowski & Cellary, 2013) discussed above are particularly relevant in investigating emerging technologies such as MR, VR, and AR technologies.

Another major extension to the original TAM, is Technology Acceptance Model 3 (TAM3) developed by Venkatesh and Bala (2008). TAM3 emphasizes an understanding of users' behavioral intention and actual usage of technologies, with a particular focus on determinants that influence Perceived Usefulness and Perceived Ease of Use—two constructs in the original TAM (Davis, Bagozzi, & Warshaw, 1989). This particular focus on Perceived Usefulness and Perceived Ease of Use in TAM3 provides a more comprehensive model to explain in greater depth users' initial acceptance of a given technology. Another advantage of and rationale for using TAM3 is that to determine users' Perceived Usefulness and Perceived Ease of Use, it offers a set of determinants that are brought from previous technology acceptance models (see Igbaria & Iivari, 1995; Mun & Hwang, 2003; and Davis, Bagozzi, & Warshaw, 1989). Venkatesh and Bala (2008) stated that TAM3 "presents a complete nomological network of the determinants of individuals' IT [information technology] adoption and use" (p. 279). It is a resulting version from combining Technology Acceptance Model 2 (Venkatesh & Davis, 2000) and the model of the determinants of Perceived Ease of Use (Venkatesh, 2000).

Figure 2.4 presents a theoretical framework of TAM3 with two major constructs: Perceived Usefulness and Perceived Ease of Use. There are also two moderators: Experience and Voluntariness. There are three new relationships among determinants that are posited: 1) Experience to moderate the relationship of Computer Anxiety and Perceived Ease of Use; 2) Experience to moderate the relationship of Perceived Ease of

Use and Perceived Usefulness; and 3) Experience to moderate the relationship of Perceived Ease of Use and Behavioral Intention (Venkatesh & Bala, 2008, p. 281).

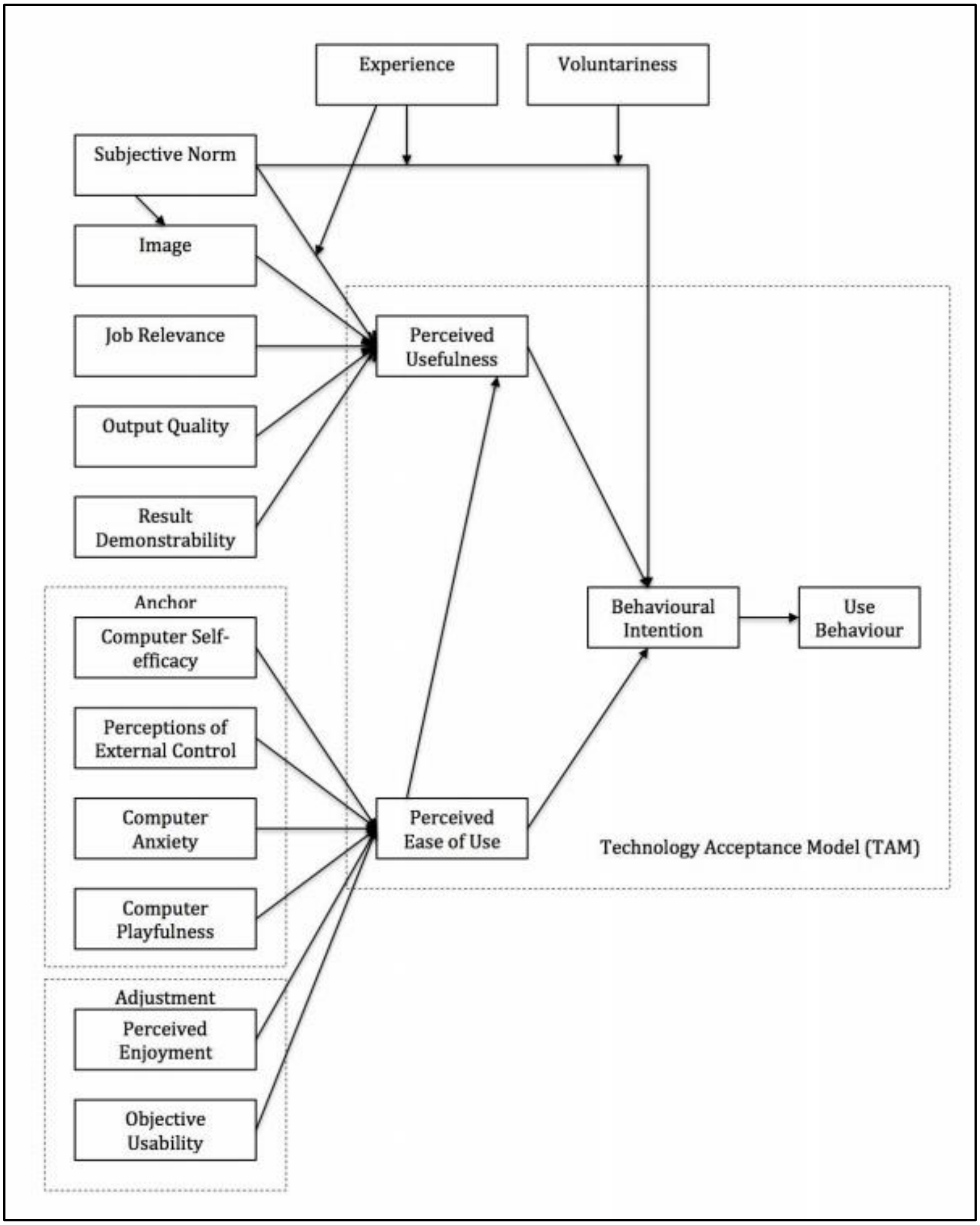


Figure 2.4 Technology Acceptance Model 3 (TAM3) by Venkatesh and Bala (2008)

Furthermore, there are six major determinants under the construct of Perceived Usefulness. They include Computer Self-efficacy, Perception of External Control, Computer Anxiety, Computer Playfulness, Perceived Enjoyment, and Objective Usability. Computer Self-efficacy connotes a level of one's belief in performing a given task using technology (Compeau & Higgins, 1995). Perception of External Control entails one's perception of how well and effectively an organization provides technical assistance to facilitate the use of a given technology (Venkatesh, Specier, & Morris, 2002). Computer Anxiety is a determinant that investigates a level of one's fear or hesitation in using a given technology, which might prohibit him or her from successfully performing a task. Computer Playfulness refers to an individual's perception of how interactive and spontaneous a given technology is (Webster & Martocchio, 1992). Perceived Enjoyment is a degree to which a task is perceived as enjoyable and fun (Venkatesh, 2000). Finally, Objective Usability is referred to as a "comparison of systems based on the actual level rather than perceptions of effort required to completing specific tasks" (Venkatesh, 2000, pp. 350-351). Table 2.1 provides a set of definitions of determinants in TAM3 that moderate Perceived Ease of Use and Perceived Usefulness.

Table 2.1

Determinants of Perceived Ease of Use and Perceived Usefulness in TAM 3

by Venkatesh and Bala (2008)

Determinants	Definitions
Perceived Ease of Use	
Computer Self-efficacy	A degree to which an individual believes that he possesses an ability to perform a specific task using the computer (Compeau & Higgins, 1995)
Perception of External Control	A degree to which an individual believes that organizational and technical support and resources facilitate their use of the technology (Venkatesh, Speier, & Morris, 2002)
Computer Anxiety	A degree to which an individual feels apprehension or fear when encountering a possibility that he has to use the technology (Venkatesh, 2000; Igbaria & Iivari, 1995)
Computer Playfulness	A degree to which an individual has a "cognitive spontaneity in microcomputer interactions" (Webster & Martocchio, 1992, p. 204)
Perceived Enjoyment	A degree or "the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology" (Venkatesh, 2000, p.351).
Objective Usability	A "comparison of systems based on the actual level rather than perceptions of effort required to completing specific tasks" (Venkatesh, 2000, pp. 350-351)
Perceived Usefulness	
Subjective Norm	A degree to which an individual perceives that people important to him in his daily life think that he should or should not use the technology (Fishbein & Ajzen, 1975)
Image	A degree to which an individual perceives that the use of the technology will enhance his social status or his social image (Moore & Benbasat, 1991)

Job relevance	A degree to which an individual believes that being able to use the technology will be beneficial for his profession (Venkatesh & Davis, 2000)
Output quality	A degree to which an individual believes that the technology aids in performing his professional tasks well (Venkatesh & Davis, 2000)
Result demonstrability	A degree to which an individual believes that the outcomes from using the technology are tangible and observable (Moore & Benbasat, 1991)

TAM3 as a Conceptual Framework in the Current Study

In line with an extended TAM that was employed in studies by Igbaria and Iivari (1995) and Compeau, Higgins, and Huff (1999), TAM3 also incoporates Computer Self-efficacy and Computer Anxiety as two of the major determinants of Perceived Ease of Use. Furthermore, while Igbaria and Iivari (1995) posited that Organizational Support and Computer Experience had an effect on the users' levels of Self-efficacy and Computer Anxiety, TAM3 adapts these two determinants by incoporating them as a determinant of Perception of External Control and as a moderator of Experience. That is, TAM3 also emphasizes the factor of technological and technical resources and supports as crucial in determining whether one will or will not feel confident or get anxious when adopting or integrating a given innovation on a task. Not only is a determinant of Computer Self-efficacy present in TAM3, a determinant of enjoyment also exists as one of the Perceived Ease of Use determinants, just as in studies by Wojciechowski and Cellary (2013) and Mun and Hwang (2003), for example.

The benefit of TAM3 is that it focuses on two primary constructs of TAM which are Perceived Ease of Use and Perceived Usefulness of a given innovation. It also consists of several relevant determinants in facilitating or obstructing users' behavioral intention and actual usage of technology, such as self-efficacy, enjoyment, organizational support and resources, as well as subjective norms, for instance. This proposed study, therefore, intends to use TAM3 as a theoretical framework in an attempt to generate and to answer research questions. The research questions are:

1. What are participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?

2. After completing the activities, what level of self-efficacy do participating Thai undergraduates have in using augmented reality technology?

3. After completing the activities, what are participating Thai undergraduates' intentions for using augmented reality technology in their future learning?

Conclusion

Even though AR is relatively new, innovators have already begun integrating it into education, and its future in education looks promising. It is in the development stage with more emerging applications in various fields including education. Several educational research studies have studied the effectiveness of particular AR instantiations and the possibilities and applicability for instructional design and pedagogical practices are of great interest. A growing body of research suggests that AR provides powerful contextual, situated learning and explorative discovery learning experiences that are engaging and new to learners so that they could render more meaningful and authentic learning. However, despite such educational affordances, i.e., advantages in digital literacy, authentic learning, constructive learning, motivation and engagement (Jerry & Aaron, 2010; Squire & Jan, 2007; and Klopfer, 2008), AR also poses some possible pitfalls including access to equipment and maintenance cost, technical training for professional development, resistance from institutions and teachers, inadequate AR contents and resources for educational purposes.

To minimize the pitfalls and maximize the contributions to education of this new technology form, academics and researchers as well as those authorities responsible for region-wide and nationwide educational development would benefit from creating communities of practice where they delve into the study of user acceptance of AR technology across contexts. As a newly emerging technology, AR offers a number of potential educational advantages for learners of the 21st century. It would be beneficial to gain an understanding of how users perceive and react to the integration of AR technology in instruction and learning. Empirically-based research into such field of user acceptance and educational productivity will help pave a way for researchers and educators to create and render engaging and motivating learning environments, develop appropriate AR-mediated instructional design, and leverage this new technological form to achieve more authentic and constructive learning experiences for learners in different contexts across subject disciplines.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter presents the proposed research methodology and design, details of research instruments, and the process and phases of data collection. Moreover, it provides information about the limitations and the ethical considerations of the study. This study will investigate the experiences of Thai learners' participating in AR-enhanced language learning activities in a language classroom. It also will investigate user acceptance of and self-efficacy in using the AR technology. The research questions are:

1. What were participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities as implemented in their classrooms?

2. After completing the activities, what level of self-efficacy did participating Thai undergraduates experience in using augmented reality technology?

3. After completing the activities, what were participating Thai undergraduates' intentions for using augmented reality technology in their future learning?

The research methodology, the selection of participants and settings, and the research instruments and measures were designed and attempt to address the aforementioned research questions.

Research Design and Research Matrix

The methodology for this dissertation research was a mixed-methods descriptive study, more specifically a convergent parallel mixed-methods design including both quantitative and qualitative methods (Creswell, 2014). The mixed-methods design aims at collecting, analyzing, and combining questionnaire data (quantitative) and interview and observation data (qualitative) within a single study to inform interpretations. However, the qualitative, descriptive design forms the base research approach, while the quantitative element is employed as a supplemental measure.

To collect the quantitative data, two major questionnaires were administered to the student participants. The first questionnaire (a questionnaire on computer and the Internet use; See Appendix 1) was administered at the beginning of the semester, before they had any interaction with the AR resources central to the research. It collected data on the students' habitual use of computer and the Internet as well as their personal demographic information, such as age, gender, and academic status. This questionnaire also had a particular open-ended section in which the participants elicited their background knowledge, if any, about the AR technology. In addition, this section of the questionnaire was later administered to the participants again at the beginning of the following semester of the same academic year. This allowed the participants to revisit and recall their existing knowledge and/or understanding about the AR technology. Pre- and post-findings from this AR section were examined for comparisons.

The second questionnaire (a questionnaire on the acceptance of AR technology; See Appendix 2) aimed at eliciting the students' experiences and their technology acceptance, perceptions, and self-efficacy in using AR technology in their classrooms. This questionnaire was made into three versions. In each version, the questionnaire items were shuffled in different order. The questionnaire was administered after each of the three phases (a teacher showcase, an AR tutorial class, and a student showcase) of a classroom AR activities treatment.

One source of qualitative data was collected from observing the student participants during their class time in which they participate in the AR-enhanced activity and during the computer tutorial workshop. The researcher used a classroom observation protocol in order to record observations of the students' interactions with each other, their reaction to the AR activity, and their communication with other students and the teacher. The observations were conducted during the teacher and the student showcases. In addition to classroom observation, the participants were invited to take part in semi-structured interviews. During the interviews, the students were asked a set of open-ended questions that elicited an in-depth description of their experiences in using the AR technology. Patton (2002, p. 4) stated that, "open-ended interview responses yield people's experience, perceptions, opinions, feelings, and knowledge." Data collected from observation and interviews will be analyzed alongside quantitative data from the questionnaires. Multiple measures are expected to provide the data for a thorough and in-depth analysis (Creswell, 2014).

The research data collection matrix that guides how data were systematically collected according to each research question is presented in Table 3.1. The research question 1 "What are participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?" was answered by using data from both questionnaires and interviews, while research questions 2 and 3 "After completing the activities, what level of self-efficacy do participating Thai undergraduates have in using augmented reality technology?" and "After completing the activities, what are participating Thai undergraduates' intentions for using augmented reality technology in their future learning?" used data from the questionnaire on AR acceptance and interviews. Data from classroom observation were used in the process of data triangulation.

Table 3.1

Research Data Collection Matrix

Research questions	Primary data sources	Secondary data sources	Analysis methods
1. What were participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?	- Questionnaires on technology use and on AR acceptance - Interview	- Classroom observation	
2. After completing the activities, what level of self-efficacy did participating Thai undergraduates experience in using augmented reality technology?	- Interview - Questionnaire on AR acceptance	- Classroom observation	- Descriptive statistical analysis - Qualitative coding of interview transcripts into emergent themes
3. After completing the activities, what were participating Thai undergraduates' intentions for using augmented reality technology in their future learning?	- Interview - Questionnaire on AR acceptance	- Classroom observation	

Selection of Context and Participants

This section describes the selection of context and the recruitment of participants for the proposed study. This includes the settings, the description of the participants, the dedicated course in which the study will be conducted, and the description of the AR-mediated activity to be implemented.

Settings

This study was conducted at the Faculty of Liberal Arts, Mahidol University, Thailand. Mahidol University is a state-run university that has a strong reputation in science and medical science. The Faculty of Liberal Arts was established in 2003 and offers only two majors, which are Thai language and English language. The Faculty's major responsibility is to provide fundamental English courses for freshmen and to offer English courses specifically for English-major undergraduates.

Participants

This study used purposive sampling to reach potential participants (Creswell, 2014). Purposive sampling ensured recruitment of a sample group with similar characteristics. Moreover, it helped to learn, to explore, and to understand a central phenomenon taking place within a particular sample group. In this study, the sample group was 48 Thai learners studying at the Faculty of Liberal Arts, Mahidol University, Thailand. These student participants came from a variety of socio-economic backgrounds, yet they had a relatively similar English language proficiency and were considered intermediate users of English, primarily based on their major in English language and their English scores from the National Admission Examination. All participants were enrolled in the course Analytical Reading, one of the core courses for English-major students.

Course Description

The course Analytical Reading was one of the required courses for English-major undergraduates at the Faculty of Liberal Arts, Mahidol University, Thailand. The course was a core English language course, usually offered in the first semester of an academic year, meeting in one, three-hour class session per week. The textbook Exercise Your College Reading Skills (Elder, 2008) was used as the main textbook. The course objective was to teach students to reason out the meanings of unfamiliar words, to determine topics, main ideas, and supporting details of a reading passage, and to apply advanced reading skills in form of discussion and writing. Based on a course syllabus, the course emphasized "practicing reading skills in various types, reading for main idea, supporting details, and drawing conclusions from the reading materials, presenting ideas and discussing in groups based on various types of the readings" (see Appendix 12).

The main rationale for choosing the course Analytical Reading was that the teacher of the course, after a discussion with the researcher, was interested in and willing to take part in this study. The teacher found that integrating AR technology into the course provided a new learning experience to the students, and the integration of technology was part of curriculum requirements promoted by the Faculty and Mahidol University, in which teachers were asked to incorporate appropriate technologies into instruction. Furthermore, the first two sessions of the course focused on word formation, word structures, and determining word meanings, which were deemed introductory sessions before reading for topics and main ideas. The teacher expressed an interest in learning if AR technology might improve student learning of these basic concepts and skills. She wanted the students to create sessions where technologies facilitate how students learn vocabulary, word parts, and word meanings in a more interactive way. In addition, she wanted the students to be able to create English language content related to vocabulary learning by using a particular type of technology, which was in this case the AR technology.

Classroom AR Activities Treatment

The concept of the classroom AR activities treatment was devised based on collaborative work and discussion between the researcher and the teacher. The AR activity was incorporated into the first two sessions of the course with a specific emphasis on teaching and learning about word structures and identifying meanings of unfamiliar words. The AR activity was that the students learn about vocabulary from AR-enhanced flashcards and then they worked in pairs or in groups to create their own AR-enhanced vocabulary flashcards by using a web-based AR creator called ZapWorks. There were three major phases in this activity: 1) a presentation of teacher-made AR-enhanced vocabulary flashcards, which was called in this study 'the Teacher Showcase', 2) an AR computer tutorial workshop which was called 'the AR tutorial class', and 3) a showcase of student-made AR-enhanced vocabulary flashcards, which was called 'the Student Showcase.'

In phase one, the Teacher Showcase, the students were assigned by the teacher to read a selected reading passage. Twelve words from the passage were then chosen and brought into the creation of the AR-enhanced vocabulary flashcards in collaboration of the teacher and the researcher. The students subsequently had a hands-on experience playing with these pre-made flashcards. On each flashcard, there was a word written with a unique QR code. The students used his or her mobile device to scan the QR codes to see various AR multimedia features about such word, such as definitions and part of speech, Thai and English translations, an image (if applicable), a pronunciation audio and/or video, and sample sentences. These features were made using AR technology features available on ZapWorks. Each word's content appeared on top of a flashcard as overlay features. With these features, the students practiced, rehearsed and reviewed words they had seen together with the reading passage they had previously read. For instance, they read a word "Assistant" and guess its meaning before scanning the flashcard using a mobile device to reveal meanings and other information as aforementioned. A rationale to select words from the reading passage was to provide a context where those words were used.

In addition, this set of AR-enhanced vocabulary flashcards was reviewed by the teacher of the course and another expert in English language teaching, for content accuracy.

In phase two, the AR Tutorial Class, after learning vocabulary from a set of teacher-made AR vocabulary flashcards, the students attended a computer tutorial workshop in which they learned and were trained to use a web-based AR application, ZapWorks, to create their own sets of vocabulary flashcards. In the workshop, the researcher was the presenter who provided hands-on assistance to the students throughout all necessary steps. The workshop took place at a computer lab at the Faculty of Liberal Arts, Mahidol University. It took three hours and a half. The 48 students were scheduled to attend the workshop in their free time off the academic schedule. They split into two groups, each of which attended the tutorial on two Wednesday afternoons. Furthermore, after the computer tutorial, the researcher made tutorial videos available online for future references for the students. E-mail correspondences were also available for technical troubleshooting.

In phase three, the Student Showcase, after the tutorial workshop, the students spent their time working in pairs or in groups to continue creating the vocabulary flashcards. Continuing assistance from the researcher was also provided as requested, both in person and via online. The students had about three weeks to finish this assignment which was due, as agreed with the teacher of the course, before the mid-term examination. Once submitted and graded by the course teacher, the vocabulary flashcard products from this activity were presented in class among the students. They had an opportunity to learn from various sets of vocabulary flashcards from other classmates, which could be re-used in following semesters with different groups of students. These students’ works of AR-enhanced vocabulary flashcards were graded by the teacher of the course. Ten points were awarded to those pairs or groups that successfully completed the assignment and met the requirements.

ZapWorks

In this study, ZapWorks, one of the emerging web-based AR content creators, was used as a learning tool. ZapWorks was a free AR creator platform, with added features for paid users, which was developed and launched in conjunction with Zappar, a mobile AR application used to view AR digital content made in ZapWorks. Both ZapWorks and Zappar had versions that worked on electronic devices running either iOS or Android operating systems. ZapWorks was comprised of three integrated tools to provide users with options for creating and distributing AR content and collecting analytics. These three tools in ZapWorks included Widgets, Designer, and Studio. However, only the tool Designer was employed in the AR tutorial workshop in which the student participants learned how to use an AR creator tool.

In sum, ZapWorks' Designer provided users with an opportunity to create customized, interactive AR content with advanced image tracking technology and a wide range of digital features, such as images, videos, hyperlinks, and interactive scenes. All these features were superimposed onto two-dimensional images that were source materials for AR content. An AR code on which AR content was viewed as called Zapcode (see Figure 3.1). A Zapcode was an individually unique, round or rectangular icon with a bolt symbol in the middle. Once scanned using a mobile device, a Zapcode would be detected and reveal pre-made, digital AR content that could be superimposed over a real object and which was saved and cloud-hosted on Zappar's servers. In ZapWorks' Designer, a Zapcode worked in conjunction with a particular image imported as a source image. That is, for a properly working ZapWorks-generated object, it should comprise a source (or tracking) image with a unique Zapcode, two of which would be scanned at once to reveal AR content.

Figure 3.1 A Zapcode

ZapWorks's Designer was employed in this study as an AR tool to create vocabulary flashcards as part of the AR activity to be implemented with the student participants. In order to create an AR vocabulary flashcard, a user had to follow these steps:

1. Students created an account at https://zap.works or www.zapcode.it.

2. Students logged-in to the account and click *Make A New Zapcode* blue button on the upper left side of the screen.

3. Students selected a style of a Zapcode, either a circular shape or a lozenge shape. Then name the Zapcode.

4. Three ZapWorks options would appear, which included Widgets, Designer, and Studio. Participants would choose Designer and then click *Create Zapcode*. At this moment, a unique Zapcode would be automatically created for this particular AR work.

5. Students selected a style for the Zapcode and download the Zapcode onto their computer in order to place it on a source image that would subsequently be called a tracking image.

6. Students clicked *Upload Tracking Image* in order to import your source image onto the working dashboard and get it ready to insert AR content. A ZapWorks system would automatically detect and analyze promising areas on the particular tracking image on which AR content should be placed for most effective and best viewing experience.

7. Once a tracking image was uploaded, a working canvas would appear (see Figure 3.2). On the right side of the screen would be a menu of AR content features. These features included Image, Photo Album, Video, Sound, Text, Button, Contact, and Calendar Event. To add AR content, drag and drop any of these features onto the tracking image to insert an AR object. Insert a previously generated Zapcode icon onto the tracking image.

8. When a ZapWorks work was ready for launching, students clicked Publish (orange button on the upper right side of the screen) to enable this work for public AR viewing.

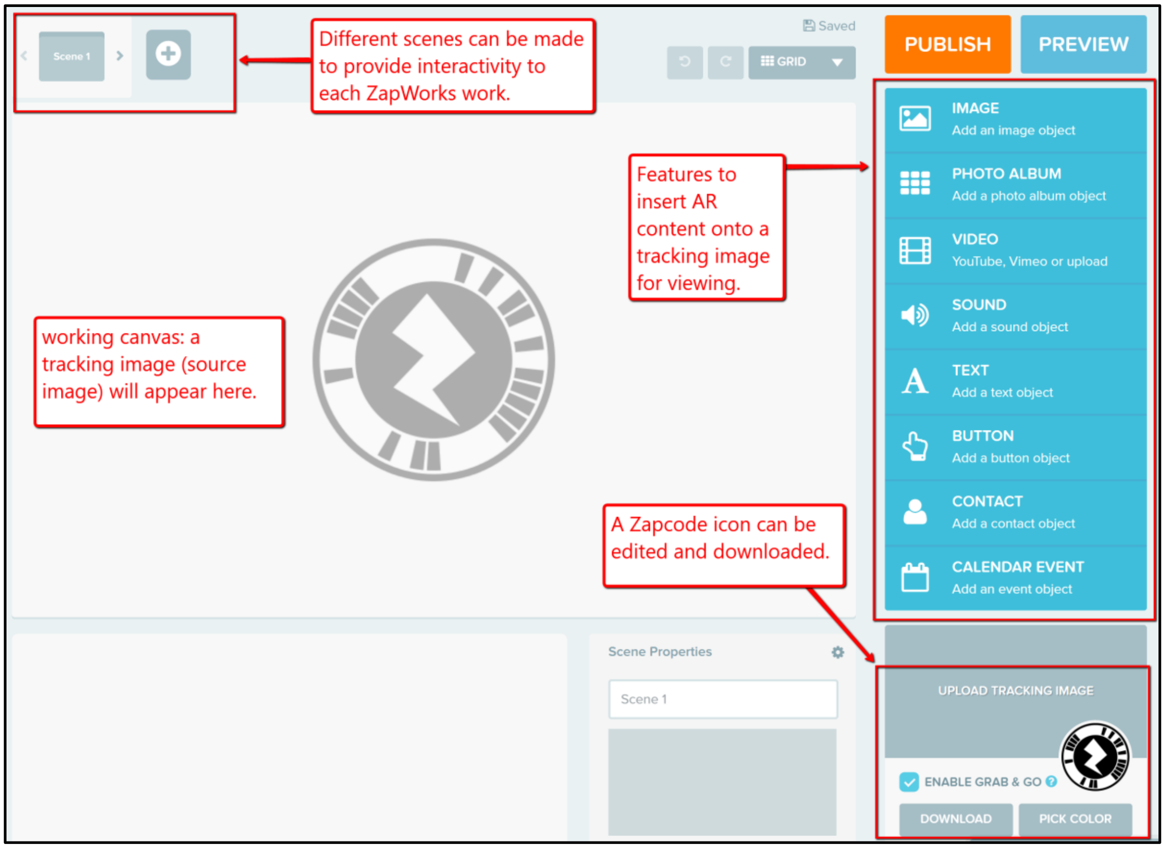


Figure 3.2 A working canvas on ZapWorks

Furthermore, to view the AR content on a given ZapWorks resource, users had to download the mobile application Zappar to their electronic devices. Zappar was available for free download both on iOS and Android operating systems. When Zappar was successfully installed, users could open it on a mobile device, then they could scan a ZapWorks resource (which is supposed to be a tracking image with an embedded Zapcode). Zappar would then automatically detect the AR content linked to the Zapcode and cloud-hosted before revealing the content instantly on a device screen. Figure 3.3 is a sample of an AR vocabulary flashcard prototype created by ZapWorks. Its AR content could be viewed by using Zappar to scan it.

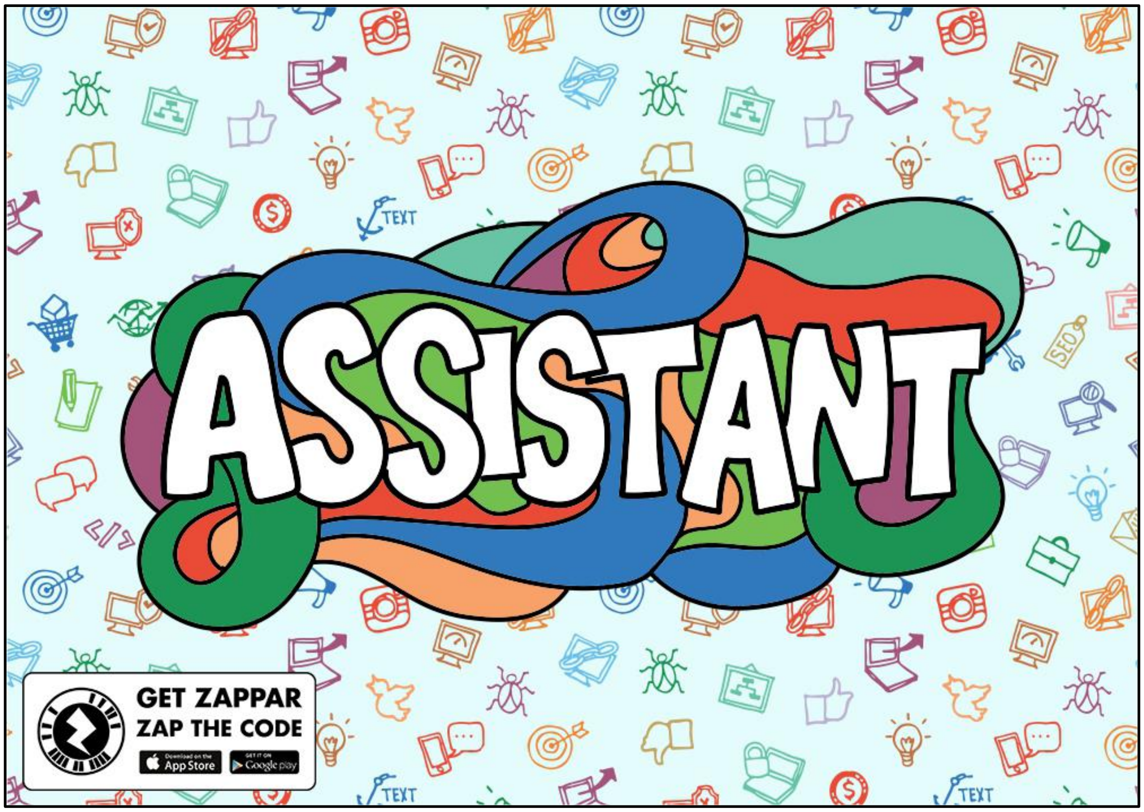


Figure 3.3 A sample of AR vocabulary flashcard

Quantitative Data Collection

The quantitative phase of the study focused on obtaining statistical data on the participants' use of technology and computer prior to and after the implementation of the AR-enhanced activity. The aim was to gain an understanding of how and to what extent they have used technologies to perform different kinds of tasks that are educationally and personally related on a daily basis. Moreover, this quantitative phase obtained initial statistical data on the participants' self-reported levels of acceptance and self-efficacy of the AR technology, which also included their perceptions about such technology. Two questionnaires were used in this phase.

Design of Questionnaires

Questionnaire on computer and the Internet use. Initially, a questionnaire on computer and the Internet use was administered with the students (see Appendix 5). This questionnaire sought to collect information about the participants' personal demographics, their familiarity with computer and the Internet use. It elicited information on the participants' technology use prior to the main implementation of the AR-enhanced vocabulary flashcard activity. Data obtained from this questionnaire were used to make revisions on the AR activity, such as the difficulty level of selected sets of vocabulary to be made into AR-enhanced flashcards. In addition, data obtained were used to estimate how many technological devices, support, and resources would be needed to provide sufficient resources to those participants with technological constraints prior to the actual AR activity.

The questionnaire was created by the researcher in cooperation with a group of experienced instructors and educational technologists with direct experience in the field of educational media and technology. Revisions on questionnaire items were made as seen appropriate from comments or suggestions from the experts (See Expert Evaluation and Pilot Study). The finally approved version of the questionnaire was then distributed and administered on paper in a classroom with the participants at the beginning of the course Analytical Reading in Fall 2017 in August, 2017.

The questionnaire on computer and the Internet use was comprised of three parts: 1) About You, 2) Computer and the Internet Use, and 3) Knowledge of Augmented Reality technology. In the first part, the questionnaire consisted of items seeking demographic information, i.e., age, gender and academic status. The second part consisted of self-identified items eliciting habitual use of computer and the Internet as well as types of technological devices used by the participants. In addition, there was a set of 5-point Likert-scale items seeking information about the frequency of computer and the Internet activities and/or applications used by the participants on a daily basis. The 5-point scale was coded as 5: All the time; 4: Often; 3: Sometimes; 2: Rarely; and 1: Never. The third part consisted of open-ended questions which seek the participants' pre-existing knowledge and/or understanding, if any, about the AR technology prior to their interactions with the AR resources central to the study. This particular AR section was used at the beginning of the study and also at the beginning of a new semester, which suggested a 3-month gap time. This allowed the participants to revisit their knowledge or understanding about the AR technology.

Questionnaire on the acceptance of Augmented Reality technology. The first research question "What were participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?", the second research question "After completing the activities, what level of self-efficacy did participating Thai undergraduates have in using augmented reality technology?", and the third question "After completing the activities, what were participating Thai undergraduates' intentions for using augmented reality technology in their future learning?" all sought to inform understanding the participants' perceptions, self-reported experiences, and self-efficacy levels in incorporating AR technology in classroom settings. To address these research questions, a questionnaire on the AR technology acceptance and self-efficacy (see Appendix 6) was devised by the researcher in cooperation with a group of experienced instructors and educational technologists with direct experience in the field of educational media and technology. Revisions on questionnaire items were then made as seen appropriate from comments or suggestions from the experts.

This questionnaire contained two main parts: 1) About Me and 2) Acceptance and Self-efficacy of Augmented Reality Technology. In the first part, the questionnaire was labelled with a unique identification code that matched each of the participants. These codes corresponded with those in the first questionnaire administered at the beginning of the course. Moreover, in this part, the 14 participants participating further in the interview session were asked to provide contact information, such as an e-mail address and/or a phone number.

The second part was divided into two sections: 1) Acceptance of Augmented Reality Technology and 2) Self-efficacy of Augmented Reality Technology. In the first section of AR technology acceptance, six constructs were assessed among the participants. These constructs were from TAM3 (Venkatesh & Bala, 2008) and included: 1) Perceived Ease of Use, 2) Perceived Usefulness, 3) Perceptions of External Control, 4) Computer Anxiety, 5) Perceived Enjoyment, and 6) Behavioral Intention. Based on each of the six constructs, four different statements were presented to measure each construct. Therefore, there were twenty-four questionnaire items overall in this section. The items' descriptions were adapted from studies by Shroff, Deneen, and Ng (2011), Luan and Teo (2011), and Venkatesh and Bala (2008). The response scale for all items in this section were a 5-point Likert scale coded as 5: Strongly agree; 4: Agree; 3: Neutral; 2: Disagree; and 1: Strongly disagree. Table 3.2 presents all twenty-four statements categorized by the six constructs to be measured.

Furthermore, prior to this data collection, the two questionnaires had been pilot tested on 10 volunteer undergraduates at Boston University and reviewed and evaluated by a few experts in educational technology (See Expert Evaluation and Pilot Study). The goal of the pilot study was to validate the instruments and to test its reliability for any revisions if necessary.

Table 3.2

Items for TAM3 constructs (Venkatesh & Bala, 2008) in questionnaire on acceptance of augmented reality technology

Constructs	Item statements
Perceived Usefulness	1. I find the AR system to be useful for my learning. 2. Using the AR system for my learning increases my productivity. 3. Using the AR system enhances my effectiveness for my learning. 4. Using the AR system improves my learning performance.
Perceived Ease of Use	1. Interacting with the AR system does not require a lot of my mental effort. 2. I find the AR system to be easy to use. 3. I find it easy to get the AR system to do what I want them to do. 4. My interaction with the AR system is clear and understandable.
Perceptions of External Control	1. I have control over using the AR system. 2. I had the resources necessary to use the AR system. 3. Given the resources, opportunities and knowledge it takes to use the AR system, it would be easy for me to use the system. 4. Resources needed to use the AR systems are sufficient for me.
Computer Anxiety	1. Working with the AR system makes me nervous. 2. The AR system makes me feel uncomfortable. 3. The AR system makes me feel uneasy. 4. Using the AR system scares me.

Perceived Enjoyment	1. I find using the AR system to be enjoyable. 2. The actual process of using the AR system is pleasant. 3. I had enjoyment while using the AR system. 4. I had fun using the AR system.
Behavioral Intention	1. Assuming I had access to the AR system, I intend to use it. 2. Given that I had access to the AR system, I predict that I would use it. 3. I plan to use the AR system in the near future. 4. I am determined to integrate the AR system for my future learning.

The second section of the questionnaire presented items to measure participants' assumed levels of self-efficacy, the seventh construct from TAM3 (Venkatesh & Bala, 2008), and was constructed based on a study by Compeau and Higgins (1995). There were ten statements overall that indicated the participants' self-reported level of self-efficacy in using the AR technology. Initially, after reading each statement, the participants chose an answer using a Yes/No dichotomous format. Then they self-rated their level of confidence based on the statement. The response scale for all items in this section was a 10-point Guttman scale (Venkatesh & Bala, 2008; Compeau & Higgins, 1995).

Besides, both questionnnaires were translated from English into Thai and were reviewed by the researcher an a translation specialist, to be administered with the Thai participants. The translations received approvals from the IRB at Boston University and Mahidol University (see Appendix 9 and Appendix 4, respectively).

Data Collection of Questionnaires

Prior to the study, the researcher sought the official Institutional Review Board (IRB) approvals from Boston University and Mahidol University (see Appendix 1 and Appendix 4, respectively). Once these approvals were obtained, the researcher contacted the dean of the Faculty of Liberal Arts, Mahidol University via an official letter to obtain an official approval to conduct the study. Upon receiving permission and prior to the start of the course Analytical Reading, the students were given with an introductory orientation about AR technology and the study. They were also informed about the research aims, scope, and procedures. They were invited to join and asked to give consent. Rights to study withdrawal and confidentiality matters were communicated with the participants to ensure that they were aware of procedures and how their data would be obtained, stored, and analyzed.

At the beginning of the course Analytical Reading, the questionnaire on computer and the Internet use was administered to the student participants in a print format. Alphabetical-numeric codes were assigned to each of the participants on their questionnaire for a convenience of further identification. Later, after each of the three phases of the implementation of the AR-enhanced activity, the questionnaire on acceptance and self-efficacy of augmented reality technology was administered among the participants. The format was also in print with alphabetical-numeric codes that matched those assigned in the first questionnaire.

Both questionnaires were administered at the Faculty of Liberal Arts, Mahidol University. The participants completed each questionnaire at a scheduled time in a designated classroom in the presence of the researcher.

Data Analyses

For the questionnaire on computer and the Internet use, a descriptive statistical report was created. Descriptive statistical analysis was conducted to show the means and standard deviations of the sample group in terms of their technology and computer use, and to display how their computer and the Internet proficiency were ranked or reported among the sample group. In addition, for the questionnaire on the AR technology acceptance and self-efficacy, a descriptive statistical report was made alongside a calculation of a factor analysis and a Cronbach's Alpha calculation on questionnaire items validity and internal consistency. The statistical calculations of Repeated Measures ANOVA and Pearson correlation coefficient were also used with the three versions of the questionnaire on the acceptance of AR technology, that was implemented at three phases during the classroom AR activity treatment. This was to detect any overall differences between related means from the same sample group.

Reliability and Validity

Pilot testing provided necessary information for revisions to obtain test-retest reliability of the questionnaire items. A group of experts in educational technology and the researcher worked collaboratively to ensure content and face validity of the questionnaire items. That is, the wording and phrasing of all questionnaire items were examined, pilot tested and revised to ensure that all item statements were accurate representatives of seven constructs based on TAM3 (Venkatesh & Bala, 2008).

Qualitative Data Collection

The qualitative phase of the study focused on obtaining in-depth data on the participants' experiences and perceptions about the integration of AR technology in their classroom after the completion of the AR activity. A multiple case-study research design was used to collect and analyze qualitative data (Creswell, 2014) which stemmed from two main sources: classroom observations and interviews.

Design of Classroom Observation Protocol

The classroom observation protocol was devised to help the researcher take notes when participating in the AR-enhanced activity in their classroom visits with potential participants' permission. The researcher created the classroom observation protocol (see Appendix 11) based on sections of the ISTE Classroom Observation Tool (ICOT) (2008). This protocol also applied the concept of Critical Events. Critical Events is an approach that "allows the observer to capture and preserve some of the essence of what is happening in lessons" (Wragg, 1999, p. 67). With this technique, the researcher acted as a non-participant observer looking for specific instances of classroom behaviors that were considered to be illustrative of salient aspect of the students' interactions or strategies in dealing with the AR-enhanced activities of which the researcher was seeking to take note.

Design of Interview Protocol

An interview protocol (See Appendix 7) was constructed by the researcher based on the TAM3 constructs (Venkatesh & Bala, 2008) to investigate how potential participants perceive the AR technology based on the seven research constructs: 1)

Perceived Ease of Use, 2) Perceived Usefulness, 3) Perceptions of External Control, 4) Computer Anxiety, 5) Perceived Enjoyment, 6) Behavioral Intention, and 7) Computer Self-efficacy. These seven constructs matched and corresponded to the two questionnaires the students had previously completed. The interview protocol was comprised of a set of open-ended, semi-structured questions/statements to elicit participants past experiences with the AR-mediated learning activities. The questions/statements were created based on each of the seven constructs. This interview protocol was administered in an individual interview which lasted about 20 to 45 minutes depending on the consent and willingness of each of the 14 interviewees. The interview session was via Skype and was audio-recorded upon interviewees' consent. It took place after the implementation of the AR-enhanced activity and after the completion of the second questionnaire. The participants who provided interview consent specified in the first part of the second questionnaire was contacted to arrange convenient interview schedule. The researcher had reviewed this interview protocol with a group of specialists in educational media and technology for possible revisions.

Data Analyses

For qualitative analysis, an interactive coding strategies approach as suggested by Creswell (2014, pp. 194-201) was employed. First of all, all audio-recordings of the interviews were digitally formatted, stored, and transcribed using Audacity, a free audio editing software. These data along the classroom observation field notes were then coded with Qualitative Software and Research (QSR) NVivo 11, a qualitative research data analysis software. Coding was carried out to identify emerging categories or themes as well as an overview of the relationships among all the data. Once coding was complete, the categories and themes were reviewed by other two Thai specialists who received their doctoral degrees in educational media and technology, to reveal the degree of correspondence among the data sets and to facilitate interpretation of the findings. Quoted statements in Thai language by the participants selected for inclusion in the dissertation were accompanied by an English translation when reporting in Chapter 4. The quoted statements were also reviewed by the two specialists for accuracy.

Reliability and Triangulation

Reliability and credibility of the qualitative instruments came from the collaborative work between the researcher and a group of specialists in educational media and technology who ensured that the interview and classroom observation protocols represented questions/statements that appropriately and accurately described or categorized the participants' experiences and perception about the use of AR technology. Pilot testing provided an opportunity for any necessary revisions. To ensure data reliability, a process of triangulation was performed. This triangulation compared for consistencies and conflicts the different sources of collected data including interviews, classroom observations, and other documents, such as a course syllabus and lesson plans. The researcher and invited specialists achieved inter-rater reliability in coding the interview and classroom observation data to provide consistency of coded categories and emerging themes.

Procedures for Data Collection

A description of the procedures for data collection, both in quantitative and qualitative phases of the study is presented next and summarized in Figure 14 below.

1. Student participants were informed of the scope and content of the research project. They were asked to read and sign a consent form for participation. They were provided with an introductory orientation on augmented reality technology and the study.

2. The questionnaire on the computer and the Internet use was administered with all 48 participants. This questionnaire elicited their experience and competency in using technology of different types and for different purposes based on their daily, common use. Moreover, they were asked to provide information about their initial understanding or knowledge of AR technology prior to the implementation of a classroom AR activities treatment.

3. The classroom AR activities treatment was later implemented with the student participants. This activity was comprised of three phases: 1) the Teacher Showcase (a showcase of teacher-made AR-enhanced vocabulary flashcards), 2) the AR Computer Tutorial Class (an AR computer tutorial workshop), and 3) the Student Showcase (a showcase of student-made AR-enhanced vocabulary flashcards). In addition, at the end of each of these three phases, a questionnaire on the acceptance of AR technology was administered. The student participants were asked to complete the questionnaire that seeks information about their perceptions, acceptance and self-efficacy levels in using AR technology.

5. The 14 consented participants for further interview were invited for one-on-one interview in which they were answering a set of semi-structured questions regarding their past experience in integrating the AR technology in their English language classroom. An interview session lasted about 20 to 45 minutes, was conducted in Thai (participants' first language), and was audio recorded upon consent.

6. Three months after the interview which was approximately at the beginning of a following academic semester (Spring 2018), the student participants were again asked to answer a set of questions regarding their understanding and/or knowledge of the AR technology. This set of questions was in a similar fashion as that in the two questionnaires.

A questionnaire on the computer and the Internet use with an added open-ended section on preexisting AR knowledge and understanding was administered.

Classroom AR activities treatment

Step 1
Teacher Showcase: the researcher gave an orientation and a showcase session in which students had hands-on experience playing with AR vocab flashcards which were pre-made. This provided them a feel of what and how AR looked like, especially in language classrooms.

Version 1 of Questionnaire on the acceptance of AR technology was administered.

Step 2
AR Tutorial Class: After the teacher explained about the session's assignment requirements, the researcher scheduled a time and organize an AR tutorial workshop at a computer lab. In this workshop, the students were taught and trained how to use ZapWorks application to create AR vocab flashcards. They were also given a guideline of minimum requirements for the flashcards. They also had freedom to use their creativity to make the flashcards more interactive and interesting, while still meeting basic requirements.

Version 2 of Questionnaire on the acceptance of AR technology was administered.

Step 3
Student Pair/Group Work and Showcase: After the computer workshop, the students spent three weeks in creating their own flashcards using ZapWorks application. During this time, technical and resource assistance were provided as requested. Then the students showcased their work in the classroom so that other classmates can tried out other pairs' works.

Version 3 of Questionnaire on the acceptance of AR technology was administered.

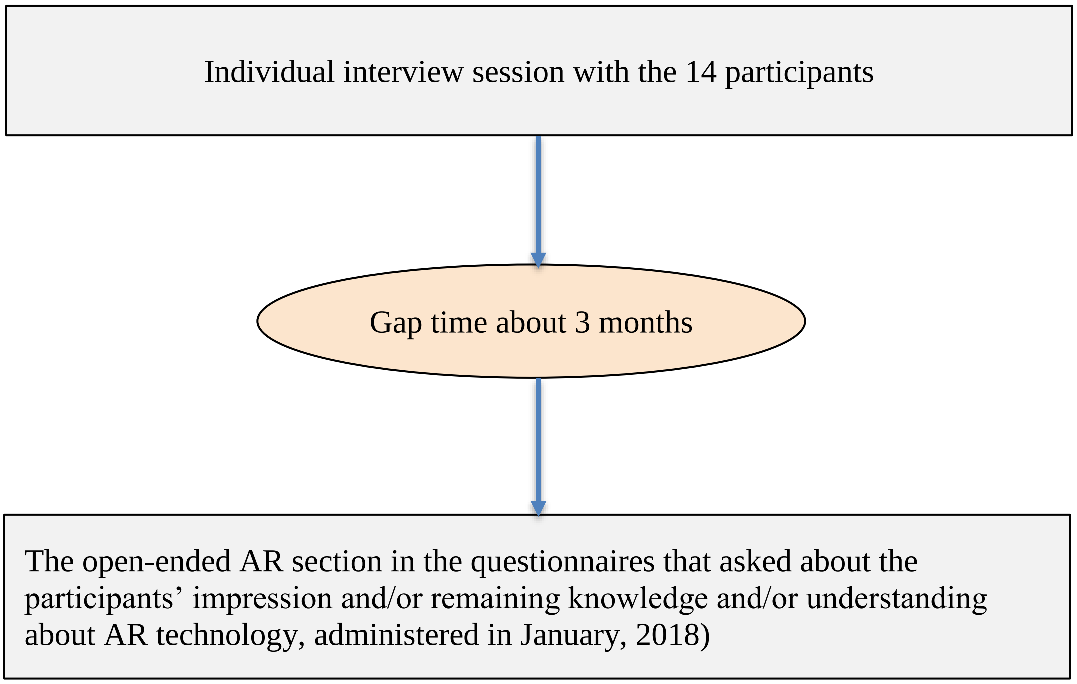


Figure 3.4 Tentative Procedures of Data Collection

Role of the Researcher

The researcher’s role and involvement in this study was in both phases of data collection. In the quantitative data collection, the researcher took a major responsibility in contacting with the participants, scheduling time for them to complete both questionnaires, and administering the questionnaires. In addition, the researcher stored, managed, and performed statistical calculation on collected data. In the qualitative data collection, the researcher participated by organizing and leading an AR tutorial workshop for the participants. During and after the workshop, the researcher provided technical assistance and support when requested. In conducting the interviews, the researcher lead the session and acted as the interviewer. The researcher recorded, stored, managed, transcribed, and performed coding and theming of the interview data. The researcher exercised due diligence during the interviews to ensure he did not bias the participants' responses, answers, or behaviors that might lead to misinterpretation or an inaccuracy of research results.

Research Permission and Ethical Considerations

This research study underwent Institutional Review Board (IRB) application processes at Boston University and at Mahidol University and successfully obtained official approvals prior to data collection. Three ethical issues that might arise from this research study included transparency, anonymity, and the confidentiality of potential data. To ensure transparency, the participants were given a clear outline of the research procedures and data analysis. It was made clear that there would be no obligation to participate in the study, and that they had rights to withdraw from the study at any time without having to give a reason. The participants who were observed and/or interviewed were given the opportunity to read and comment upon the transcriptions for accuracy and clarification, upon their request. To ensure anonymity, the identity of participants and their personal data (e.g. demographic information and education backgrounds), were transferred to using an alphabetical-numeric code. All data files and paper documents were labeled with these participant numbers, and the list linking participant identity with participant number was kept separately from the data. Only my dissertation committee members and I had access to the raw data. Participants were referred to by codes (e.g., S01) in the dissertation. Data recorded on paper were kept in a securely locked cabinet to which only the researcher has access. All collected data were digitally formatted, encrypted, organized, and stored in a password-protected external hard-drive and on a OneDrive for Business cloud folder. Data were transferred via an encrypted USB flash drive or via OneDrive for Business, a HIPAA and FERPA compliant cloud hosting service. Any identifying information was omitted from the transcriptions, which was anonymized. All data containing potentially identifying information were kept securely until the dissertation was approved, and then destroyed; anonymized data were retained indefinitely for use by academic researchers.

CHAPTER FOUR

FINDINGS

Introduction

This study investigated Thai undergraduate perceptions of using Augmented Reality (AR) technology in an English-speaking classroom in an English as a Foreign Language (EFL) setting. It also investigated the undergraduate experience and participants' perceived self-efficacy and technology acceptance of the integration of AR technology. The research utilized both qualitative and quantitative data analyses to address the following research questions:

1. What were participating Thai undergraduate perceptions of the usefulness and ease of use of augmented reality technology activities as implemented in their classrooms?

2. After completing the activities, what level of self-efficacy did participating Thai undergraduates experience in using augmented reality technology?

3. After completing the activities, what were participating Thai undergraduates' intentions for using augmented reality technology in their future learning?

The data to answer the above research questions were drawn principally from individual interviews. However, descriptive statistical reports from a questionnaire on the use of computers and the Internet, and three forms of a questionnaire on AR technology acceptance and self-efficacy also were implemented. Additionally, field-note accounts from classroom observations and document analyses of the course syllabus and other teaching materials from the course Analytical Reading. The interviews, the questionnaires, the observations, and the document analyses provided triangulation as a check on the data to improve research reliability. In this chapter, the findings are reported by the research questions and supported by selected excerpts of interview data coded as emerging themes and sub-themes. Because the interviews were conducted in Thai language, all quoted excerpts are English translations. Codes from S01 to S24 individually designated each of the 24 participants. Some parts of the quoted excerpts are in bolded fonts for emphasis.

Overview of Quantitative and Qualitative Analyses

Statistical calculations provided analysis of the questionnaire data. For the questionnaire on computer and Internet use, a descriptive statistical and frequency report presents the means and standard deviations in terms of participants' demographic information, technology and computer usage, and display of how their computer and Internet proficiency were ranked among the sample group. In addition, this chapter also presents a calculation of Cronbach's Alpha on the internal consistency of the questionnaire items on AR technology acceptance and self-efficacy. The statistical calculation of Pearson product-moment correlation coefficients and Repeated Measures ANOVA also examined any significant associations between the determinants/constructs based on the Technology Acceptance Model 3 (TAM3, Vankatesh & Bala, 2008) across the three forms of the questionnaire on the acceptance and self-efficacy of AR technology. A Repeated Measures ANOVA detected any overall differences between related means of the constructs studied across all the phases of questionnaire administration.

Qualitative analysis of semi-structured interviews and classroom observation field notes collected from the three phases of the classroom AR treatment provide context and depth to the questionnaire findings. The interviews were semi-structured with a set of open-ended questions based on the determinants or constructs in TAM3, including 1) Perceived Usefulness, 2) Perceived Ease of Use, 3) Behavioral Intention, 4) Computer Anxiety, 5) Perception of External Factor, 6) Computer Self-efficacy, and 7) Perceived Enjoyment (Vankatesh & Bala, 2008).

The interview questions also aimed at investigating opinions, experiences and perspectives of the students regarding their perceptions and self-efficacy of using AR technology in enhancing their learning performance. The interviews were between 25 and up to 45 minutes in duration depending on the extent of an individual interviewee's responses. Each interview was audio recorded, digitized and digitally stored as an MP3 file, translated by the researcher, and transcribed into a Microsoft Word document file. All document files of transcriptions were loaded into NVivo11, a qualitative analysis software package, for coding and theme categorization. Subsequently, the categorized, coded themes were inter-rated and cross-checked for accuracy and agreement in coded themes by two experts: an educator and a lecturer of English with doctoral degrees in Curriculum and Teaching with a specialization in Educational Media and Technology. The inter-rating process provided reliability to the coded themes. These two inter-raters, who are fluent in English and Thai natives, also reviewed the English translations of those coded scripts included in this dissertation.

The researcher assigned participants an alphanumeric code name spanning from S01 to S24 to protect his or her confidentiality and identity. Interactive coding strategies by Creswell (2014) and interpretational analyses by Patton (2003) provided the methods of qualitative data analysis.

The researcher employed a classroom observation protocol consistently across all classroom observations in which the three-phase AR treatment was implemented. The protocol was devised based on the International Society for Technology in Education (ISTE)'s Classroom Observation Tool (ICOT, 2008) in combination with the concept of Critical Events in classroom observation by Wragg (1999, p. 67). The researcher took notes while observing and monitoring the class activity during each of the three phases: Teacher Showcase, AR Computer Tutorial, and Student Showcase. Nevertheless, because the researcher served as a workshop presenter in the AR Computer Tutorial, he spent time during allocated periods to observe individual work. He also made observational notes from the workshop video-recordings.

Characteristics of the Participants in the Questionnaires Phase

Participants in this study comprised a cohort of forty-eight Thai undergraduates (*N*=48) in the English major at the Faculty of Liberal Arts, Mahidol University, Thailand. The cohort consisted of 39 females (81.3%) and 9 males (18.8%) ranging in age from 19 to 21 years. One participant was 19 years old, 35 students were 21 years old, and 12 students were 21 years old. All the participants were in their third academic year and enrolled in the core course Analytical Reading in the Fall 2017 semester—the course that provided the context for this research. These 48 undergraduates all participated in the questionnaire phase, which involved a total of four questionnaires; the questionnaire on the computer and the Internet use, and three forms of the questionnaires on the acceptance and self-efficacy of AR technology. These participants reportedly learned English as a foreign language (EFL), and they had studied English for a different number of years. They also came from diverse socio-economic backgrounds, and they came from different cultural regions of Thailand. Table 4.1 presents self-reports of the participants' perceived English proficiency in four language skills: listening, speaking, reading, and writing.

Table 4.1

Participants' self-reported levels of English proficiency (*N*=48)

Writing				
		Frequency	Percent	Cumulative Percent
Self-reported proficiency level	Intermediate	27	56.3	56.3
	Upper-intermediate	19	39.6	95.8
	Advanced	2	4.2	100.0
	Total	48	100.0	
Reading				
		Frequency	Percent	Cumulative Percent
Self-reported proficiency level	Intermediate	15	31.3	31.3
	Upper-intermediate	28	58.3	89.6
	Advanced	5	10.4	100.0
	Total	48	100.0	
Speaking				
		Frequency	Percent	Cumulative Percent
Self-reported proficiency level	Beginner	4	8.3	8.3
	Intermediate	19	39.6	47.9

		Frequency	Percent	Cumulative Percent
	Upper-intermediate	18	37.5	85.4
	Advanced	6	12.5	97.9
	Expert (Native)	1	2.1	100.0
	Total	48	100.0	

Listening

		Frequency	Percent	Cumulative Percent
Self-reported proficiency level	Beginner	2	4.2	4.2
	Intermediate	17	35.4	39.6
	Upper-intermediate	19	39.6	79.2
	Advanced	10	20.8	100.0
	Total	48	100.0	

Table 4.1 presents self-reports of the participants' perceived English proficiency in four language skills, i.e. listening, speaking, reading, and writing. The majority of the participants perceived themselves to be either Intermediate or Upper-intermediate users of English in all four language skills. Only a small fraction reported that they were either beginner or advanced users of English.

Characteristics of the Participants in the Interview Phase

Of the 48 participants, 24 individually consented to have a one-on-one phone interview with the researcher: 21 females and 3 males. The researcher initially asked participants for their interview consent during the questionnaires phase. He then contacted those who agreed via either e-mail or phone and informed them about their rights of confidentiality. In cases where the researcher required any clarification of their previously provided responses, some interviewees also participated in a follow-up interview.

Use and Usage of Computers and the Internet

The researcher administered the questionnaire about computer and Internet use at the beginning of the course Analytical Reading. Participants' information about their habitual usage of computers and the Internet provided the following quantitative data. All participants reported that they owned smartphones of varying models and operating systems. Nearly all the participants (97.9%) also reported that they owned personal computers, while only 35% had tablets. As for their frequency of personal computers use, 72.9% of the participants reportedly spent on average 1 to 4 hours per day of screen time, whereas 2% had over 12 hours of daily screen time. Furthermore, 76.9% of those with tablets reported spending approximately 1 to 4 hours of screen time on a daily basis. Regarding the usage of smartphones, almost half of the participants (45.8%) spent about 5 to 8 hours per day of screen time, 27.1% had less than 4 hours of screen time, and another 27.1% had about 9 to 12 hours of daily screen time. In addition to the usage of computers and tablets, half of the participants (50%) spent an average of 5 to 8 hours surfing the Internet daily, 31.3% spent 9 to 12 hours, and 18.8% spent 1 to 4 hours.

Not only did the questionnaire elicit the participants' frequency of screen time, it also collected data on participants' frequency of engaging in different kinds of activities through their devices and the Internet. Two sub-sections: personal use and educational use present this data in the student activity section (see Table 4.2). The response scale for all the questionnaire items in this section was a 5-point Likert scale coded as 5: All of the time; 4: Often; 3: Sometimes; 2: Rarely; and 1: Never.

Social Media (*M*=4.42, *SD*=.64), Movies and Music (*M*=4.06, *SD*=.43), and File Sharing (*M*=3.50, *SD*=.98) were the three most frequently reported activities for which the participants used their devices and the Internet for personal purposes (see Table 4.2). Graphics (*M*=2.08, *SD*=.79) and Gaming (*M*=2.79, *SD*=1.2) were the least frequent activities, respectively. As for the participants' learning purposes, the descriptive statistical data in Table 4.3 revealed that the participants reaped the benefit of computers and the Internet for communicating with peers and teachers through Social Media (*M*=4.23, *SD*=.59) the most, followed by Information Searching (*M*=4.21, *SD*=.54) and Online Applications for Homework (*M*=3.81, *SD*=.53), respectively. File Sharing (*M*=3.35, *SD*=.81) was ranked the least frequent activity for educational use, though it was placed among the top three activities for personal purposes.

Table 4.2

Descriptive statistical reports of the participants' personal use of computers and the Internet (*N*=48)

	Minimum score	Maximum score	Mean	Std. Deviation
1 Gaming	1	4	2.79	1.202
2 Movies & Music	3	5	4.06	.433
3 Graphics	1	4	2.08	.794
4 Office software	2	5	3.46	.683
5 Email	2	5	3.42	.739
6 File sharing	1	5	3.50	.989
7 E-commerce	1	4	3.23	.805
8 E-banking	1	4	3.04	1.010
9 Social media	2	5	4.42	.647

Table 4.3

Descriptive statistical reports of the participants' educational use of computers and the Internet (*N*=48)

	Minimum score	Maximum score	Mean	Std. Deviation
1 Info searching	3	5	4.21	.544
2 Office software	2	5	3.65	.668
3 Online apps for homework	3	5	3.81	.532
4 Email	2	5	3.65	.699
5 File sharing	1	5	3.35	.812
6 Social media	3	5	4.23	.592

The last section of the questionnaire on the computer and the Internet use asked participants to report their experience in using technologies in other courses as well as their prior or existing knowledge about AR technology. The findings showed that all participants reported extensive integration of diverse technologies in several other core and elective courses offered by university faculty. Nevertheless, when asked whether they had ever used, known about, or previously heard of AR technology, 93.8% of the participants noted that they had no knowledge about it, while only 6.3% reported that they saw some AR technology applications in advertisements, entertainment and social media, and medical science. None of the participants, however, reported that they had ever experienced a hands-on, direct implementation of AR technology.

Self-Derived Definitions of Augmented Reality (AR) Technology

Before the commencement of the classroom AR treatment and the administration of the questionnaires on acceptance of AR, the researcher provided an introductory presentation to all 48 participants on the overview of the research study and about mobile AR. In this orientation presentation, the participants learned about AR in general, its varied terms and descriptions, and its fundamental technical/operational functions, as well as its present utilizations in disparate fields, such as architecture, medical science, engineering, and advertising. It was significant that very few of the participants had ever heard of or used AR before. Further, none could provide descriptions of what AR is and could do.

Two weeks after the three-stage classroom AR treatment, the researcher asked the 24 students who consented to a follow-up interview once again to state their understanding of AR technology by providing their explanations of AR and what it can do. This resulted in a variety of responses. Some provided relatively accurate conceptual definitions or descriptions of AR, but others struggled to express a general concept of AR because they focused narrowly on the technical or operational features of the AR tools, such as ZapWorks and Zappar.

For instance, S13 inaccurately defined AR as "a program that brings all kind of knowledge into images or flashcards…and when we use smart phones to scan the flashcards, the information will appear on our phones." Her description of AR apparently was derived from her impression of how ZapWorks functions and, in particular, how Zappar operates, rather than expressing AR as a concept or idea. By contrast, S19 defined AR technology more accurately as "a technology that uses graphics and other elements which are realistic to create realistic simulation experience that combines the reality world." Another even more concise definition was reported by S24 who stated that AR technology "…take[s] advantage of computer graphics to invent realistic two-dimensional and even three-dimensional objects to be on top of/superimposed on the real objects in our real world."

Some interviewees simply associated AR with computer games they had played in their attempt to render their own understanding of what AR is. S02, for instance, mentioned:

> *"AR [technology] could be like realistic graphics something like that…when you play [the zapcode of ZapWorks] you will feel like you are in some sort of computer game where you are in a newly invented world with lots of characters or objects to play with…"*

S02's definition of AR was moderately misconceived, closer to a definition of Virtual Reality technology (VR), in which the computer environment is "completely immers[ing] a user inside a synthetic environment" (Kipper & Rampolla, 2013, p.1) than to AR. AR environments, by contrast, are real yet enhanced by virtual sensory inputs of different kinds. Milgram and Kishino (1994) defined computer games as extending across a continuum of Mixed Reality (MR) rather than as VR experiences in purely computer-generated environments without any association to real-world surroundings. S07 provided an example of successfully relating AR to VR through a feasible definition:

> *"…VR is the technology in which we are supposed to wear some sort of glasses or helmets to view content in a computer world.* ***But AR, to me, probably uses a different set of equipment, yet it provides similar simulation experiences that link the virtual and the real world, not all the real world****."*

In brief, all interviewees differed in their execution of AR definitions. A few even admitted that they could not define AR at all, yet they were able to explain the functions of ZapWorks and Zappar. Some of the interviewees, by contrast, confidently defined AR based on the knowledge gained from the introductory orientation, entwined with their use of the tools in the AR Computer Tutorial. A few others provided AR definitions that were confusing, principally through mistaking AR technology for VR technology.

Perceptions of the Usefulness of AR

This section presents quantitative and qualitative findings to answer partially the research question: "*What are participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?* (RQ1)." The researcher utilized both descriptive statistical analysis of the questionnaire on the acceptance and self-efficacy of AR technology and qualitative data obtained from the interviews and classroom observations to address RQ1. Different sets of quantitative data are presented first, followed by extensive qualitative data from the interviews, classroom observations, and other course materials.

Statistical Findings of Perceptions of the Usefulness of AR

Davis defined Perceived Usefulness as, "the degree to which a person believes that using a particular system would enhance his or her job performance" (1989, p. 320). The next section presents statistical analysis of the data collected on perceived usefulness from the three paper forms of the questionnaire on the acceptance of AR technology, which were administered at three different stages as described above.

Table 4.4

Descriptive statistical reports of the mean scores of participants' Perceived Usefulness, after Teacher Showcase, AR Computer Tutorial, and Student Showcase (*N*=48)

Questionnaire items	After Teacher Showcase (Form 1)	After AR Computer Tutorial (Form 2)	After Student Showcase (Form 3)
1. I find the AR system to be useful for my learning.	4.08	4.15	4.19
2. Using the AR system for my learning increases my productivity.	4.02	4.00	4.04
3. Using/ playing with the AR system enhances my effectiveness for my learning.	3.98	3.90	3.94
4. Using/ playing with the AR system improves my learning performance.	3.92	4.13	4.04
Descriptive Statistics			
Mean	16.00	16.16	16.20
Std. Deviation	1.72	1.73	1.99
Cronbach's Alpha	.826	.729	.865

Table 4.4 shows the set of four questionnaire statements that measured the construct of Perceived Usefulness, and the mean scores, collected at three, sequential stages of the research procedure: after the Teacher Showcase; after the AR Computer Tutorial, and after the Student Showcase. The students reportedly perceived AR technology as generally useful (*M*=16.00, *SD*=1.72, *α*=.82) after they received an orientation presentation on AR technology followed by a play session with a set of teacher-made AR-enhanced vocabulary flashcards. This was despite the fact that most of them (93.8%) never had any hands-on experience with AR. The students' Perceived Usefulness marked a continuing increase after the AR Computer Tutorial (*M*=16.16, *SD*=1.73, *α*=.72). These findings suggest that once the students were equipped with technological training or workshop exposure in which they learned firsthand about how a certain technology operates, they started to realize its potential usefulness. In addition,

after the Student Showcase, the students' Perceived Usefulness also increased (*M*=16.20, *SD*=1.99, *α*=.86). Their perceptions of the usefulness improved, which could suggest that, with the time needed to get accustomed to new technologies, users tended to feel more fully cognizant of the prospective advantages of the given AR technologies employed in this research. The rise in the Perceived Usefulness measure may also be associated with the extent to which the students fully acknowledged practical applications brought about by the given technology, rather than simply appreciating it from a conceptual perspective. Full discussion of these interpretations is presented in Chapter 5.

A calculation of Repeated Measures ANOVA (see Table 4.5) compared the difference in the means across the construct of Perceived Usefulness in the three repeated questionnaire administrations at three different times. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean Computer Self-Efficacy level did not differ statistically significantly across the three time points ($F(1.1671, 89.845) = .273$, $p=.752$). Post hoc tests using the Bonferroni correction revealed a small increase in the participants' Perceived Usefulness after the Teacher Showcase and after the AR Computer Tutorial (16.00 ± 1.72 mg/L vs 16.16 ± 1.73 mg/L, respectively), which was not statistically significant ($p=1.00$). Perceived Usefulness measured after the Student Showcase showed a slight increase to 16.20 ± 1.99 mg/L, but this was not significantly different from the measures after the Teacher Showcase ($p=1.00$) and after the AR Computer Tutorial ($p=1.00$) session. Statistically, the three-phase AR activity treatment did not elicit any significant difference in the construct of Perceived Usefulness among the 48 participants.

Table 4.5

Statistical report of Repeated Measures ANOVA of the compared means of the level of Perceived Usefulness, collected after the Teacher Showcase, the AR Computer Tutorial and the Student Showcase (*N*=48)

Descriptive Statistics

	Mean	Std. Deviation	N
Overall mean (Form 1) after the Teacher Showcase	16.00	1.72	48
Overall mean (Form 2) after the AR Computer Tutorial	16.16	1.73	48
Overall mean (Form 3) after the Student Showcase	16.20	1.99	48

Tests of Within-Subjects Effects

Perceived Usefulness

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	1.167	2	.583	.273	.762
	Greenhouse-Geisser	**1.167**	**1.912**	**.610**	**.273**	**.752**
	Huynh-Feldt	1.167	1.991	.586	.273	.761
	Lower-bound	1.167	1.000	1.167	.273	.604
Error (Time)	Sphericity Assumed	200.833	94	2.137		
	Greenhouse-Geisser	200.833	**89.845**	2.235		
	Huynh-Feldt	200.833	93.562	2.147		
	Lower-bound	200.833	47.000	4.273		

Pairwise Comparisons

		Mean Difference	Std. Error	Sig.a	95% Confidence Interval for Differencea Lower Bound	Upper Bound
(Form 1) after the Teacher Showcase	(Form 2) after the AR Computer Tutorial	-.167	.280	**1.000**	-.861	.528
	(Form 3) after the Student Showcase	-.208	.329	**1.000**	-1.025	.608
(Form 2) after the AR Computer Tutorial	(Form 1) after the Teacher Showcase	.167	.280	1.000	-.528	.861
	(Form 3) after the Student Showcase	-.042	.284	**1.000**	-.747	.663
(Form 3) after the Student Showcase	(Form 1) after the Teacher Showcase	.208	.329	1.000	-.608	1.025
	(Form 2 after the AR Computer Tutorial					

Pearson product-moment correlation coefficients were also computed to assess the relationship(s) between the determinant Perceived Usefulness and other determinants in TAM3 (Venkatesh & Bala, 2008) which included Perceived Ease of Use, Behavioral Intention, Perception of External Factor, Computer Anxiety, and Perceived Enjoyment (see Table 4.6).

Following the Teacher Showcase, there was a weak positive association between the variables Perceived Usefulness, Perceived Enjoyment ($r(48)=.478$, $p=.001$), Perceived Ease of Use, ($r(48)=.402$, $p=.005$) and Behavioral Intention ($r(48)=.397$, $p=.005$), respectively. The findings, however, addressed no significant correlation between Perceived Usefulness, Computer Anxiety and Perception of External Factor.

Table 4.6

Report of the Pearson correlation coefficients of Perceived Usefulness and other determinants in TAM3 (Vankatesh & Bala, 2008), from after Teacher Showcase, AR Computer Tutorial and Student Showcase. (*N*=48)

		Perceived Useful-ness	Perceived Ease of Use	Beha-vioral Intention	Percep-tion of External Factor	Computer Anxiety	Perceived Enjoy-ment
Perceived Usefulness After Teacher Showcase	Pearson Correlation	1	**.402***	**.397***	.258	-.202	**.478****
	Sig. (2-tailed)		.005	.005	.077	.169	.001
Perceived Usefulness After AR Computer Tutorial	Pearson Correlation	1	**.580****	**.658****	**.370****	-.067	**.468****
	Sig. (2-tailed)		.000	.000	.010	.653	.001
Perceived Usefulness After Student Showcase	Pearson Correlation	1	**.592****	**.511****	**.610****	**-.437****	**.399***
	Sig. (2-tailed)		.000	.000	.000	.002	.005

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Furthermore, based on the correlation coefficients analyzed after the AR Computer Tutorial, the statistical data revealed that there was a moderate positive association between the variables Perceived Usefulness, Perceived Ease of Use (r(48)=.580, *p*<.000) and Behavioral Intention (r(48)=.658, *p*<.000). Meanwhile, there was a weak positive association between Perceived Usefulness and Perceived Enjoyment (r(48)=.468, *p*=.001). The data also showed a weak positive correlation between

Perceived Usefulness and Perception of External Factor (r(48)=.370, *p*=.01) after the AR Computer Tutorial, which was statistically insignificant after the Teacher Showcase. The statistical evidence suggests that after the participants attended the tutorial workshop, they were more likely to be aware of the role of technical and technological resources to assist them in successfully carrying out the AR flashcard projects or tasks. The coefficients of Perceived Ease of Use and Behavioral Intention rose relatively dramatically from those in the Teacher Showcase phase. This suggests that the participants found a stronger relationship between these two variables and their Perceived Usefulness.

The Pearson correlation coefficients were also calculated from the questionnaire administered after the Student Showcase phase. In Table 4.6, the determinant Perceived Usefulness presents a significant, moderate positive association with Perception of External Factor (r(48)=.610, *p*<.000), Perceived Ease of Use (r(48)=.592, *p*<.000), and Behavioral Intention (r(48)=.511, *p*<.000), whereas it showed a weak positive association with Perceived Enjoyment (r(48)=.399, *p*=.005). The data showed that the coefficients of Perception of External Factor almost doubled from that found after the AR Computer Tutorial phase (from r=.370 to r=.610). The coefficient of Perceived Ease of Use also slightly increased (from r=.580 to r=.592), whereas the coefficient of Behavioral Intention displayed a small decline (from r=.658 to r=.511). Moreover, the data also revealed that there was a significant, weak negative correlation between Perceived Usefulness and Computer Anxiety (r(48)=-.437, *p*=.002), which was previously statistically insignificant after the Teacher Showcase and after the AR Computer Tutorial.

This negative correlation suggests that a continuing increase in the participants' Perceived Usefulness over the three phases was significantly associated with a decrease in the participants' Computer Anxiety over the same time.

In brief, this report of Pearson correlation coefficients of the determinant Perceived Usefulness after the three phases, which were Teacher Showcase, AR Computer Tutorial, and Student Showcase, demonstrates statistical evidence that Perceived Usefulness had a continuing stronger positive association with Perceived Ease of Use. This suggests a correlation between the participants' increased Perceived Ease of Use and their increased Perceived Usefulness. The evidence also shows an increasingly significant correlation between Perceived Usefulness and Perception of External Factors, starting after the AR Computer Tutorial. Furthermore, despite positive associations of Perceived Usefulness, Perceived Enjoyment, and Behavioral Intention across the three phases, the coefficients of these associations fluctuated slightly. In addition, the statistical data suggest that over time, with constantly heightened Perceived Ease of Use, Perceived Enjoyment, Behavioral Intention, and Perception of External Factor, the participants' Computer Anxiety would likely reduce.

Interview Findings of Perceptions of the Usefulness of AR

All 24 interviewees reported varying degrees and different aspects of their perceptions of the usefulness of AR. They were also requested to consider the usefulness of AR on a conceptual basis. They were encouraged to think about AR as a kind of emerging technology that superimposes computer-generated sensory input, such as text, images, audio, and video on real-world surroundings. Thus, the researcher instructed the participants not to view AR technology as a particular commercial technological product, for example ZapWorks and Zappar but to consider that many different products could fulfill AR as a conceptual organization.

Overall, the interviewees' reports on the Perceived Usefulness of AR were categorized into four primary affordances: 1) AR useful as an entertainment tool, 2) AR useful as an engaging informational presenter, 3) AR useful as a course-oriented experiential motivation, creativity, and memory enhancer, and 4) AR useful as a promoter of digital literacy skills. The interviewees also addressed their projections of AR's potential manifestations in diverse fields of multidisciplinary social and medical sciences. The researcher also revisited these topics in the follow-up questionnaire on the participants' remaining knowledge and/or perceived usefulness of AR technology, administered approximately three months after the individual interview. The next sections present the findings that emerged from the analysis of the interview data on these topics.

AR Useful as an Entertainment Tool

The first aspect of Perceived Usefulness arose from the interviewees' understanding of AR usefulness by considering its technical and/or technological functions or features that were and could be advantageous for certain purposes. In this respect, most interviewees agreed that they might access AR for entertainment purposes. Here the interviewees often intermingled their perceptions of VR technology with that of AR. Because some interviewees had played computer games and were familiar with VR-based games and platforms, such as The Sims and Minecraft, they saw some similarity to those games platforms with how AR technology worked. Therefore, they thought that it would be fun and useful to utilize AR in making future generations of computer games. S22 viewed AR as this type of entertainment tool:

> *"It [AR technology] is a new form of entertainment. From what I think, AR creates realistic world within a real world. For example, I play the games called Minecraft where you can build anything in the game world.* ***What if I could use AR with Minecraft? I think we could express our creativity by using AR in playing games that link with the real world. Build virtual objects in the real world****…"*

A few other interviewees also supported this concept, based on their habitual behavior as YouTube content consumers and contributors, and as moviegoers. They stated that entertainment—films, music, and games—and advertising could be more fun and engaging with use of AR. They reported that they saw on social media that some movie companies had already brought AR into promoting new film releases; the users read a digital movie poster and AR content popped up to introduce movie characters. Then they could also click on hyperlinks on the digital movie poster to go directly to YouTube videos for more movie trailers. Some students even made assumptions that in the future there might be opportunities where people could watch movies or listen to songs and music, using AR technology.

AR Useful as an Engaging Informational Presenter

The second instance of Perceived Usefulness refers to AR technology as an engaging presenter or deliverer of information in multimodal formats. This aspect is generally closely associated with AR as an entertainment tool as mentioned above.

However, this instance primarily deals with AR in efficiently serving as a presentational or representational tool of available information in an unprecedented, more interactive, audio-visualized fashion. As a consequence of their experiential tasks of creating AR vocabulary flashcards in the assigned treatment, the majority of the interviewees regarded AR technology as an 'innovative channel' to access information. They saw AR, as an informational presenter, with two major attributes: 1) fun, engaging, and attention-getting, and 2) an easier information access gateway.

Interview data revealed numerous accounts of AR technology as "fun and interesting to use" (S02), and that it made "learning and getting information from sources fun, not boring, as in traditionally reading or reciting from books" (S03). S04 expressed similar thoughts in referring to her classroom AR experience when she had created AR flashcards. She thought that it would be fun for succeeding groups of students to use her AR resource. She firmly believed that AR should be interwoven into English language course syllabi as supplements because it "…could make teaching and learning more attractive to learners. Students would stay more focused on what they were learning. They [would] enjoy learning with and by using fun [AR] technology."

The observation notes and interview, revealed that these accounts emerged immediately after the Teacher Showcase, in which the interviewees were given a hands-on activity to play with teacher-made AR flashcards. That is, the 'fun factor' had resulted from the fact that the participants had never seen or tried AR technology before. The participants in the Teacher Showcase were observed to be extremely excited to see how AR flashcards worked and how digital content popped up on their mobile devices.

Expressions of excitement and amazement were heard; for example, “Wow, that is cool”, or “Oh my God. This is awesome.” In addition, the researcher observed that the students spontaneously gathered in small groups during the Teacher Showcase, not only trying different vocabulary flashcards, but also talking among themselves to see if any of them had ever seen this application before.

In addition, after the AR Computer Tutorial and the Student Showcase, they all agreed that they still found AR attention-getting. S02 provided a good example that demonstrated her continuing interest in AR technology. She mentioned that after all the phases in the AR treatment; she still thought AR suited her learning preferences as she got bored easily with dull materials. She said:

> *“A selling point of AR is that it is easy to use. It is fun.* ***It makes boring things more interesting and enlivening. Imagine you can make a plain paper become alive****. Use your smartphone to read the QR code and you get many buttons to click and they lead to YouTube videos and stuff.* ***It keeps me hooked, not bored***.”

In addition to reporting that AR technology was engaging and fun, participants also considered it an easier, more convenient gateway for information access. With the potential of multimodality of information presentation, AR was also a promising technology to assist users in accessing information seamlessly and quickly. The researcher observed that the interviewees’ habitual use of computers and the Internet facilitated this type of utilization. That is, all the participants in this research personally owned smartphones, though varying in types of models and operating systems. They reported looking up information generally via their mobile devices because it was handy and convenient. The Internet infrastructure and access at the Faculty of Liberal Arts and Mahidol University, which was robust and reliable, with great coverage, supported this habit. Moreover, as evidenced in the questionnaire findings and interview data, most participants were allowed to bring smartphones and laptops to use in classrooms to complete assignments or tasks in other courses prior to this research project. That opportunity meant that they were already accustomed to using electronic devices, especially mobile phones, in looking up information. A few interviewees witnessed that they were able to scan typical QR codes in some classes to access assignments or to do real-time polling as an ice-breaking activity. Therefore, based on this evidence, they found AR technology assisted and expanded their existing information searching habits.

S06 described her classroom experience with and without AR technology. She said that before this research, she would use Google, YouTube, and other website sources to access information to complete homework or to gain understanding of the written passages she read from the textbook. Sometimes, she said, this method involved several steps in getting information from various sources. However, after finishing the vocabulary flashcard task using AR technology, it dawned on her that AR could “bring information all together in one place, for example on a card or piece of paper.” She suggested that it would be extremely useful and innovative for teachers and students alike to collaborate in creating AR resources where:

> *“…we [students and teachers] just scan a text-filled paper* ***and all the links from other sources pop up right there. You see, we do not have to Google, open lots of websites because the information was brought together****, and it is convenient.*”

S06's narrative resonated well with how S08 described AR as "a one-stop knowledge portal." S07 also provided supporting opinions. She explained that when she read a text and wanted to search for more information, she would need to search it on her phone. It was a typical activity, yet it would be more engaging to "…just not see what is in front of our eyes, on the paper, but to see things with dimensions float on top of what I read and I can see those things on my phone." Nevertheless, when asked further whether AR technology would make any difference in the validity or reliability of information compared to when she used traditional technology for information search, S07 did not hesitate to say that it would make no difference, as the information could be the same. Yet, the presentation of such information with AR would draw her greater attention, and motivate her stay focused.

S14, however, only partially agreed with S07 about the engagement factor of AR. She reasoned that the quantity and accuracy of content presented via AR might not be as detailed, varied and precise as searching from books or from other, more typical Internet resources. She cautioned that even though AR could make information access easier and more convenient, "the content in the search may not be deep enough, as such information is just a tiny fraction of the whole. If we need full information, we Google it. AR can give compact information, not all that would be optimal."

A remark by S08 added perspective to participants' assessment of AR:

> *"**I think AR content as our supplementary sources, someone has to make it. They will have to collect information from various places, sources, media before making it with AR technology.** It is sure that we do not have to spend much time*

> *looking up for the information by ourselves because it has been gathered for us. No need for libraries. Time saving. Just at fingertips*."

Evidently, S08 also agreed that AR technology could provide an innovative presentational tool. However, whether it served effectively was not solely about the technology itself, but rather about how developers used the technology to deliver well-sourced, well-selected information in ways appropriate for the information receivers. She was fully aware that the content needed to be available, either by generating it anew or by gathering it from different sources of information, and AR would subsequently be employed in the presentational process. She finally said that for the time being, she did not completely understand how AR technology worked and how it would evolve in the future. However, if given opportunities to choose between using AR-enhanced learning materials in her future classes and traditional materials, she would not hesitate to accept the former.

AR Useful as a Course-oriented Experiential Motivation, Creativity, and Memory Enhancer

This section depicts the qualitative findings of how and to what extent the interviewees found AR technology useful for integration into the language education curriculum. This aspect of Perceived Usefulness emerged from the interviewees' after their instructor adopted it pedagogically into one of the first lessons of the core course, Analytical Reading, about word structure and word formation. In general, the interviewees found that employing AR technology through creating AR-mediated vocabulary flashcards, had advantages in three significant ways: 1) to heighten intrinsic motivation, 2) to allow creativity and problem-solving in digital design, and 3) to enhance memory and memorization. The next sections present summary data on these three items.

Motivation

All interviewees readily reported their increased motivation in the Analytical Reading course due to the integration of AR technology. Both classroom observation and the interview data showed that increased motivation emerged during the Teacher Showcase and the Student Showcase phases, whereas it was not significantly evident during the AR Computer Tutorial. This increase in motivation reflects what has been found in the studies by Jerry and Aaron (2010), Azuma (1997) and Klopfer (2008), for example. Nevertheless, the researcher did not observe any increase in participant motivation during the AR Computer Tutorial because all of their concentration shifted to the practical AR workshop, which required intense focus and skills training in the moment.

In brief, 22 out of 24 interviewees generally found AR innovative technology captivating and motivating for classroom adoption because it could enhance overall engagement of the students in staying focused in the course and to create a more enlivening learning environment optimal for possibly improved learning performances.

Creativity

AR technology was also reported to indirectly promote creativity and problem-solving skills in the process of making the flashcards. The interviewees stated that bringing AR into the assignment helped decentralize teaching and learning. Previously in traditional classes, the interviewees were usually acquainted with teacher-led or teacher-centered lectures with minimal student autonomy in learning on project-based or problem-based tasks. However, once AR technology was adopted in the Analytical Reading course, the teacher no longer transmitted information about vocabulary. Instead, the students (the interviewees) were fully responsible for researching, exploring resources, gathering information, learning the AR tools, collaborating with peers, and problem-solving any course-related or technical problems that arose. S02 described this process:

> *"…Because the students do it [creating vocabulary flashcards] by themselves.* ***The students did all the researching process for the reading passage, selecting words…this helps us to memorize words and helps us to be more creative in designing the flashcards.*** *It is more than just the teacher telling us what to do*."

Many interviewees also stated that after the Student Showcase, they began to see the potential of AR technology. According to the observations and the interview data, the Student Showcase was deemed a valuable session where all participants had hands-on playtime with peer-made vocabulary flashcards for the first time. In this session, most interviewees admitted that their peers' flashcards somehow showed varying degrees of creativity in design and in execution that were either superior or inferior to theirs. Some confessed that they should have exercised more creativity in their work, while some said that learning from peers' flashcards made them aware of more possibilities of careful storyboarding and planning that could contribute to better flashcard making. For example, there was a pair of students whose flashcards delivered an exciting level of interactivity. Not only did they provide generic word elements, such as pronunciations and sample sentences, they also created some sort of a spelling-bee mini-exercise that challenged users to spell the word. The users would get feedback when spelling either correctly or incorrectly. Another pair decided to create their own video recordings in which they acted in scenario-based situations in an attempt to explain the designated word. Not all these interactive features, however, were found in most of the participants' work. The engaging interactivity and creativity of these two pairs' flashcards were the most played by their classmates and the most mentioned as good examples of creativity in practice during the interview.

Memory and memorization

Many interviewees also asserted that they thought using AR-mediated vocabulary flashcards improved their memorization. This evidence was closely associated with the potential of AR in providing multimodality of various types of sensory input and output, by utilizing texts, images, and videos. Not only did this capability of audio-visualization mediate engaging and interactive learning content, it made the content 'stick' as reported by 12 participants.

An additional finding that has not been seen in the research literature was that of peer interaction. Fifteen participants also agreeably said that their peers' flashcard content was very memorable. This evidence also arose from observations during the Student Showcase and in the interviews, showing that learning from peers' work could somehow enhance their perception of usefulness, particularly in terms of durability of memory. They mentioned that when they saw repetitive use of suffixes and prefixes via the flashcards, this knowledge was slowly ingrained in their memory. S22 and S20 recounted their experience of how they actually learned some new vocabulary from friends' flashcards during the Student Showcase.

> "*...there are some words that I did not know before. Their meanings were blurry to me,* ***but I see the words on my friends' cards and it is interesting because they brought good sample sentences with vivid context to explain the words*** (S22)."

> "*...I understand the content better, I guess.* ***Because when I play the flashcards, there are many prefixes and suffixes that are repeated used in several [student] pairs. And when I play, I see those affixes again and again and I just remember 'Oh this is suffixes and prefixes this and that' and I can differentiate how they work****...so easy for me to categorize them* (S20)."

Even though the interview reports suggested that AR technology facilitated memory and memorization that supplemented the Analytical Reading course, a few interviewees differed in their opinion. They opined that, despite the novel functions of ZapWorks and Zappar to tailor interactive content, they did not find themselves learning about word structures and word formation at a satisfactory level. They said that they thought that although the assignment was well intentioned for improved understanding of and performance on word formation, the results fell short of their expectations. Two reasons they cited were that there was a very limited number of only 12 to 15 flashcards per pair of students and only a single task,. The one-time implementation did not, they thought, deeply root continual pedagogically-based and lesson-integrated use of such technology and would not have a lasting positive effect on learning. Another prevalent reason was that the selected lesson plan on word structure and word formation was a very miniscule segment of the entire course syllabus. That is, nearly all of the course objectives concentrated on practicing critical, inferential reading skills through a wide selection of long, complex written genres. These interviewees did not think their knowledge gained from AR vocabulary flashcards on word structures continued to be useful for the majority of the content remainder.

As a result, some interviewees expressed negative perspectives toward the on-going effects of AR technology for learning improvement. S10 provided an example:

> *"The course is more about critical reading. Like analyzing texts. But what we do is extracting words from a passage. And I did not have a chance to read my friends' texts thoroughly; therefore, I have no clue.* ***Of course, I learned from their flashcards but if you ask me if I gain more new knowledge, I would have to say not much***."

S12 shared a similar thought that the flashcards were useful for word-formation learning, yet did not fulfill or meet the course's holistic learning objectives.

> *"What we learn now is to read for main ideas, finding topic sentences in a text, something like that…* ***does not mainly focus on word structure…so I do not use the knowledge [about word formation] that much. I feel that our course is analytical, so it may have helped if AR is extended to other topics in the course***."

In sum, the interviewees expressed mixed opinions on the usefulness of AR to their learning in the course as a whole. However, the implementation was part of a research project and thus more limited than a full course implementation and many did state that they thought AR technology held the potential to yield promising classroom applications for new facets of learning environments, learning technology-enhanced supplements, all of which may have positive effects on overall student performances.

AR Useful as a Promoter of Digital Literacy Skills

The interview data showed that some participants thought AR technology could promote greater opportunities for improving their digital literacy skills and knowledge. This finding appeared after the AR Computer Tutorial Showcase and the Student Showcase and was non-existent during the Teacher Showcase. To explain in more detail, during and after the Teacher Showcase of the teacher-made AR vocabulary flashcards, nearly of all the 48 participants were observed to be extremely animated and were enjoying the play session. Many were already eager to learn using AR technology to create their own flashcards despite uncertainty about what technological tools they would be using. Nevertheless, a few of the interviewee participants expressed some frustration; they were unsure whether they would be able to accomplish the task. This frustration, or perhaps apprehension, arose from the fact that they had thought the making of AR flashcards would require a high level of proficiency in complex computer programming languages unknown to them.

Analysis revealed that this variance was attributed to participants' confidence with computers. Those who showed some frustration reported that they had an intermediate level of proficiency in typical computer applications and software, namely, Microsoft Office. However, those with greater eagerness to start making AR resources reported that they already had fundamental skills in more complex computer software, such as Adobe Photoshop, Adobe Illustrator, iMovie, and some other video editing tools.

This evidence suggests that the students' previous knowledge and computer skills may have had a positive effect on how they perceived themselves as able AR beginner users, which also connotes that learning new computer skills may likely be easier for them. S02 was among several interviewees who expressed this connection between prior computer skills and eagerness to engage with AR creator tools. She said:

> *"I think my computer skills improve a lot.* ***Actually, I have quite good skills in doing this and that by using advanced software. So when I had my hands on this [AR creator tools], it makes sense to me in seconds, very easy****. But for my friends who do not have skills, who never touch Photoshop or retouch photos, they get confused easily. They are clueless as to what to do* (S02)."

As evidenced in the interview data, especially after the AR Computer Tutorial and the Student Showcase, the vast majority of the interviewees commented that their digital skills developed tremendously through developing the AR flashcards. They attributed this mainly to learning to use ZapWorks and from integrating other supporting technological applications, tools, or software to complete their AR vocabulary flashcards. All interviewees agreed that ZapWorks and Zappar were totally new to them, even to those with advanced computer skills. Participants described that the AR tools offered tools relatively similar to those in Microsoft PowerPoint, with which they were already familiar, and this enabled them to quickly gain expertise with the AR tools. The observations also showed that most workshop attendees followed guidelines and procedural steps very attentively and enthusiastically. They sometimes requested assistance and raised questions, which the researcher, who was also the workshop leader, immediately answered or resolved.

Evidence suggests that participants' digital knowledge and skills improved after the AR Computer Tutorial and after the Student Showcase. It was during these two phases of about three weeks apart in which the interviewees, especially those with lower advanced software proficiency, reported that they did not only excel at ZapWork skills, but also in using additional, supplemental technological tools. Participants reported that those tools and social media included the use of, for example, YouTube videos, Pixlr (a free web-based photo editor), Adobe Photoshop, Microsoft Word, Microsoft PowerPoint, and some unnamed video makers and editors. S03, for instance, commented that she "had zero skills in video editing" prior to the assignment, but her pair wanted to insert a set of explanatory videos on the vocabulary flashcards. At first, she, with assistance from a peer, half-heartedly learned to use a video and photo editor; otherwise, the assignment burden would solely be on her peer's shoulders. When asked if this obligation posed any problems, or any anxiety or threat to her confidence in performing the task, she replied enthusiastically:

> *"…I think it gives me a chance to try something new because I never edited digital videos before.* ***Then I have to sit down and search for tutorial videos on YouTube so I can do it [using video editor]***."

Another example was S23 who stated that ZapWorks skills made her operate a video editor "quicker and with more ease." S10, S09 and S13 also reported on similar experiences in which they thought they improved their digital skillsets. They agreed that their betterment of digital skills came from extending their ZapWorks skills to other tools that would make their pair-work flashcards more complete. They regarded this improvement as an asset:

> *"**I get to learn to use other programs, something like that. It helps 'open my world' because I have to search for information, right tools for our task from different resources.** These new tools are nothing I know before. So I can use them to do things I never thought I will be able to* (S10)."

> *"I never use Pixlr, but I had to use it**. I need to learn. So when I use it for retouching graphics [for flashcards, I get accustomed to it. The more I use, the better I become*** (S09)."

> *"In the future, I will still use ZapWorks, if I need to. **But I get a chance to use Photoshop as a by-product. Before this, my Photoshop skill was zero. When I use it, it is like 'Oh it's not that hard' but yes still difficult. But I feel much better** [in using Photoshop] than before* (S13)."

Most participants found that AR technology was not only beneficial in itself but also in encouraging them to master other digital skillsets to create the instructional resources they wanted to create. The interview data showed that the participants also had expectations and the desire to extend their use of digital skills in the future. As S16 put it, "these digital technology skills, no matter what they are or how advanced they are, will be important for us. People will depend more on the Internet and the fact that we are good at new technologies may help us thrive in the competitive world."

Projections of Usefulness of AR in the Future

All 24 interviewees were asked to reflect on their assumptions about plausible usability and capability of AR in the near future. They were asked, "Apart from creating vocabulary flashcards as assigned in the course [Analytical Reading], what do you think are possible ways for AR to benefit other disciplines?" The interview data revealed considerable insights and agreement that AR was advantageous, to differing degrees in the humanities, social sciences, and pure science. These included prospective usefulness in engineering, historical studies, applied linguistics and language education, mathematics, medical science, tourism and hotel industry, marketing and advertising, computer animation, and career preparation.

Most interviewees communicated that AR as a tool for multimedia representation of information was an extremely promising technology to be used in fields that deal with complexity in conceptual knowledge and abstractions. AR features, which are likely to vary across different available tools in the market, could transform intangible or difficult concepts into computer-generated audio-visualizations easily digestible for users. S14 suggested that it would be interesting in chemistry classes if students "…could use AR technology in their labs to learn about the structural formulas of chemical compounds in a three-dimensional way, rather than from plain and boring illustrations in the textbook." She also mentioned that to even elevate the level of interactivity, AR could supposedly allow students to see a video demonstration of chemical reactions once two different compounds combined, and "it would be good to see it [a video demonstration] pop up right on top of the mobile device."

Similarly, S10, S05, and S16 subjectively envisioned AR as a suitable supplement in mathematics classes to assist those learners who struggle with complicated mathematical calculations. S10 stated that mathematics teachers could possibly create AR-enhanced materials that "show step-by-step math solutions for remedial students with low proficiency." S16 proposed that "math graphs, tables or even equations could be added with detailed explanations, probably in the form of a video clip made by the teacher," which would assist students' self-study outside of class. However, when asked whether it would be more convenient to visit websites with already-made videos or math equations and solutions, such as YouTube or Khan Academy, instead of accessing such information from AR-mediated learning resources—which could take longer time and require greater technological skills—some interviewees expressed the idea that the key factor was "interestingness", as S10 asserted. She explained further that if students depended on YouTube or Khan Academy videos, that would be, of course easy and convenient. However, the difference was:

> *"…If we use AR to present math problems and solutions, those steps [for the students] to get answers can be gradually revealed to them a little bit at a time. Next steps can still be hidden so that the students have some challenging time to think before taking the next step…**I mean with AR, we can do many things with interactivity; it is playful. And it also gives a sense of playfulness because the student can press [virtual objects] on the phone**."*

Another projection of AR usefulness was in medical science. A number of interviewees speculated, based on their experience with AR features, that AR could be highly useful for medical students in anatomy classes and in clinical training. Medical students face the inevitable necessity of coping with heavy memorization and comprehension of medical terms and information about human anatomical structures, for example. With this need in mind, AR was found to lend its potential in visualizing bodily structures in a more engaging, interactive fashion. S08 and S09 saw that AR could be an appropriate and effective solution in this respect stating:

> *"…when [medical students are] studying anatomy, they will need to see organs and muscle tissues. Sometimes, pictures in the textbooks are not good. And it might be difficult or impossible for them to even go see the real ones, in flesh.* ***So I think AR can add '3-D visualized' things****, not only in ordinary 2-dimensional way as other people learn. This can let them see 'Oh this is how it actually looks like and works.'* ***Because 3-D objects can move and they look realistic, yet not real but technology-enhanced***."

Many interviewees, who were English-major undergraduates, excitedly asserted that they would like to use AR in their future classes of morphology, syntax, phonology, and even intercultural communication in different versions of English around the world. S14 envisioned the idea of AR flashcards or the like integrated in other English subjects. She mentioned that with the multimodality capability of AR, she could apply AR technology to create self-learning resources from which she would learn and practice different accents by various native speakers of English. These resources, as she put it, could be in a form similar to the AR vocabulary flashcards she had made from this research project. These undergraduates reported that after creating AR vocabulary flashcards, they were likely to see how this technology was applicable to other language education subjects. For instance, S06 and S08 both agreed that by utilizing the feature of AR that could embed auditory input onto real-world objects, they would "add IPA (International Phonetic Alphabet) transcriptions with the audio clips of pronunciations of the words…to help learn better, to understand the words better, and to correctly pronounce the words."

Other aspects of usefulness of AR technology cited by participants included its potential in historical studies, career preparation and professional development, tourism and the hotel industry, and computer animation. Through these examples, it became clear that the vast majority of participants viewed AR as a promising innovative technology applicable in diverse fields.

Retention of Perceived Usefulness of AR after the Classroom Treatment

Three months after the interviews, a follow-up questionnaire was administered to gather information about participants' knowledge of AR technology, as well as their perceptions of using AR. The questionnaire items were the same as those in the questionnaire on AR acceptance and self-efficacy. However, only Part 1 (AR acceptance) was implemented, not Part 2 (self-efficacy). Additionally, in this follow-up questionnaire, open-ended questions asked the participants for their opinions or perspectives about AR technology.

The follow-up questionnaire was made into a Google Form questionnaire and the link was emailed to all 48 participants. There were 16 respondents (N=16), 14 of who were females and 2 were males. However, to avoid confusion with the previous sections, the identity of these 16 respondents was assigned alphanumeric codes running from R01 to R16.

Based on the quantitative analysis of the four items (α=.924) that elicited students' Perceived Usefulness, it was clear that the 16 respondents reported positive Perceived Usefulness of AR technology. Based on the questionnaire data with the 5-point Likert scale coded as 5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; and 1:

Strongly Disagree, no respondent chose Disagree or Strongly Disagree. All of them ranged their responses from Strongly Agree to Neutral, suggesting that they had positive perceptions of the potential of AR. This evidence predominantly aligned well with the quantitative findings from the three previously administered questionnaires on AR acceptance and self-efficacy. Table 4.7 illustrates the descriptive statistics of the mean scores of 16 respondents' Perceived Usefulness scores on the follow-up questionnaire, together with the reliability and item statistics of the four items.

Table 4.7

Descriptive statistical reports of the mean scores of respondents' Perceived Usefulness, three months after the interviews (*N*=16)

Questionnaire items	Mean	Std. Deviation
1. I find the AR system to be useful for my learning.	4.00	.632
2. Using the AR system for my learning increases my productivity.	3.94	.574
3. Using/ playing with the AR system enhances my effectiveness for my learning.	3.75	.683
4. Using/ playing with the AR system improves my learning performance.	4.00	.516
Cronbach's Alpha	.924	

As for the qualitative evidence, responses from the open-ended questions also revealed interesting findings. When asked for an explanatory concept of AR, most respondents were able to explain in relative depth of how AR technology works. They mentioned the interplay of virtual objects superimposed onto real, tangible objects in their real-world surroundings. They also mentioned the use of computer-generated, two- and three-dimensional objects to enhance user receptive senses. R07 summarized her AR concept in stating that it "supports or creates representation of information through computer-made elements and combines those elements with the reality world by using some equipment." R11 offered a similar definition that AR technology "uses digital graphics to 'merge' with the real world" and R15 said that the technology is "…like realistic simulation technology."

When asked if they still found AR technology useful for their work productivity, learning, or other aspects, either at present or in the future, responses trended towards the same positive direction. Most respondents mentioned the advantages for entertainment, learning and teaching purposes, which aligned well with other qualitative findings. A few asserted some usefulness in terms of boosting creativity and engagement; they still thought that college curricula should somehow integrate AR technology into curriculum redesign. R08's description captures an enthusiastic perspective on AR technology in the future:

> *"…**With an understanding and skills, it [AR technology] is beneficial for both learning and professional advancement as well as daily activities.** For instance, in some recent camera models or games consoles, they have AR features. Even iPhones X have AR built-in functions. If you have no clue about AR, it will be such a waste; you will miss this 'cool' stuff**. And if you know how to apply it to your learning, it makes you look like a 'modern' person**."*

In addition, the respondents were asked to think critically about the roles of AR technology in improving or progressing student learning in language education curricula in Thailand. The responses resonated well with the previous qualitative findings. All respondents agreed that adopting AR technology pedagogically in language teaching as well as in other disciplines would be beneficial. They referred to AR's potential as an engaging informational presenter and as a motivating supplemental learning tool. They voiced that materials development could prospectively benefit from AR integration to make course materials more interesting and relevant to students' interests and skills in digital media and technology. R16 clearly expressed this thought:

> *"…AR makes us access information more easily. It helps visualize information. For instance, if you learn about 3-D modeling, AR will be a perfect answer.* ***It can visualize virtual objects and overlay the virtual objects with the real objects in the real world. So it saves time and money and resources because you do not need to print out that digital 3-D objects using the 3-D printing machine.*** *You can simply just use AR to make them digitally available for viewing by anyone."*

Perceptions of the Ease of Use of AR

This section reports quantitative and qualitative findings on the participants' Perceived Ease of Use of AR technology. These findings address the second part of RQ1, which asked: "*What are participating Thai undergraduates' perceptions of the usefulness and ease of use of augmented reality technology activities implemented in their classrooms?*" Descriptive statistical analysis of relevant questionnaire items as well as qualitative data provided the material with which to address the participants' Perceived Ease of Use of AR technology.

The sequence of reports on the ease of use aspect of RQ1 begins with different sets of quantitative data followed by extensive qualitative data from the interviews, classroom observations, and other course materials.

Statistical Findings of Perceptions of Ease of Use of AR

Based on TAM3 (Vankatesh & Bala, 2008), Perceived Ease of Use refers to the degree to which an individual perceives that a given technology is easy to use. Davis (1989) defined it as "the degree to which a person believes that using a particular system would be free from effort." Computer Self-Efficacy, Perceptions of External Control, Computer Anxiety, and Perceived Enjoyment are four selected moderators from TAM3 this dissertation investigated. This section presents quantitative and qualitative findings on the participants' Perceived Ease of Use of AR technology, in relation to the interviewees' insights and experience revolving around or associated with their Perceived Enjoyment, Computer Anxiety, and Perceptions of External Control, over the period of the vocabulary flashcard-making task.

Table 4.8

Descriptive statistical reports of the mean scores of participants' Perceived Usefulness, after Teacher Showcase, AR Computer Tutorial, and Student Showcase (*N*=48)

Questionnaire items	After Teacher Showcase (Form 1)	After AR Computer Tutorial (Form 2)	After Student Showcase (Form 3)
1. Using/ playing with the AR system does not require a lot of my mental effort.	4.19	3.98	4.29
2. I find the AR system to be easy to use.	4.17	4.00	4.29
3. I find it easy to get the AR system to do what I want them to do.	3.90	3.92	3.98
4. My interaction with the AR system is clear and understandable.	4.06	3.90	4.23
Descriptive Statistics			
Mean	16.31	15.79	16.79
Std. Deviation	2.08	1.92	1.79
Cronbach's Alpha	.790	.650	.655

As evidenced in Table 4.8, based on the mean scores of the four questionnaire items that measured students' perceived ease of use, the students reportedly perceived AR technology as easy to use (*M*=16.31, *SD*=2.08, *α*=.790) after they attended a play session with a set of teacher-made, AR-enhanced vocabulary flashcards. Later, the students' Perceived Ease of Use dropped after the AR Computer Tutorial (*M*=15.79, *SD*=1.92, *α*=.65). These findings suggest that they started to realize and recognize ZapWorks' operational features and might find some of the features more complex or difficult than they had expected. The computational complexity, therefore, might be leading to a decrease in their perceived ease of use in this stage. Nevertheless, after the Student Showcase, the students' Perceived Ease of Use escalated (*M*=16.79, *SD*=1.79, *α*=.655). Their perceptions of the ease of use improved over the previous two stages. This could suggest that with the time needed to get accustomed to new technologies, users tended to feel more fully cognizant and able to use the tools. Chapter 5 includes discussion of possible explanations for this finding.

A repeated measures ANOVA compared and tested the difference in the means across the construct of Perceived Ease of Use in three repeated questionnaire administrations at three different times. Table 4.9 reports the results of the repeated measures ANOVA. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean Perceived Ease of Use level differed significantly between the three time points ($F(1.975, 92.843) = 6.134$, p=.003). Post hoc tests using the Bonferroni correction revealed a small decrease in the participants' Perceived Ease of Use after Teacher Showcase and after the AR Computer Tutorial (16.31 ± 2.08 mg/L vs 15.79 ±

1.92 mg/L, respectively), which was not statistically significant (*p*=.237). However, Perceived Ease of Use after the Student Showcase had increased to 16.79 ± 1.79 mg/L, which was not statistically significant compared to that after the Teacher Showcase (*p*=.246). However, it showed a significant difference compared to that after the AR Computer Tutorial (*p*=.004) session. Therefore, the data suggests that the students' Perceived Ease of Use of AR technology exhibits a statistically significant difference during the phases of the AR Computer Tutorial and the Student Showcase.

Table 4.9

Statistical report of Repeated Measures ANOVA of the compared means of the level of Perceived Ease of Use, collected after the Teacher Showcase, the AR Computer Tutorial and the Student Showcase (*N*=48)

Descriptive Statistics

	Mean	Std. Deviation	N
Overall mean (Form 1) after the Teacher Showcase	16.31	2.08	48
Overall mean (Form 2) after the AR Computer Tutorial	15.79	1.92	48
Overall mean (Form 3) after the Student Showcase	16.79	1.79	48

Pairwise Comparisons

		Mean Difference	Std. Error	Sig.a	95% Confidence Interval for Differences	
					Lower Bound	Upper Bound
(Form 1) after the Teacher Showcase	(Form 2) after the AR Computer Tutorial	.521	.290	.237	-.200	1.241
	(Form 3) after the Student Showcase	-.479	.270	.246	-1.149	.190
(Form 2) after the AR Computer Tutorial	(Form 1) after the Teacher Showcase	-.521	.290	.237	-1.241	.200
	(Form 3) after the Student Showcase	-1.000	.296	**.004**	-1.736	-.264
(Form 3) after the Student Showcase	(Form 1) after the Teacher Showcase	.479	.270	.246	-.190	1.149
	(Form 2 after the AR Computer Tutorial					

Tests of Within-Subjects Effects

Perceived Ease of Use

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	24.014	2	12.007	6.134	.003
	Greenhouse-Geisser	**24.014**	**1.975**	**12.157**	**6.134**	**.003**
	Huynh-Feldt	24.014	2.000	12.007	6.134	.003
	Lower-bound	24.014	1.000	24.014	6.134	.017
Error (Time)	Sphericity Assumed	183.986	94	1.957		
	Greenhouse-Geisser	183.986	**92.843**	1.982		
	Huynh-Feldt	183.986	94.000	1.957		
	Lower-bound	183.986	47.000	3.915		

Pearson product-moment correlation coefficients were also computed to assess the relationship(s) between the determinant Perceived Ease of Use and other determinants in TAM3 (Venkatesh & Bala, 2008) which included Perceived Usefulness, Behavioral Intention, Perception of External Factor, Computer Anxiety, and Perceived Enjoyment. Table 4.10 displays a report of the correlation coefficients analyzed from the three forms of the questionnaire on AR acceptance collected after the Teacher Showcase, AR Computer Tutorial, and Student Showcase phase.

Table 4.10 depicts that after the Teacher Showcase there was a moderate positive association between the variables Perceived Ease of Use, Perceived Usefulness (r(48)=.402, *p*=.005), Behavioral Intentions (r(48)=.571, *p*<.000), Perceptions of External Control (r(48)=.491, *p*<.000), and Perceived Enjoyment (r(48)=.577, *p*=.001), respectively. The test also revealed a significant negative correlation between Perceived Ease of Use and Computer Anxiety (r(48)=-.362, *p*=.011).

Furthermore, based on the correlation coefficients analyzed after the AR Computer Tutorial, the statistical data revealed that there was a moderate positive association between the variables Perceived Ease of Use, Perceived Usefulness (r(48)=.580, *p*<.000), Behavioral Intentions (r(48)=.451, *p*=.001), Perceptions of External Control (r(48)=.532, *p*<.000), and Perceived Enjoyment (r(48)=.507, *p*<.000), respectively. Nonetheless, it showed no significant correlation between Perceived Ease of Use and Computer Anxiety. It was noteworthy that the correlation coefficients of Perceived Usefulness and Perceptions of External Factor were greater than those after the Teacher Showcase. By contrast, the correlation coefficients of Behavioral Intentions and

Perceived Enjoyment dropped.

Table 4.10

Report of the Pearson correlation coefficients of Perceived Ease of Use and other determinants in TAM3 (Vankatesh& Bala, 2008), from the three forms of the questionnaire on AR acceptance (*N*=48)

		Perceived Ease of Use	Perceived Useful-ness	Beha-vioral Intention	Perception of External Factor	Computer Anxiety	Perceived Enjoy-ment
Perceived Ease of Use After Teacher Showcase	Pearson Correlation	1	**.402****	**.571****	**.491****	-.362*	**.577****
	Sig. (2-tailed)		.005	.000	.000	.011	.000
Perceived Ease of Use After AR Computer Tutorial	Pearson Correlation	1	**.580****	**.451****	**.532****	-.241	**.507****
	Sig. (2-tailed)		.000	.001	.000	.098	.000
Perceived Ease of Use After Student Showcase	Pearson Correlation	1	**.592****	**.420****	**.724****	**-.541****	**.495****
	Sig. (2-tailed)		.000	.003	.000	.000	.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The Pearson correlation coefficients were also analyzed from the questionnaire administered after the Student Showcase phase. The determinant Perceived Ease of Use presents a significant, moderate positive association with Perceived Usefulness (r(48)=.592, *p*<.000), Behavioral Intention (r(48)=.420, *p*=.003), Perceptions of External (r(48)=.724, *p*<.000), and Perceived Enjoyment (r(48)=.495, *p*<.000), whereas it showed a significant negative association with Computer Anxiety (r(48)=-.541, *p*<.000). Evidently, the correlation coefficients of Perceived Ease of Use, Perceived Usefulness and Perceptions of External Control increased from the previous two phases, whereas Behavioral Intentions and Perceived Enjoyment fluctuated over the three time points.

The data suggested that the students' Perceived Ease of Use had a continuing positive association with their Perceived Usefulness and Perceptions of External Control over the period of the vocabulary flashcard project. That suggests that when the students were well equipped with necessary technical resources and facilities and when they recognized the capabilities and potential of AR technology, these factors could contribute to how they perceived the technology as easy to use. In addition, with their high level of Perceived Ease of Use, they were not likely to develop much anxiety. Instead, they enjoyed the technology, yet their Perceived Enjoyment evidently decreased over the three stages of the project.

Interview Findings of Perceptions of Ease of Use of AR

In the interviews, 24 interviewees addressed different aspects on how they perceived AR technology as easy to use and not requiring too much mental effort. The interview data also reveal accounts of students' Perceived Ease of Use in relation to other determinants in TAM3 (Vankatesh & Bala, 2008), which included Perceived Enjoyment, Computer Anxiety and Perceptions of External Control. These determinants act as moderators of Perceived Ease of Use of a given technology.

The students were asked to reflect on their experience during the period of using ZapWorks and Zappar in creating the vocabulary flashcards. They were cautioned, however, to view the AR tools from a conceptual point of view, not a product-oriented evaluation. That is, they were told that their answers were not to assess whether ZapWorks and Zappar were effective, sophisticated commercial products. Instead, they were encouraged to reflect upon the usability and ease of use of AR technology via ZapWorks and Zappar as representative tools of such technology. However, it was unavoidable that some of the following interview accounts involved references to ZapWorks' and Zappar's operational features to illustrate the students' perspectives towards ease of use.

When asked if AR technology was easy to use, most interviewees agreed that they considered the technology complicated and sophisticated during the Teacher Showcase. Given that 98% of the participants reported never having had direct, hands-on experience with AR technology prior to the research, they were observed to be excited and somewhat nervous while exploring the teacher-made vocabulary flashcards in actual use. The observations also revealed, however, that their nervousness wore off quite quickly when they experienced how AR operated firsthand. Twenty interviewees found AR technology, particularly when using Zappar, relatively technically intuitive, convenient and easy with user-friendly interfaces and features. Nevertheless, a few interviewees experienced some technical pitfalls that affected their perceived ease of use. For instance, S03 stated that "…Zappar took a long time to scan the [AR] content [on teacher-made flashcards], and I was a bit anxious…" S09 mentioned similarly that, "…Zappar is a bit slow sometimes in scanning the flashcards. It is time-consuming that we have to wait for content streaming…" This finding was evident during the Teacher Showcase because the participants were only required to use Zappar with the teacher-made flashcards.

Later in the AR Computer Tutorial, the interviewees still reported that they were comfortable using AR technology although some reported it to be only slightly more incrementally complex than it had been previously. This was because during this phase, all the participants were taught how to use ZapWorks in combination with Zappar, together with some other editing tools, for a full-fletched execution of vocabulary flashcards. A small number of participants commented that their perceived ease of use fluctuated depending on how much they needed to concentrate on the workshop. They also addressed that their roles as content ‘players/users’ and as content ‘creators’ influenced their perceived ease of use at some points. When asked about their perceived ease of use of AR technology during this phase, the interviewees reflected that the operational features of the AR tools did not primarily influence the feeling of ease of use. Instead, their planning of the task caused them temporary worry.

Nevertheless, during the Student Showcase, about four weeks after the AR Computer Tutorial, the interviewees reportedly found AR technology subjectively satisfactory technology to use. They regarded the technology as easy to use and not as difficult as they had thought or encountered during the AR Computer Tutorial. Many interviewees reflected that after the three-week, pair-work to create the flashcards, they gradually learned and acquainted themselves with the technology to the point that they became familiar with its technical steps. Consequently, this familiarity helped raise the level of perceived ease of use. In addition, during the Student Showcase, all participants were already aware of how ZapWorks and Zappar worked, and they could use Zappar to play effortlessly with their peers' work.

The following sections present the interview data concerning the moderators of Computer Anxiety, Perceived Enjoyment, and Perceptions of External Control, all of which, based on TAM3 (Vankatesh & Bala, 2008), theoretically mediate users' Perceived Ease of Use. The reports depict the interviewees' perspectives on these three moderators, in their practice as part of this dissertation research, together with their insights about other findings, such as accessibility of the AR technology. All of these moderators influenced how they perceived the ease of use of the AR technology employed in this research.

Computer Anxiety

Computer Anxiety refers to a degree at which a user feels apprehension or fear when encountering the possibility that (s)he will use a given technology (Venkatesh, 2000; Igbaria & Iivari, 1995). Computer Anxiety in TAM3 is one of the determinants of a user's Perceived Ease of Use of a given technology.

Overall, most interviewees did not report anxiety during the period of getting to learn to use AR technology, and during the vocabulary flashcard task. They reported that they neither experienced emotional difficulties directly caused by the technology, nor developed persistent fear in using the technology, nor found the technology obstructive to their learning. Nonetheless, a few interviewees disclosed that during the AR Computer Tutorial session and the pair work periods they temporarily felt mentally overwhelmed by the complexity of ZapWorks and Zappar operational features. However, they did not regard this frustration as significant computer anxiety. These interviewees regarded it like a feeling of ‘sudden technology encounter’ that brought about a new learning curve in learning how to use a new technology. They viewed this feeling as ‘assignment-wise pressure’ that did not escalate to a level of serious anxiety, and that later faded swiftly once the AR workshop was completed, and they had a sense of how the AR tools operated.

When asked if this emerging pressure ever became persistent anxiety and/or caused them to perceive AR technology as difficult technology to use, most of the 24 interviewees disagreed. That still insisted that AR technology was easy to use, considering how ZapWorks and Zappar had user-friendly interfaces and features, and some of their operational features were similar to those in Microsoft Office software with which the interviewees were familiar.

When asked about the roots of such temporary feeling of new technology encounter, the interviewees said that generally the causes were not initially from the AR tools themselves, but they stemmed indirectly from their confidence, to be precise their computer self-efficacy. The interviewees mentioned that ZapWorks and Zappar were not complicated to use, but they were fundamentally worried that they might fail in the process of making flashcards, and that they would ruin the entire work and cause themselves reduced scores. For instance, S02 and S12 expressed their shared concern that:

> ***“…At first, I was a bit afraid for a moment. Not because of the tools [ZapWorks and Zappar], but because of myself.*** *I was afraid that I would not successfully carry out the task as planned. That I would fail or unintentionally*

> *skip some necessary steps.* ***I was afraid that the flashcards would not work properly…That worried me.*** *(S02)"*

> *"**It was not about fear or anxiety like that. I think it is more like a 'hard fun.'** I enjoyed the work and sometimes I wondered how my friends would create their flashcards. I loved to see their creativity. (S12)"*

S04 also shared a similar concern. However, she thought it was not a matter of self-confidence, but more like a work pressure. She said that:

> *"…[It was] not about self-confidence, exactly.* ***I think I got a pressure, a pressure that I had to succeed. I think the tools [ZapWorks and Zappar] are not difficult to use.****"*

These anxieties were more from their worry about being able to achieve their desired outcome rather than anxiety about the AR technology, particularly ZapWorks and Zappar, as they generally perceived the tools as easy to use, especially during the Teacher Showcase. However, some reported a slightly increased feeling of being overwhelmed because ZapWorks was equipped with so many sets of operational features and steps necessary for making the AR-mediated flashcards. The interviewees reported developing a modest level of frustration or anxiety mainly caused by their own planning of procedural steps and their collaborative work with peers, not by the technology itself. For instance, S17 illustrated this point:

> *"**I felt a bit of anxiety, or you can call it pressure instead.** It's a mixed feeling. But I was just afraid that when I created my flashcards, some of the information*

> *would be lost or did not display properly.* ***I was afraid that I would fail at some important steps and would have to re-do all the work once again.*** *So I needed to be very attentive and careful and precise. It was like I practiced my staying focused."*

S20 shared concern over the procedural process and collaborative work, which resulted in her frustration. When asked if she was worried about the task at all, she said:

> *"…Somehow yes.* ***But it did not last for so long.*** *I was just worried because in our pair, we split to work on five flashcards each.* ***So I was worried that my flashcards would be very different from my friends', like different colors, different design and patterns, or even the content.*** *We had a little argument though, but it was not serious…"*

Perceived Enjoyment

Venkatesh (2000) defined Perceived Enjoyment as a degree or "the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology" (p. 351). According to TAM3 (Vankatesh & Bala, 2008), Perceived Enjoyment moderates an individual's Perceived Ease of Use, which eventually influences how (s)he is likely to adopt such technology in the future. All 24 interviewees agreed that using AR technology, specifically ZapWorks and Zappar as representative tools, brought enjoyment throughout the process of vocabulary flashcard making. That is, all interviewees admitted that they had fun in all three major phases that included the Teacher Showcase, the AR Computer Tutorial and the Student Showcase. However, the degrees of enjoyment in each phase varied subjectively, and the feeling of enjoyment contributed to how the interviewees perceived AR technology as easy and/or convenient to use.

In the Teacher Showcase, all interviewees stated that they had fun playing with the teacher-made vocabulary flashcards using Zappar as a primary AR content reader. In this phase, they did not yet use ZapWorks, the AR content creator. Enjoyment, combined with excitement, reportedly emerged from the novelty of the technology as none of the students had ever experienced a hands-on AR play session before. Classroom observations showed that all participants exhibited excitement, excitedly talking to each other in small groups about how the flashcards unfolded interactive digital content in an unprecedented way. However, the interviewees said that initially they encountered a small technical glitch in downloading Zappar on their personal mobile devices during this phase, which caused them to be slightly insecure. Yet, this insecurity was momentary and disappeared immediately when the teacher and/or the researcher were able to provide assistance. Furthermore, the interview data revealed that the level of fun and excitement wore off in the second half of the Teacher Showcase. This was attributed to the students' loss of the initial experience of novelty, or what Venkatesh (2003, p. 351) referred to as the "instrumental value" of the tools. S08 reflected that at the beginning, she enjoyed the Teacher Showcase, but overall she found herself "…in awe just for a moment because later [in the Teacher Showcase] once I played with a couple of teacher flashcards, I actually did not enjoy it anymore. It was like 'That's it? Oh, Ok. So what's next?'" She elaborated her process in stating that:

"I think it is because of the content [on the flashcards]. It was like there were not so many content elements to play with. It was like each flashcard had a certain number of buttons to tab with limited word information on each. When I played with the flashcards and was done with all of them, I was like 'Anything else?'"

S08's reflection suggests that longer retention of enjoyment of such technology may possibly come from the extent to which the technology could provide more options for the developers to use in engaging the users' interest and learning process. Chapter 5 presents further discussion of this point.

Later in the AR Computer Tutorial, the interviewees still reported levels of enjoyment over AR technology, however with differing points of view. In this phase, they attended a training workshop in which they were given hands-on practices of ZapWorks and Zappar. Subsequently, they were also allocated three weeks of pair work for the flashcard completion. Most interviewees commented that their perceived enjoyment originated from onsite training and outside-classroom pair work in which they brainstormed with peers, underwent storyboarding and planning, collaborated with peers, solved teamwork and technical problems, and tested the usability of the complete set of their flashcards. Many interviewees admitted that they had less fun than they did in the previous phase. However, they appreciated it as challenging fun that offered them an opportunity to integrate digital technology into a language course. S10, for instance, reported that her enjoyment in this phase was "…turning to be quite academic because it is not about playing with someone else's work anymore. You have to create your own work with accurate information about a selection of words of your own choice…It is still fun, but not the same kind of fun I had earlier [in the Teacher Showcase].” S14 also mentioned that she enjoyed learning ZapWorks and Zappar in this phase. She elaborated, “…the [ZapWorks] training was most fun because [she] actually used the tools, scanned the content right in the computer room.” On the other hand, some interviewees posited that they developed some mental overload during this phase due to a lack of creativity in designing the flashcards. S20, for instance, commented that she enjoyed AR technology the least during the AR Computer Tutorial because she “…had to think about how to make [the flashcards] more interesting and outstanding than her peers’ versions…had to plan carefully; otherwise, the flashcards may be ruined.” Overall, the interviewees reported using AR technology as an entertaining and enjoyable experience woven into their actual English course. Their varying levels of enjoyment, however, did not seem to result from the instrumental value of the given AR tools. Rather, the interviewees seemed to experience the most enjoyment in the processes of project planning and designing, peer collaboration, and problem solving over the course of the task.

In the Student Showcase, nearly all the interviewees agreed that they had the most enjoyment, compared to the previous two phases. In this phase, all participants gathered in the classroom to experience their peers’ finished vocabulary flashcards. This was the very first time they saw peers’ flashcards in action. The interviewees expressed thrill and enjoyment because they were eager to experience their classmates’ flashcards. They said that seeing the final products made by classmates expanded their horizon of creativity and original ideas for creating memorable, well-executed flashcards. S16 reflected on his experience during the Student Showcase:

> *"**…I think I had so much fun during this phase [Student Showcase] because I can see my friends play with my pair's flashcards and they seemed to work perfectly as I planned.** It was successful. All the flashcards worked just fine; all content was displayed well…And I got to see other friends' works too."*

S20 also thought she had the most fun during the Student Showcase:

> *"Most fun? **I think it was the Student Showcase. I think it is because I could share ideas and creativity with my friends. We saw how each pair worked out the flashcards in different ways and with techniques of information presentation.** It gave me new ideas in case that I have to do a similar task again in the future."*

S21 added that she also learned tremendously from her peers' work in commenting:

> *"I think the most fun I got is when I got to see [the teacher's] flashcards and my friends'. **It was so good to see new creative ideas my friends put into their work, which were different from mine or even other pairs.** For instance, some of the pairs used an unbelievably interesting scenario-based video technique. They had awesome tricks I never thought of…"*

Not only did enjoyment encourage users' greater Perceived Ease of Use of AR technology, they also reported it to increase their levels of perceived computer self-efficacy. Some interviewees whose works their classmates played frequently mentioned that they felt confidence and pride when witnessing their flashcards being praised and appreciated. These findings provide evidence to conclude that most interviewees found integrating AR technology into a language course to be entertaining, enjoyable, not only by its instrumental features, but also through the procedural processes of planning, brainstorming, collaborating and testing the final products. Out of the three phases of the task, most interviewees also agreed that the Student Showcase brought about the most enjoyment because they had the opportunity to experience hands-on sessions with the peers' works, enabling them to learn from each other's creativity.

Perceptions of External Control

Perceptions of External Control refers to a degree to which an individual believes that organizational and technical support and resources facilitate their use of the technology (Venkatesh, Speier, & Morris, 2002). To assist the participants to successfully carry out the flashcard-making project, several resources were provided. These ranged from, for example, the AR overview (orientation) presentation, the AR Computer Tutorial, YouTube-hosted recordings of the AR Computer Tutorial, ZapWorks and Zappar manuals, and assistance via e-mail correspondence. In addition, each of the participants was given a personal Student Account on ZapWorks providing them a one-year all-access subscription to ZapWorks tools. Internet access and computer facilities were also available on campus free of charge for faculty members and students.

When asked whether and to what extent they were satisfied with and/or encountered difficulties aspects of external control such as technical support, resources and/or facilities, most interviewees commented that they received sufficient support and necessary resources for successfully completing the project. Given that sufficient Internet access was a critical element of external control, the findings revealed that most students used WiFi access on campus because it was reliable and fast, despite low coverage in some campus spots. However, a few interviewees reported that they preferred to use the Internet access offered by other parties, such as on-campus coffee shops, whereas a few other students used the Internet access at their residences and dormitory rooms, as they said that they had more bandwidth and the speed was faster. When asked whether the Internet speed was a critical criterion for improved productivity and/or perceived ease of use, all interviewees agreed that it was.

As for teacher- and researcher-prepared resources such as the AR orientation presentation, ZapWorks and Zappar manuals, the AR Computer Tutorial, and the YouTube-hosted training videos, most interviewees said that they were useful for them to consult when technical problems persisted. The interviewees agreed that the AR Computer Tutorial was extremely useful and enhanced their understanding and practical skills in using ZapWorks more effectively and accurately. For instance, S06 stated that he would not have accomplished the task without the training:

> *"**…I would not have done all the work [without the AR Computer Tutorial] because if you let me to go find information by myself, I would not know where and how to do so.** Of course, there might be information out there but I think the tool [ZapWorks] was still new and I never search for it on the Internet. Without the training, I would have failed at some points…Not as accurate as the teacher showed us in the training."*

The interviewees reported finding the recording of the AR Computer Tutorial, hosted on YouTube, very helpful. Although some said that they never re-watched or consulted the video after the training, a few other interviewees thought the video was useful for practice review. When asked whether they searched for additional online resources for further clarification, the interviewees replied no and reasoned that the teacher-prepared materials provided adequate instruction for preparing their own AR resource. In addition, a few interviewees found the researcher's e-mail correspondence assistive when they contacted him for technical clarification.

In terms of the technical resources needed to complete the project, it was noteworthy that the interviewees preferred working on their personal laptops and other mobile devices, instead of using computer labs housed at the Faculty of Liberal Arts or the university's Learning Center. Two reasons emerged from the data to explain this finding. One was that it was more convenient and the second was that their own equipment was better than the university's. S22, for instance, explained his decision to refrain from using university-run computer facilities that he found "…[university's] computer labs are large but the computers there have inferior specs. Their RAM and operating systems are quite outdated and slow. So I will have to switch to work on my own laptop and prefer to work in my dorm room." His account also aligned with the accounts of a few other interviewees who mentioned that the work venue played a part in encouraging students' perceived ease of use. When asked where they actually or preferably worked on the project, most of the interviewees expressed their preferences for on- and off-campus dorm rooms, private residences, and even coffee shops. This was because they perceived these settings as more comfortable, convenient, and private. When asked further about how they collaborated with peers while working in different locations and time, they replied that they usually communicated via e-mail, social networking applications, such as Facebook and Line, and they arranged face-to-face meetings while meeting in classes as necessary.

Time management and accessibility of AR technology, specifically ZapWorks and Zappar as representative tools, also were viewed as integral factors indirectly affecting an individual's perceptions of the technology's ease of use. Evidence emerging from the interview data showed that most interviewees found the time allocated to the task (approximately three weeks of pair work) to be an important external factor in the process of making the flashcards. While the majority of the students agreed that the three-week period of collaborative work was appropriate and sufficient, 7 interviewees commented that they felt under time pressure, which led to reduced self-confidence and heightened frustration. Nevertheless, it was noteworthy that the time factor did not theoretically fit under Venkatesh, Speier, & Morris' 2002 construct of the Perceptions of External Factor that specifically covered organizational and technical support and resources. Even so, limited time did create some pressure on the students. For instance, S05 admitted that "…time factor definitely put [her] under stress because it took [her] considerable time to do the task and it seemed [she] did not have enough time." In addition, several interviewees expressed concern about their obligations to fulfill other course requirements while simultaneously meeting the deadlines of the flashcard-making task. S07 thought that if she had had more time on the task, she:

> *"…would have spent more time thinking about something more interesting and slowly working on each flashcard more attentively.* ***But unfortunately, I also have lots of assignments in other courses and the deadlines overlapped.*** *If this problem did not occur, I might have more time on this task [of flashcard making]."*

In addition to time, accessibility of AR technology appeared to affect the users' perceived ease of use as well. In this context, accessibility refers to "the quality or characteristic of something that makes it possible to approach, enter or use it" (Cambridge Dictionary, 2018). The findings showed that some interviewees found that ZapWorks, a representative AR creator tool used in this research, lacked some features that were found to decrease the users' ease of use to some extent. For example, one such absent feature was the availability of non-English typography or fonts. The interviewees had expected that ZapWorks and Zappar would offer the inclusion of foreign-languages fonts, including Thai fonts. The absence of such a feature obstructed the users from different sociocultural backgrounds to maximize benefits of the tools, at least commercially. However, technically, the users solved the problem by integrating other software applications, such as Pixlr, Adobe Photoshop, Adobe Illustrator, and Microsoft PowerPoint, to do graphic editing work when they wanted to insert Thai text or descriptions on their flashcards. However, working around the limitations of the software resulted in longer work hours. When asked whether this unavailable feature affected her workflow and the ease of use of the tools, S01 explained:

> *"I think so…What I want it to change is to add Thai fonts and more fonts of other languages and styles. This is because the fonts they have sometimes look boring. Of course that I can do some Photoshop works to fix this glitch, but it would be very time-consuming, considering that we already have limited time. So I would appreciate more time, more font varieties…"*

In sum, it was evident that assistive resources, software features or lack thereof, and facilities were factors in users' productivity and how they perceived a given technology as convenient and easy to use.

Retention of Ease of Use of AR after the Classroom Treatment

Three months after the interviews, the researcher administered a follow-up questionnaire to gather information about the participants' knowledge of AR technology, and their perceptions of using it. The questionnaire items were the same as those in the questionnaire on AR acceptance and self-efficacy. However, only Part 1 (AR acceptance) was implemented, not Part 2 (Self-efficacy). Additionally, in this follow-up questionnaire, open-ended questions that asked the participants to provide their opinions or perspectives about AR technology were added.

The follow-up questionnaire was created as a Google Form questionnaire and the link was emailed to all 48 participants. There were 16 respondents (*N*=16), 14 of whom were females and two were males. For convenience and to avoid confusion with the previous sections, the identify of these 16 respondents was assigned with alphanumeric codes running from R01 to R16 when referring to their selected quotes.

Based on the quantitative analysis of the four questionnaire items that elicited students' Ease of Use, it was clear that the 16 respondents reported positive Perceived Ease of Use of AR technology. Table 4.11 presents the descriptive statistics of the mean scores of 16 respondents' Ease of Use based on the follow-up questionnaire.

Table 4.11

Descriptive statistical reports of the mean scores of respondents' Perceived Ease of Use, three months after the interviews (*N*=16)

Questionnaire items	Mean	Std. Deviation
1. Using/ playing with the AR system does not require a lot of my mental effort.	3.44	1.209
2. I find the AR system to be easy to use.	3.75	1.125
3. My interaction with the AR system is clear and understandable.	4.00	.730
4. I find it easy to get the AR system to do what I want them to do.	4.00	.516
Cronbach's Alpha	.535	

Responses from the open-ended questions soliciting qualitative evidence revealed relatively similar findings as the statistical evidence. Most respondents found the AR technology easy to use, if they had necessary and accessible resources, particularly sufficient Internet access and access to the requisite tools. However, a few respondents mentioned that they did not possess full retention of how ZapWorks and Zappar operated as they previously did during the classroom treatment. Therefore, they pondered it might take them some time to review the tools if they had to use it again in the future.

The following illustration summarizes the quantitative findings of the 48 participants' mean scores and standard deviations of Perceived Usefulness, Perceived Ease of Use, Behavioral Intention, Perception of External Control, Computer Anxiety and Perceived Enjoyment. The mean scores were mapped, based on the theoretical framework of Technology Acceptance Model 3 (Vankatesh & Bala, 2008). The mean scores of each of those six constructs were from the data obtained from the questionnaire of AR acceptance and self-efficacy administered in the three different phases of the classroom AR activity treatment which included the Teacher Showcase, the AR Computer Tutorial and the Student Showcase.

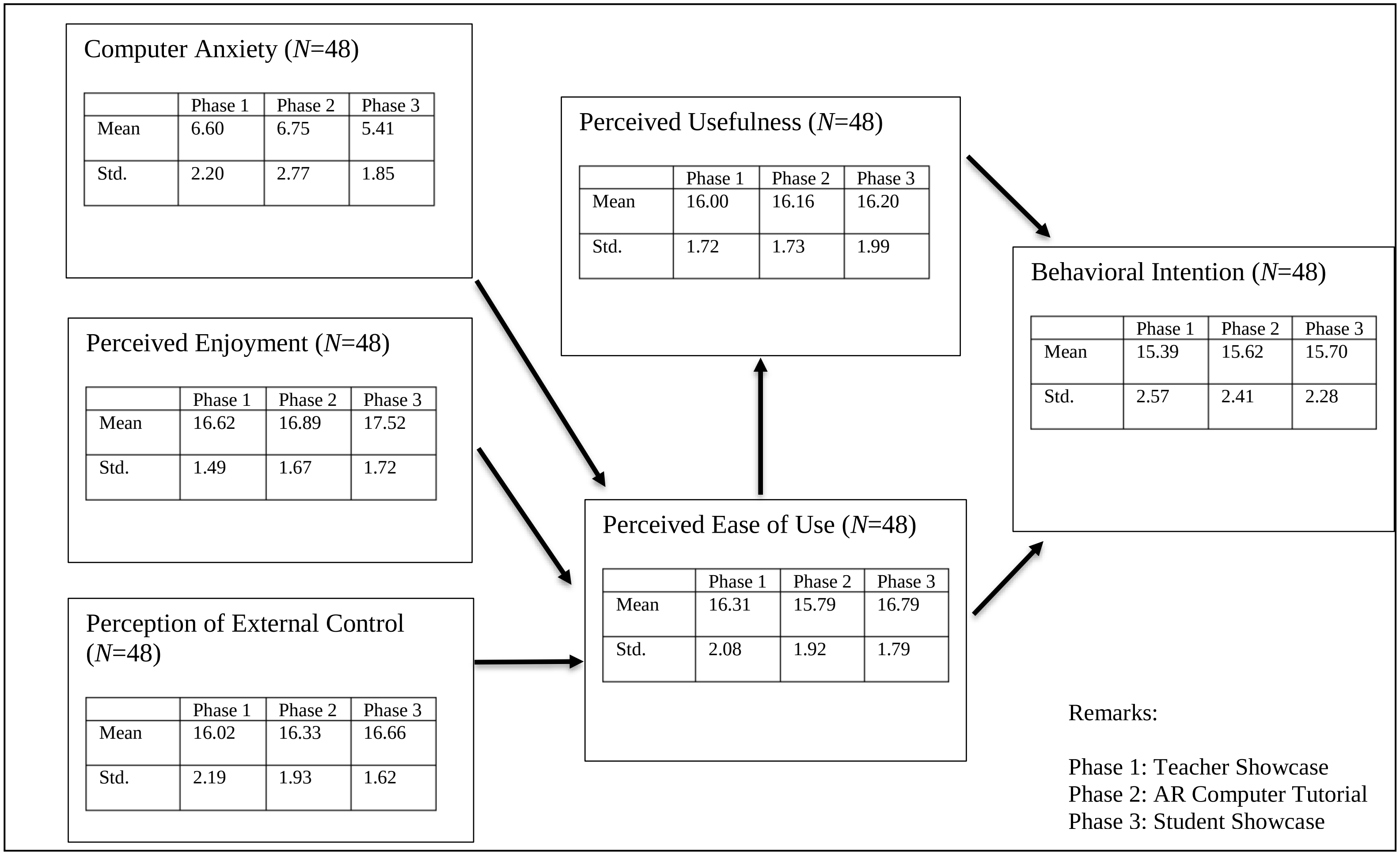


Figure 4.1 A summarizing illustration of six constructs' mean scores from three phases of the AR activity, mapped loosely on Technology Acceptance Model 3 (Vankatesh & Bala, 2008)

Participants' Levels of Computer Self-Efficacy of AR

In this section, quantitative and qualitative findings were reported in answering the research question: "*After completing the activities, what level of self-efficacy do participating Thai undergraduates have in using augmented reality technology?* (RQ2)." RQ2 was addressed through descriptive statistical analysis of the questionnaire on the acceptance and self-efficacy of AR technology, and through qualitative data obtained from the interviews and classroom observations. The sequence of reports began with different sets of quantitative data. Then the extensive qualitative data from the interviews, classroom observations, and other course materials followed.

Statistical Findings of Levels of Computer Self-Efficacy of AR

Bandura's (1982) concept of self-efficacy strongly influences the construct of Perceived Ease of Use of a given technology. Bandura (1982) defined self-efficacy as "judgments of how well one can execute courses of action required to deal with prospective situations" (p. 122). In the Technology Acceptance Model 3 (TAM3, Vankatesh & Bala, 2008), computer self-efficacy connotes the level of one's belief in performing a given task using technology (Compeau & Higgins, 1995).

In an attempt to statistically report the participants' levels of computer self-efficacy in using AR technology, quantitative data were reported using questionnaire data collected from the questionnaire on AR acceptance and self-efficacy of AR technology administered in three different phases throughout the research: 1) after the Teacher Showcase, 2) after the AR Computer Tutorial, 3) after the Student Showcase. Part 2 of the questionnaire on AR acceptance and self-efficacy was used in these analyses. This questionnaire section presented items to measure participants' assumed levels of computer self-efficacy, one of the constructs studied based on TAM3 (Venkatesh & Bala, 2008). These ten statements were adapted based on a study by Compeau and Higgins (1995). The 48 participants were asked to carefully read ten statements that indicated their self-reported level of self-efficacy in using the AR technology. After reading each statement, the participants chose an answer using a Yes/No dichotomous format. That is, they picked either Yes or No for each statement. Then they self-rated their perceived level of confidence using a 10-point Guttman response scale for all items in this section, where 1 represented the lowest level of self-confidence and 10 represented the highest (Venkatesh & Bala, 2008; Compeau & Higgins, 1995).

Table 4.12 shows a descriptive statistical report of the overall 48 participants' perceived levels of self-efficacy in using AR technology that was collected after the Teacher Showcase. The table represents the mean scores of each of the 10 statements in which the respondents provided Yes answers. Nearly all the respondents responded positively to the questionnaire items. The internal consistency of the 10 statements was acceptable at .798. However, there evidently were only 28 respondents who reported that they had self-confidence or self-efficacy across all 10 statements (α=.79), connoting that they consistently perceived themselves as proficient users of AR technology during the Teacher Showcase. This statistical evidence of positive computer self-efficacy may suggest that during the session where the students had a hands-on play session with teacher-made vocabulary flashcards, they did not require from themselves too much mental effort in attempting to achieve the task objective. That is, they were only asked to download Zappar on their mobile devices and to scan the zapcodes on each flashcard to experience embedded AR content. This task assignment, therefore, was not complicated and possibly resulted in a higher rate of reported computer self-efficacy.

Table 4.13 exhibits a descriptive statistical report of the same 48 participants' levels of self-efficacy in using AR technology that was collected after the AR Computer Tutorial showcase. The table shows the mean score of each of the 10 statements in which the respondents provided Yes answers. During this showcase, they attended a workshop in which they were trained and taught how to use ZapWorks and Zappar applications to create their own flashcards. As evidenced in Table 4.8, most of the participants still reported relatively high levels of computer self-efficacy. There were 28 participants out of 48 who consistently answered that they were confident in using AR technology across all 10 statements (α=.62), slightly fewer than those with Yes responses in the Teacher Showcase. This evidence possibly suggests that some participants may have felt frustration in tackling the task or operating the AR content creators.

Table 4.12

Descriptive statistical reports of levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the Teacher Showcase phase (*N*=48)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of participants who answered Yes	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	42	4	10	7.74	1.563
2. I could complete the task using AR technology if I had never used the AR system before.	42	1	10	7.29	1.991
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	44	2	10	7.80	1.983
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	46	3	10	8.22	1.943
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	40	3	10	7.38	2.047
6. I could complete the task using AR technology if someone else had helped me get started.	46	4	10	8.37	1.854
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	44	3	10	7.11	1.967
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	45	3	10	7.40	1.888
9. I could complete the task using AR technology if someone showed me how to do it first.	47	5	10	8.34	1.773
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	40	4	10	7.48	1.679
Cronbach's Alpha of the 10 statements	0.798				
Number of the participants who answered Yes to all the 10 statements	28				

Table 4.13

Descriptive statistical reports of levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the AR Computer Tutorial phase (*N*=48)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of participants who answered Yes	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	36	1	10	6.78	2.282
2. I could complete the task using AR technology if I had never used the AR system before.	29	1	10	6.14	1.977
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	41	3	10	7.17	2.048
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	46	4	10	7.76	1.876
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	43	5	10	7.16	1.717
6. I could complete the task using AR technology if someone else had helped me get started.	47	5	10	8.11	1.760
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	47	3	10	7.83	1.892
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	46	3	10	7.89	1.900
9. I could complete the task using AR technology if someone showed me how to do it first.	48	5	10	8.56	1.500
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	45	3	10	7.89	1.886
Cronbach's Alpha of the 10 statements		0.621			
Number of the participants who answered Yes to all the 10 statements		24			

Table 4.14

Descriptive statistical reports of levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the Student Showcase phase (*N*=48)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of participants who answered Yes	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	45	1	10	7.49	2.074
2. I could complete the task using AR technology if I had never used the AR system before.	39	1	10	6.44	1.917
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	46	3	10	7.74	1.819
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	46	5	10	8.33	1.477
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	44	5	10	7.48	1.548
6. I could complete the task using AR technology if someone else had helped me get started.	45	5	10	8.40	1.268
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	48	5	10	8.19	1.424
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	48	2	10	8.23	1.614
9. I could complete the task using AR technology if someone showed me how to do it first.	45	5	10	8.62	1.336
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	44	5	10	8.32	1.567
Cronbach's Alpha of the 10 statements	0.606				
Number of the participants who answered Yes to all the 10 statements	33				

Table 4.14 shows a descriptive statistical report of the participants' levels of self-efficacy in using AR technology that was collected after the Student Showcase. The table shows the mean score of each of the 10 statements in which the respondents provided Yes answers. During this showcase, all 48 participants gathered in the classroom to play with vocabulary flashcards created by other student pairs. This was their first time to experience their peers' works after three weeks of the AR Computer Tutorial and independent pair work. As evidenced in Table 4.9, the majority of the participants still reported high levels of computer self-efficacy. Moreover, there were 33 respondents who chose Yes responses across all 10 statements (α=.60), the number higher than those after the Teacher Showcase (24 persons) and after the AR Computer Tutorial (28 persons). This evidence may convey the impression that after all the three major phases of the AR treatment activities, the participants, who underwent a long session of hands-on practice and pair work, became fully familiarized with the AR creator tools and perceived themselves as successful, proficient users of AR technology. The completion of their final product-based outcomes, i.e. the flashcards, and weeks-long work process may contribute to how they positively viewed their accomplishment and self-efficacy in finishing the task.

Nonetheless, Table 4.12, Table 4.13 and Table 4.14 only present holistic statistical evidence on computer self-efficacy reported by the 48 respondents from each of the three phases in separate reports. It is noteworthy that it was inapplicable, based on those three tables, to run a quantitative calculation to measure the difference in the mean level of computer self-efficacy across the three phases. The reason was that the respondents with Yes answers on the 10 statements in each questionnaire form could not apparently be guaranteed to be the same persons across the three phases. For instance, S01 may have reported Yes in Form 1 and No in Form 2 and Form 3. This resulted in the fact that the reports of computer self-efficacy level should and must be initially presented separately for each phase. This was also true for the reports of the overall means of the self-reported scale of confidence/efficacy (from 1 to 10 points) from the questionnaire in each phase.

Hence, to analyze and present statistical reports, particularly about those respondents with all Yes answers over the three-phase period of the AR activity treatment, the numbers of respondents with Yes answers across the 10 statements in all three forms of the questionnaire were calculated to designate those with all-Yes answers in all 10 statements across all the three forms. Subsequently, based on this analysis criterion, out of 28, 24, and 33 all-Yes respondents from the three phases, there were only 13 persons that met the criterion.

Table 4.15 shows a further descriptive report of computer self-efficacy of the 13 all-Yes respondents collected after the Teacher Showcase phase. As evidenced in the table, the by-item mean for each of the 10 statements was also reported. This mean figure represents the average self-reported level of computer self-efficacy by the 13 all-Yes respondents, where 1 point means the lowest and 10 points the highest. However, the overall mean of the 10 statements was calculated by the sum of the rated scale point (1 to 10) of computer self-efficacy by each respondent in each statement. To simply put, considering that the full points for each statement is 10, and the number of respondents is

13, the overall full point is therefore 130. Based on this calculation, the overall mean of the rated scale point of computer self-efficacy after the Teacher Showcase is 7.83, while the Cronbach's Alpha shows a figure of .85, which demonstrates good internal consistency of the questionnaire items. These statistical data suggest that these 13 participants had a relatively high level of self-confidence in using AR technology during the session in which they played with the teacher-generated vocabulary flashcards at the beginning of the Analytical Reading course.

Table 4.16 also represents a descriptive report of computer self-efficacy of the 13 all-Yes respondents collected after the AR Computer Tutorial phase. The overall mean of the rated scale point of computer self-efficacy is 8.11 with a Cronbach's Alpha figure of .74, showing acceptable internal consistency of the 10 statements. These data suggest that the all-Yes participants seem to have a greater level of self-confidence compared the data collected after the Teacher Showcase. This slight decrease in the level of self-efficacy may result from that the participants familiarized themselves with how to use ZapWorks and Zappar and experienced some sort of operational/technical glitches or difficulties in successfully using the tools. This sense of computational glitches may lead to anxiety or frustration, which lowered the level of their overall self-efficacy.

Table 4.15

Descriptive statistical report of all-Yes participants' levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the Student Showcase phase (*N*=13)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of all-Yes participants across 3 forms	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	13	4	9	7.62	1.325
2. I could complete the task using AR technology if I had never used the AR system before.	13	1	9	7.08	2.178
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	13	5	10	8.23	1.363
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	13	7	10	8.62	1.044
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	13	5	10	7.38	1.609
6. I could complete the task using AR technology if someone else had helped me get started.	13	5	10	8.38	1.502
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	13	4	10	7.23	1.964
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	13	5	10	7.85	1.725
9. I could complete the task using AR technology if someone showed me how to do it first.	13	5	10	8.23	1.481
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	13	5	9	7.69	1.316
Cronbach's Alpha of the 10 statements	0.853				
Overall mean score of the 10 statements (i.e. 130 items combined)	7.83				
Std. Deviation of the 10 statements	1.605				

Table 4.16

Descriptive statistical report of all-Yes participants' levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the AR Computer Tutorial phase (*N*=13)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of all-Yes participants across 3 forms	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	13	1	9	6.69	2.529
2. I could complete the task using AR technology if I had never used the AR system before.	13	1	8	6.00	1.871
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	13	4	10	8.38	1.660
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	13	5	10	8.46	1.330
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	13	5	10	7.69	1.702
6. I could complete the task using AR technology if someone else had helped me get started.	13	8	10	8.85	.801
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	13	5	10	8.69	1.316
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	13	5	10	8.54	1.330
9. I could complete the task using AR technology if someone showed me how to do it first.	13	8	10	9.23	.599
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	13	5	10	8.54	1.266

Cronbach's Alpha of the 10 statements	0.743
Overall mean score of the 10 statements (i.e. 130 items combined)	8.11
Std. Deviation of the 10 statements	1.766

Table 4.17

Descriptive statistical report of all-Yes participants' levels of computer self-efficacy of AR technology, collected from the Questionnaire on AR acceptance and self-efficacy after the Student Showcase phase (*N*=13)

	Descriptive Statistics				
Ten statements on the Computer Self-Efficacy of Using Augmented Reality Technology (Form 1: After the Teacher Showcase)	N of all-Yes participants across 3 forms	Minimum rated score	Maximum rated score	Mean	Std. Deviation
1. I could complete the task using AR technology if there was no one around to tell me what to do as I go with the AR system.	13	1	10	7.54	2.367
2. I could complete the task using AR technology if I had never used the AR system before.	13	1	8	6.23	1.922
3. I could complete the task using AR technology if I had only the AR system manuals for reference.	13	4	10	7.85	1.676
4. I could complete the task using AR technology if I had seen someone else using the AR system before trying it myself.	13	5	10	7.92	1.382
5. I could complete the task using AR technology if I could call or ask someone else for help if I got stuck.	13	5	9	7.54	1.127
6. I could complete the task using AR technology if someone else had helped me get started.	13	7	10	8.31	.855
7. I could complete the task using AR technology if I had a lot of time to complete the task for which the AR system was provided.	13	7	10	8.62	.870
8. I could complete the task using AR technology if I had the built-in help facility for assistance.	13	8	10	8.69	.751
9. I could complete the task using AR technology if someone showed me how to do it first.	13	8	10	9.08	.862
10. I could complete the task using AR technology if I had used similar system(s) before this one to do the same task.	13	8	10	9.15	.899

Cronbach's Alpha of the 10 statements	0.836
Overall mean score of the 10 statements (i.e. 130 items combined)	8.09
Std. Deviation of the 10 statements	1.567

Table 4.17 shows the third-phase level of computer self-efficacy of the 13 all-Yes respondents collected after the Student Showcase phase, which was approximately two and a half months after the Teacher Showcase. The overall mean of the rated scale point of computer self-efficacy is 8.09 with a Cronbach's Alpha figure of .836, showing good internal consistency of the 10 statements. The overall mean figure was only .02 lower than that reported after the AR Computer Tutorial (M=8.11). This very miniscule drop may suggest that the 13 participants maintained a relatively constant self-confidence during these two phases.

In addition, the calculation of Repeated Measures ANOVA was also conducted to compare and test the difference in the means across the construct of computer self-efficacy in three repeated questionnaire administrations at three different time periods. Table 4.18 represents a report of Repeated Measures ANOVA. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean Computer Self-Efficacy level did not differ statistically significantly between three time points ($F(1.1671, 215.585) = 2.297$, p=.112). Post hoc tests using the Bonferroni correction revealed a slight increase in the participants' level of Computer Self-Efficacy after Teacher Showcase and after the AR Computer Tutorial (7.83 ± 1.60 mg/L vs 8.11 ± 1.76 mg/L, respectively), which was not statistically significant (p=.312). However, Computer Self-Efficacy after the Student Showcase had been reduced to 8.09 ± 1.56 mg/L, which was not also statistically significantly different from that after the Teacher Showcase (p=.243) and after the AR Computer Tutorial (p=1.00) session. Therefore, it could be concluded that the three-phase AR activity treatment does not elicits any statistically significant difference in the self-perceived level of Computer Self-Efficacy among the 13 all-Yes participants.

Table 4.18

Statistical report of Repeated Measures ANOVA of the compared means of the level of Computer Self-Efficacy by all-Yes participants, collected after the Teacher Showcase, the AR Computer Tutorial and the Student Showcase (*N*=13)

Descriptive Statistics

	Mean	Std. Deviation	N
Overall mean (Form 1) after the Teacher Showcase	7.83	1.605	130
Overall mean (Form 2) after the AR Computer Tutorial	8.11	1.766	130
Overall mean (Form 3) after the Student Showcase	8.09	1.567	130

Tests of Within-Subjects Effects

Computer Self-Efficacy

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	6.297	2	3.149	2.297	.103	.017
	Greenhouse-Geisser	**6.297**	**1.671**	**3.768**	**2.297**	**.112**	**.017**
	Huynh-Feldt	6.297	1.691	3.725	2.297	.112	.017
	Lower-bound	6.297	1.000	6.297	2.297	.132	.017
Error (Time)	Sphericity Assumed	353.703	258	1.371			
	Greenhouse-Geisser	353.703	**215.585**	1.641			
	Huynh-Feldt	353.703	218.081	1.622			
	Lower-bound	353.703	129.000	2.742			

Pairwise Comparisons

		Mean Difference	Std. Error	Sig.a	95% Confidence Interval for Differencea	
					Lower Bound	Upper Bound
(Form 1) after the Teacher Showcase	(Form 2) after the AR Computer Tutorial	-.277	.169	**.312**	-.687	.133
	(Form 3) after the Student Showcase	-.262	.149	**.243**	-.622	.099
		.277	.169	.312	-.133	.687
	(Form 3) after the Student Showcase	.015	.112	**1.000**	-.256	.287
(Form 3) after the Student Showcase	(Form 1) after the Teacher Showcase	.262	.149	.243	-.099	.622
	(Form 2 after the AR Computer Tutorial	-.015	.112	1.000	-.287	.256

Interview Findings of Levels of Computer Self-Efficacy of AR

As for the interview findings regarding Computer Self-Efficacy, 24 interviewees reported varying degrees and different aspects of their self-reported level of self-efficacy or perception of their ability to accomplish the task of the making vocabulary flashcards by using ZapWorks and Zappar, designated AR content creator tools. Nevertheless, it should be acknowledged in this respect that the interview protocol, specifically on the computer self-efficacy, was administered in Thai, which was originally translated from an English version. In Thai, there is no specific term that is semantically equivalent to the term “self-efficacy”, whereas the closest Thai term “ความมั่นใจในตัวเอง” that literally means “self-confidence”, seemed to be widely understood and therefore used in place of the term “self-efficacy.” According to Oxford Dictionary, the word “confidence” refers to “a feeling of self-assurance arising from an appreciation of one’s own abilities or qualities”, while the word “efficacy” similarly refers to “the ability to produce a desired or intended result” (Oxford Dictionaries, 2018). Therefore, due to this factor of a socio-cultural and linguistic difference and an equivalent of translation, the term “self-confidence” was used during the interview to better assist the participants to elicit accurate insights and experience toward their level of self-efficacy. Moreover, the terms “self-efficacy” and “self-confidence” are also used interchangeably in this chapter to convey the same meaning. In addition, the words “achievement” (i.e. the process of succeeding in something), “accomplishment” (i.e., the successful achievement of a task), and “success” (i.e. the accomplishment of an aim or purpose) (Oxford Dictionaries, 2018), were also used alternatively in this chapter to convey a similar meaning.

To begin with, in the collection of interview data, all 24 interviewees were asked to self-rate their perceived level of computer self-efficacy and to elicit their in-depth experience and contributing factors in using AR technology that was relevant to either increasing or lowering their self-confidence. Initially, they were asked to verbally identify themselves as a confident user of AR technology. They were requested to give themselves a ‘self-confidence score’ based on a 10-point scale, where 1 meant the lowest confidence and 10 the highest. The following Table 4.19 presents the self-reported self-confidence scores of the 24 interviewees.

Table 4.19
A report of self-perceived level of self-confidence/efficacy in using AR technology (*N*=24)

Interview participants	Reported Level (1-10) of self-perceived Computer Self-Efficacy
S01	9
S02	7
S03	7
S04	8
S05	7
S06	7
S07	8
S08	9
S09	8
S10	8
S11	8
S12	6
S13	8
S14	9
S15	8
S16	7
S17	7
S18	7
S19	8
S20	7
S21	8
S22	7
S23	8
S24	8
Mean	**7.66**

In Table 4.19, the mean score of the self-perceived level of computer self-efficacy among all 24 interviewees during the one-on-one interview was 7.66 which was relatively high. This suggests that at the outset, they regarded themselves as proficient users of AR technology with solid levels of self-confidence. However, despite these figures, it was found that all the interviewees cited a number of factors, that somehow either positively or negatively influenced or affected their self-confidence. These contributing factors could not be distinctly classified into two disparate groups because the interviewees viewed these factors differently. The following descriptive report of the interviewees' perceived computer self-efficacy is presented in three categories: 1) intrapersonal factors, 2) interpersonal factors, and 3) technological and technical factors, all of which reportedly either facilitate or obstruct levels of computer self-efficacy.

Intrapersonal factors

The intrapersonal factors comprised 1) self-satisfaction, 2) anxiety or frustration, and 3) creativity and enthusiasm.

Self-satisfaction

According to the interview data, self-satisfaction emerged as a piece of captivating evidence that revolved around an individual's perception of computer self-efficacy. Self-satisfaction appeared to express how one felt content, happy, and fulfilled after accomplishing the task. When asked what level of and to what extent their computer self-efficacy they thought they possessed, most of the interviewees, fundamentally associated their perspectives with how much they were satisfied with their performances on the task and with the final products—AR vocabulary flashcards. Their expressions of self-satisfaction, consequently, were said to contribute to how the interviewees formed and reshaped their computer self-efficacy over the three-phase period of the task project.

Qualitative accounts of self-satisfaction were firstly observed during the AR Computer Tutorial, continued over the following three-week, pair-work period, and were obviously evident during and after the Student Showcase. These accounts of self-satisfaction were divided into two primary aspects: process-oriented and product-oriented. The process-oriented self-satisfaction was concerned with how the users felt that they successfully carried out the flashcard-making task by effectively, attentively and accurately followed necessary operational steps as instructed or as self-taught. That is, the users had a sense of fulfillment of the working process toward *a means to an end*. A good example was S23 who reported that she was very happy with herself as an AR first-time user. When asked about how and why she felt satisfied with her work, she replied:

> *"**I am very happy with my work because my friend and I paid so much effort and energy on it even though we had limited time**. And I was proud of myself that I can achieve it. The outcome was as good as I had expected."*

S02 shared another interesting reflection. When asked if she perceived her own satisfaction similarly or differently, judging from the AR Computer Tutorial to the Student Showcase, she responded:

> *"**I felt more satisfied with my flashcards.** In the Teacher Showcase, when I saw your flashcards, I asked myself if it would be too hard for me to do, sort of that. It's like how I can get started with this thing. However, **after the training and all the process, I tried to do the work on my own, and I gained more confidence and satisfaction because it was not as difficult as I had thought**."*

A considerable number of the interviewees admitted that they felt relieved and proud of themselves after the completion of the task. This was because prior to the task, they were apprehensive of the AR technology itself, and by their lack of confidence. Therefore, once they accomplished the task, their self-confidence and self-satisfaction heightened quite drastically.

Furthermore, the interviewees also reported self-satisfaction driven by their state of contentment of how their complete vocabulary flashcards looked. That is, they projected a sense of task achievement based on *the end result*, rather than *means*. This product-oriented self-satisfaction initially stemmed from the moment when the interviewees finished their task after the three-week, pair-work period, and somehow this specific self-satisfaction shifted apparently to varying degrees during and after the Student Showcase. Nevertheless, it was noteworthy that the product-oriented self-satisfaction was not primarily determined by the aesthetics aspect of the final products. Rather, it was induced by the completeness of the final products; that all the flashcards contained all required elements that they should have. The interviewees mentioned that their self-satisfaction with their products either escalated or slightly dipped when they had the opportunity to play with and compare their work with other pairs during the Student Showcase. Some students obtained higher product-oriented self-satisfaction, while some reported the lower.

When asked to reflect on her satisfaction with her work before and after the Student Showcase, S01, for instance, stated that:

> *"**My satisfaction changed, but in a positive way.** This is because after we finished our work, we agreed that it was the best we could do. They looked perfect. But when we saw the works made by our peers. Oh! They did that thing that we did not. **We did not have that feature as they did. But we also had different other 'cooler' things they did not have too.**"*

S08 offered an interesting narrative. She realized that her work was not as beautiful-looking as her peers. However, she firmly believed that her content was very satisfactory, and she still reported the same high level of satisfaction. She elaborated thusly:

> ***"…I am fully satisfied although my flashcards are not as beautiful as my friends'.*** *When I compared my work with theirs, it occurred to me that 'Hey, I got better content, better information sources—at least that's how I feel. I made the content easy to digest and to understand…Some pairs use 'Back' button to go back to the homepage, whereas I use better navigation links that make it easier for users…"*

S22 also reflected a similar experience. When asked if he was happy with his work, he summed up that:

> *"…I think my satisfaction is above average, I would say quite high…My work is easy to understand because of a minimalist-looking interface and graphic design. **I think my flashcards work better than some of the other pairs' even though my flashcards are not paid with much attention [during the Student Showcase].**"*

When asked further if his self-satisfaction changed at all after the Student Showcase, he simply replied "No. I think it is just a matter of individual creativity that makes our work different."

By contrast, some interviewees asserted that their satisfaction negatively changed after they had a hands-on session with their peers' works. S11, for instance, admitted that her satisfaction with her product decreased only slightly when comparing her work with peers'. She said:

> ***"…I am satisfied…but when I saw my friends' works, I am like 'there are so many other features I should have tried.'*** *On their works, I saw that they put a graphic of a cat on top of the flashcard and made it an animation. And I am like 'Wow! How did they do that?'* ***So I asked them to give me some tricks…****"*

S11's reflection also aligned well with S14's experience in which she said she was surprised that some of her friends' works "looked much better" than hers; accordingly, she thought she had "average satisfaction" with her work. She said:

> *"…When I do not see my friends' flashcards,* ***I am ok with my work. But when I see their works, they look so beautiful and they have features that I never thought are available on ZapWorks.*** *So I ask myself 'How did they do that because I can't?'* ***I tried my very best but I just do not know that there are a lot more things…****"*

In brief, the product-oriented self-satisfaction differed in individuals. S17 was a thoughtful example, as indicated by her reflective insights. She said that she was highly satisfied with her work because she did her best and accomplished the task just fine without major problems. Furthermore, her self-satisfaction remained unchanged, although her work seemed to be less beautifully-executed than her peers.. She commented that each of the pairs had different outcomes, but they all looked good "in their own way…they are beautiful…not that this pair made more beautiful work…they are just different kinds of beauty."

In addition, the interviewees were asked whether self-satisfaction, particularly after comparing their works with peers, influenced any changes on their perception of computer self-efficacy at all. The evidence showed mixed results. Many interviewees viewed self-satisfaction and computer self-efficacy as different constructs that shared no association with each other. They explained that no matter how low or high they felt about their satisfaction, their computer self-efficacy stayed intact. On the other hand, some other interviewees agreed that the comparison of the students' work made them realize that they needed to improve, and that caused a drop in their computer self-efficacy. As for those whose flashcards were highly-praised by their peers during the Student Showcase, they resolutely said that they gained more confidence. Despite mixed findings, nearly all the interviewees mutually agreed that they learned tremendously from their peers' work and found that the Student Showcase was an excellent, eye-opening opportunity to witness and to think about future improvement of their work based on each other's creativity.

Anxiety or frustration

Some interviewees agreed that their levels of computer self-efficacy were rudimentarily influenced by emotional or psychological stability. They thought that their states of mind played a role in determining whether and to what extent they felt they had control over AR technology, which finally led to greater, or even lower, self confidence in using AR technology. Anxiety, or frustration in some interview cases, turned out to be a key mental factor. This finding seemed to align well with one of TAM3 framework's (Vankatesh & Bala, 2008) constructs—Computer Anxiety—in which a user feels apprehension or fear when encountering the possibility that (s)he has to use technology (Venkatesh, 2000; Igbaria & Iivari, 1995). Computer Anxiety in TAM3 is also a determinant to a user's Perceived Ease of Use of a given technology. The majority of the interviewees rarely identified anxiety during the vocabulary flashcard task. Most only asserted that they were slightly overwhelmed by the complexity of ZapWorks and Zappar operational features during the AR Computer Tutorial session and during their first week of pair work. However, the influx of workload and complicated AR computational features only posed 'temporary frustration', i.e. a state of confusion with something they had never experienced before, which later disappeared even before they finished their flashcard making. When asked if this emerging frustration ever became persistent anxiety and/or caused them to perceive themselves as a less proficient or confident user of AR, all of them disagreed; they said increased anxiety/frustration was not proportional to lowered computer self-efficacy because the level of anxiety was not originally from inner mental states, but from occasional external factors. Once solutions to difficulties caused by these external factors were provided, such frustration completely wore off.

However, a few interview cases gave different stories. For instance, S12 who reported only 6 out of 10 self-efficacy points stated that her 4 missing points were subtracted because she was "frustrated at first and [she] never knew or did anything with AR technology before. And [she was] afraid that she could not do it well enough to meet expectation." S12 also mentioned that her anxiety started during the AR Computer Tutorial and continued until the end of the task. Nevertheless, when asked if the anxiety reduced or eliminated at all after the Student Showcase, she answered:

> *"It [state of being anxious or frustrated] gets better. I feel like after I see my own works,* ***I feel the anxiety decreases a bit because here I have successful workpieces, I followed steps and guidelines correctly, I think.*** *I become more understanding of how [AR technology] works."*

Her experience suggests that anxiety or frustration may interplay with the level of computer self-confidence as perceived by users of emerging technologies. However, with appropriate guidelines, assistance, and tailored solutions, the anxiety could be reduced or even permanently removed.

Creativity and enthusiasm

Creativity and enthusiasm are also mentioned as intrapersonal factors. Many interviewees reported that their level of computer self-efficacy was heightened primarily due to an opportunity for them to put creativity and imagination to work. The designated AR tools—ZapWorks and Zappar—allowed them to create work pieces in a way they never thought they would be able to. However, even though a number of interviewees agreed that through using AR technology to produce vocabulary flashcards, they could manipulate their original ideas into tangible forms, a few of them found that creativity also played the role of a double-edged sword. A very small group of interviewees shared a similar account when working in pairs. They felt they lacked enough creativity to contribute. They stated that while playing with the teacher-made vocabulary flashcards during the Teacher Showcase, they were excited about and learned from the flashcard design and patterns as seen on the teacher's work. Yet, when it came to generating their own work, they lacked equivalent or more creative ideas to surpass the teacher's work. Consequently, they simply followed the design patterns without initiating any originality. This inadequacy of relative originality or creativity led to a reduced level of self-confidence among a few participants.

S20 and S09 (with a 7-point and an 8-point self-efficacy, respectively) shared the same inhibitions in applying originality and creativity to their work. They described their experience as follows:

> *"I deducted 2 points because one of the reasons was that* ***I am not a creative person. I did not have many ideas. And without guides or ideas, I just did not know what to do [to create complete vocabulary flashcards.]*** *(S09)"*

While S09 seemed to struggle with her creative ideas, S20 said that she was generally content with her final product, but the reason for her 7-point self-efficacy was that:

> *"I feel that I could do all the work, though there were some struggle throughout. It was because I was not a 'dynamic user' of AR. But once I got my hands on the work, I could keep doing it better and better.* ***My major problem might be that I did not put enough creativity in my work, not as much as I wanted. Even though my flashcards look beautiful, but it is not enough.****"*

In addition to anxiety and lack of creativity, the absence of enthusiasm is surprisingly an emerging piece of evidence that prevents a very few participants from obtaining full self-confidence in using AR technology. This finding, however, was only found among two interviewees who reported that they felt neither active nor motivated to do the task. This resulted indirectly from the task requirements that entailed considerable criteria and guidelines to follow, all of which were reported to be "too much," as S18 put it, for example. She initially credited herself as a 7-point-confident AR user. However, she abruptly gave herself one more point, but she still thought that she "…was not as enthusiastic as [she] expected…" When asked for the reasons, she simply said that "everything was too much…all the steps too much and I just do not want to do it." This account suggests that to some extent intrapersonal factors may also be influenced, either directly or indirectly, by other external ones. Yet, one's state of mind definitely played an important role in determining how confident (s)he would be in adopting a new technology.

Interpersonal factors

These interpersonal factors concerned the contextual influences from interactional circumstances and discourses during the task progress. These factors included 1) pair-work execution plans, 2) peer assistance and peer pressure, and 3) teacher assistance.

Pair-work execution plans

To begin with, some interviewees commented that collaborative work with another classmate caused some difficulties in negotiating and mutually agreeing on workflow plans. This constraint somehow reportedly brought about a clash of ideas and operational disputes, particularly during the three-week pair-work period. S19, for instance, remarked that she had a firm comprehension of how ZapWorks and Zappar worked after attending the AR Computer Tutorial. Nevertheless, once pairing up with another classmate for idea brainstorming, minor disagreement on planning occurred and restrained her pair from settling on shared decisions for quite some time. One of the consequences was that the pair needed to re-work some of the finished flashcards because some of the navigation links did not sync and work properly. She remarked that:

> ***"…[Our] planning with the other friend was not so smooth. And it delayed our work progress quite a bit even though I can work with all the features [on ZapWorks].*** *They are easy. They are very similar to the features on PowerPoint."*

S19 further added that this pitfall made her decide to deduct 2 out of 10 points of her computer self-efficacy level. She also provided the insight that if the task had been an individual one, she would have done a better job with more satisfactory final products because she would have ultimate freedom for planning and taking appropriate action as she saw fit.

Peer assistance and peer pressure

Apart from imprudent planning, peers were also highlighted as a crucial factor. In this respect, peers rendered two major effects on one's computer self-efficacy—giving assistance and/or pressure. As evidenced in the interview data, some of the interviewees reflected greater self-confidence when rapport with another pair member was established and maintained. This account was also related to how well the pair executed the task planning as mentioned in the previous section. When the pair sustained healthy interpersonal communication, they reported smoother and more successful collaboration and cooperation as a team, rather than as an individual. Furthermore, peer assistance from other pairs also showed strengthening of the level of computer self-confidence in some participants. For instance, S10 and S12 reported that they gained more confidence from peer assistance. S10 shared her experience in these words:

> *"...**My friends helped me a lot.** For example, when I tried to use Pixlr* (*a free web-based graphic editor, translator*) *to retouch photos for flashcards**, my friends helped me a lot because I did not know how to work with the program. So I could follow the steps. It helped me to have more confidence with the program and with creating the flashcards.**"*

Like S10, S12 stated that the complexity of ZapWorks sometimes caused her to be unmotivated. Yet, she found support from 'more acknowledgeable friends' very useful and valuable, which reportedly elevated her computer self-efficacy. She added:

> *"...I did not look for too many resources. **I just sought help from my friends, and did it on my own. But I got a lot of help from other pairs [of friends].** They helped me with teaching me how to add links, add texts and symbols [onto flashcards], something like that. **So I could get going with the rest by myself.**"*

A few other interviewees also asserted that peer effects stemming from comparing the work slightly affected their computer self-confidence in some way. This finding emerged quite apparently during the Student Showcase in which all the 48 participants had the opportunity to see and play with other peers' flashcards for the very first time. Some pairs said that it was not uncommon in subjectively judging their work quality by comparing it to other classmates. In this process negative and positive peer reinforcements arose according to the interview findings.

In terms of negative peer reinforcement, some students commented that they felt their flashcards were of inferior quality and aesthetics compared to their classmates, which resulted in a slight lowering of computer self-confidence. For instance, S13, with an 8-point computer self-efficacy, revealed that her 2 deducted points was due to her "less beautiful and less worth-playing flashcards." She said that during the Student Showcase, she was in awe of other pairs' flashcards because they were highly creative with aesthetically-looking graphic design and interactive content, such as scenario-based videos and some small word quizzes. These features were non-existent in her work. When asked further whether this lowered her confidence in using AR, she unhesitatingly admitted that it "reduced [her] computer self-confidence just 'a little'" and added that if she had put in more effort and creativity, her work would have been more satisfactory, given that everyone was using the same AR tools.

In contrast, a small number of participants expressed the opinion that they became even more highly proficient and confident AR users after the Student Showcase particularly because of positive peer reinforcement. They stated that they felt heightened motivation and computer self-confidence in adopting AR technology after unexpectedly receiving positive feedback and praise during the Student Showcase by many other classmates. They mentioned that they did their best on the flashcards, and, to their surprise, others seemed to enjoy playing with their flashcards very much.

Teacher assistance

In addition to peer effects, teacher assistance was also reported to play a crucial role in boosting one's level of computer self-efficacy. Evidently, many participants with fewer computer skills found that e-mail correspondences with the workshop presenter, in this case the researcher, very useful and supportive. They mentioned that even though they had gained an understanding of how ZapWorks and Zappar operated during the AR Computer Tutorial, receiving further explanations, solutions, or suggestions via e-mail from the researcher also helped them gain more confidence. The minority of the participants reported that they felt more secure when receiving assistance directly from the workshop presenter rather than looking up information from online tutorials or print resources they were given in the workshop. This kind of one-on-one communication somehow made them feel secure that they were on the right track. For instance, S15 admitted that she experienced some technical glitches and she often "e-mailed [the workshop presenter] for answers." When asked whether she ever sought solutions from peers, she said:

> *"…No.* ***I just asked for information from [the workshop presenter] directly.*** *It was better because I was sure that it was correct information. Sometimes, my friends got confused as well.* ***And with the answers, I felt relieved and more confident to go on with my project****."*

In brief, it was clear that teacher and peer effects played significant roles in influencing an individual's level of computer self-efficacy to varying degrees.

Technological and technical factors

These technological and technical factors referred to the influences of, for example, facilities, infrastructure, and/or resources that were used during the task project to facilitate the participants in successfully completing the flashcard making. As evidenced in the interview findings, these factors could be said to be closely equivalent to the construct of Perception of External Control as in TAM3 (Vankatesh & Bala, 2008). Perception of External Control is defined as a degree to which an individual believes that organizational and technical support and resources facilitate their use of the technology (Venkatesh, Speier, & Morris, 2002). According to TAM3, this construct acts as a direct determinant that influences an individual's Perceived Ease of Use of a given technology. However, the construct is not, theoretically, induced by or driven by the construct of Computer Self-Efficacy, which is also a direct determinant of one's Perceived Ease of Use. Nevertheless, evidently in the interview data, it occurred that the participants' levels of computer self-efficacy were by some means affected by how they perceived technical infrastructure and resources as useful and assistive to their work progress. In this section, these technical and technological factors consisted of 1) AR training, 2) facilities and Internet infrastructure, and 3) AR computational/operational complexity.

AR training

To begin with, AR training refers to the AR Computer Tutorial session in which all 48 participants attended a three-hour workshop where they were taught and trained about how to use ZapWorks and Zappar. Based on the interview data, it was clear that all interviewees found the workshop extremely necessary and helpful in providing a step-by-step computational walkthrough of the AR tools. Some interviewees mentioned that it would be difficult for them to use the tools on their own without prior skills training, and that would definitely affect their perceived computer self-efficacy to some degrees. Furthermore, they found the orientation presentation on AR very eye-opening for them in learn about AR technology in general. S06 and S08 shared similar accounts on the usefulness of AR training in equipping them with sufficient knowledge and skills needed, lifting their levels of computer self-confidence. When asked about how he viewed the importance of AR training on his computer self-confidence, S06 reported:

> *"...**I think it is very important and we should have it [the training].** This is because without the training, I would not be able to do it. In the workshop, [the workshop leader] told me every single step, very detailed and clear. **And I learned from that step by step until I could carry out the task on my own afterwards**."*

S08 provided a similar account of her experience when asked the same question. She said:

> *"I think the training must be given for the students, no matter what. **I think if we do not have a training, if we do not have a chance to try to create a mock flashcard in the workshop, how would we be able to finish the project?** Right? Because we will not know how it works, what features or functions it has. **And when we know all of that and we create our work, it (computer self-efficacy) gets better…**"*

This evidence suggests that to successfully integrate an emerging technology into an educational setting, prior training should be taken seriously into account.

Facilities and Internet infrastructure

Facilities and infrastructure at the faculty and the university level also played a significant role in shaping and reshaping how the participants perceived themselves as AR-confident users. These factors included the Internet access and coverage and the faculty-housed computer lab. All 24 interviewees mutually agreed that Mahidol University and the Faculty of Liberal Arts were well equipped with robust and reliable hi-speed Internet access and wide coverage across the campus and in on-campus student residences. The Internet, therefore, was not a problematic issue. They also observed that the computer lab and facilities at the university's Learning Center was also facilitative. These readily available computer and Internet facilities reportedly raised the participants' confidence in using AR as they encountered very few technical glitches concerning the loss or the instability of Internet access. The interviewees also agreed that for AR technology to thrive and to gain more acceptance among students, the facilities should be made widely available, easily accessible and highly stable. Otherwise, unnecessary or unexpected technical constraints and glitches could and would pose a threat to a student's confidence level. S01 described her experience interestingly: when the university or faculty facilities were ready and available, students would confidently carry out the project. She gave a rationale for her 2 missing points of computer self-efficacy:

> *"…I deleted 2 points because I think it [using computer and Internet at home/dorm to complete the project] is very electricity-consuming. Because my friend and I use two computer notebooks at the same time and we work at my dorm. So I think it will be better if we work on campus instead because we do not have to pay the electricity bills and Internet plans."*

When asked a follow-up question why she still decided to use the Internet and electricity at her student residence instead of at the university with ready and free-of-charge infrastructure, S01 went on saying:

> *"…I know I am supposed to do so [work on campus with a peer], but sometimes I just feel like working from home. And that's probably why I do not feel so much confident because our Internet at dorm is not as good as that on campus. I know a lot of friends work on the project by using university facilities like the WiFi and I just now realize that I should have done the same."*

However, while S01 reported that the shortcoming of infrastructure and facilities affected her role as a confident AR user at some point, S07 told a slightly different story. She reported that even though she encountered slow WiFi access, her computer self-efficacy was not affected at all; she just felt "temporarily upset" with the weak bandwidth. She elaborated that slow Internet speed caused a problem in streaming AR content while using Zappar. She further added:

> *"…Sometimes, I got a bit upset because I had to wait for a long time for the [AR] content to pop up. The technology itself should be fast and easily accessible, but I still had to wait for the loading time. It took a while before a zapcode was read and the content showed."*

When asked further if this technical inconvenience reduced her level of computer self-efficacy, S07 replied that she "…did not think so."

AR computational/operational complexity

AR computational or operational complexity refers to the application-oriented technical procedural steps of executing a task using given technological tools, which in this case were ZapWorks and Zappar together with additional editing tools, such as Pixlr and Adobe Photoshop. As evidenced in the interview data, many interviewees admitted that they tended to have higher computer self-confidence in using AR tools if or when the designated AR tools were easy to use with familiar or user-friendly operational interfaces or features. Simply put, the interviewees seemed to have related their first-time, hands-on training with ZapWorks to their prior experience with some other technological applications with which they were more familiar. These familiar tools reportedly included Microsoft Office applications (particularly Microsoft PowerPoint), Adobe Photoshop, Abode Illustrator, and iMovie. They mentioned that some of the features and user interface of ZapWorks were similar to those in the aforementioned programs or software, which enabled them to use the AR tools more easily and comfortably. For instance, in ZapWorks, there was Animation in which a user can insert animated object movements onto the content elements (e.g. Fade In, Fade Out, Move In From the Left, for example). Moreover, the navigation menu looked quite similar to most of Microsoft Office applications, enabling them to locate necessary function icons, such as Save and Edit Text, easily.

Despite the above reasons, some interviewees admitted that ZapWorks' features and functions were too considerable and relatively complex, so that at times these caused them to feel nervous and affected their self-confidence. For instance, S04 rated herself only 4 out of 10 points for computer self-efficacy mainly because she admitted, "… [ZapWorks] has too many functions that [she does] not have time to use all those." Consequently, she felt that she must have missed some great features that her friends took advantage of while she did not. S11 also shared a similar experience, as she asserted that even after the AR Computer Tutorial, she was not "well adept at all the available features on ZapWorks." Therefore, at times, she was stuck in the process and needed to seek assistance, an incident which she reported caused both frustration and that reduced her self-confidence.

Furthermore, a few other interviewees provided the information that with the already complex procedures of using ZapWorks, they found embedding AR content quite mentally overwhelming. They reported a moderately high learning curve in which they carefully—and laboriously—planned and created a set of complete, well-programmed flashcards with working navigation hyperlinks. The overload and complexity of technical steps reportedly exhausted the interviewees' energy and attention to the task. This constraint made them perceive themselves as mediocre AR users when compared to other classmates with equivalent or higher computer proficiency. For instance, when asked why she gave herself 8 points, S21 reluctantly expressed her concern about her computer self-efficacy:

> *"**It's like my skills are limited** and this is all I know, so that is all I can do.* ***But I know that there are so many other things I could have done differently,*** *just like your flashcards [teacher-made flashcards] that you embedded pop-up animations****. But I cannot go to that level because [ZapWorks] sometimes gets me confused…****"*

S14, S15, and S20 also had similar reflections on the complexity of the AR tools. S20, for instance, said that her 3 missing points resulted from:

> *"**…my unfamiliarity with the program [ZapWorks],** I think. When I use it, I will have to think 'So what's next? Which button to tab?' It is like I sometimes forget*

> *what to do next, so I will have to re-work my flashcards for quite some time. Have to check again and again to make sure that all the hyperlinks work."*

S14 and S15 backed up these points by mentioning that Zappar, the AR reader application, caused them to be modestly insecure. Once they used Zappar to scan the flashcards to reveal the content, it occasionally took considerable time for information to be loaded. This technical drawback may be involved with weak WiFi access or server downtime on the other end, yet it evidently affected self-perceived computer confidence.

In brief, the interviewees' levels of computer self-efficacy differed based on several factors: intrapersonal, interpersonal and technical and technological ones. The intrapersonal factors referred to users' self-satisfaction on both process-based and product-based levels and anxiety or frustration during the flashcard making process. The interpersonal factors covered student planning and execution of the task, peer effects, and teacher assistance. The technical and technological factors explained how computer and the Internet facilities and resources, AR computer training, and the operational complexity of designated AR applications could play a crucial role in shaping how an individual perceives himself or herself as a confident user of AR technology. All these above-mentioned factors were reported to have either positive or negative influences on one's computer self-efficacy to varying degrees, depending on subjective perceptions and experiences.

Participants' Behavioral Intentions in Using AR

In this section, quantitative and qualitative findings were reported to answer the research question: "*After completing the activities, what are participating Thai* *undergraduates' intentions about using augmented reality technology in their future learning?* (RQ3)." RQ3 was addressed through descriptive statistical analysis of the questionnaire on the 48 participants' Behavioral Intentions in using AR technology in the future, and through qualitative data obtained from the interviews and classroom observations. The sequence of reports began with quantitative data. Then the extensive qualitative data from the interviews, classroom observations, and other course materials followed.

Statistical Findings of Behavioral Intentions in Using AR

As a construct in the original Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989) and in the Technology Acceptance Model 3 (Vankatesh & Bala, 2008), Behavioral Intentions refer to the degree to which an individual is determined to use, to apply or to adopt a given technology for improved productivity in the future. Behavioral Intentions are said to be directly influenced or moderated by Perceived Usefulness and Perceived Ease of Use, while Perceived Ease of Use plays a role in determining one's Perceived Usefulness. The following statistical data were collected from the three paper forms of the questionnaire on the acceptance of AR technology, which were administered at three different stages.

Table 4.20

Descriptive statistical reports of the mean scores of participants' Behavioral Intentions, after Teacher Showcase, AR Computer Tutorial, and Student Showcase (*N*=48)

Questionnaire items	After Teacher Showcase (Form 1)	After AR Computer Tutorial (Form 2)	After Student Showcase (Form 3)
1. Assuming I had access to the AR system, I intend to use it.	4.02	4.06	4.10
2. Given that I had access to the AR system, I predict that I would use it.	4.10	3.98	4.13
3. I plan to use the AR system in the near future.	3.65	3.67	3.75
4. I am determined to integrate the AR system for my future learning.	3.63	3.92	3.73
Descriptive Statistics			
Mean	15.39	15.62	15.70
Std. Deviation	2.57	2.41	2.28
Cronbach's Alpha	.855	.835	.877

Table 4.20 shows the set of four questionnaire statements that measure the construct of Behavioral Intentions, and the mean scores, which were analyzed from three stages of the questionnaire administration: After Teacher Showcase; After AR Computer Tutorial and After Student Showcase. Evidently, the participants reportedly intended to use AR technology even after the Teacher Showcase in which they experienced the technology for the very first time (*M*=15.39, *SD*=2.57, *α*=.855). Later, after the participants attended the AR Computer Tutorial session, their Behavioral Intentions elevated slightly (*M*=15.62, *SD*=2.41, *α*=.835). These data suggest that once the students were equipped with technological training of a given technology with which they had been previously unfamiliar, they might feel more confident and more willing to continue using it. They possibly started to formulate possibilities of the technology in improving learning productivity or in facilitating their future career preparation. In addition, after the Student Showcase, the students' Behavioral Intentions also increased (*M*=15.70,

SD=2.28, *α*=.877). This increase may suggest that the students were well acknowledged about practical or applied applications AR technology could offer. Also, the students might have better understanding of how AR technology work and feel more secure in using it in the future.

In addition, the calculation of Repeated Measures ANOVA was also conducted to compare and test the difference in the means across the construct of Behavioral Intentions in three repeated questionnaire administrations at three different time periods. Table 4.21 represents a report of Repeated Measures ANOVA. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean Computer Self-Efficacy level did not differ statistically significantly between three time points ($F(1.958, 92.035) = .711$, p=.491). Post hoc tests using the Bonferroni correction revealed a small increase in the participants' Behavioral Intentions after Teacher Showcase and after the AR Computer Tutorial (15.39 ± 2.57 mg/L vs 15.62 ± 2.41 mg/L, respectively), which was not statistically significant (p=1.00). However, Behavioral Intentions after the Student Showcase had slightly increased to 15.70 ± 2.28 mg/L, which was not also statistically significantly different from results after the Teacher Showcase (p=.855) and after the AR Computer Tutorial (p=1.00) session. Therefore, it could be concluded that the three-phase AR activity treatment does not elicits any statistically significant difference in the construct of Behavioral Intentions among the 48 participants.

Table 4.21

Statistical report of Repeated Measures ANOVA of the compared means of the level of Behavioral Intentions, collected after the Teacher Showcase, the AR Computer Tutorial and the Student Showcase (*N*=48)

Descriptive Statistics

	Mean	Std. Deviation	N
Overall mean (Form 1) after the Teacher Showcase	15.39	2.57	48
Overall mean (Form 2) after the AR Computer Tutorial	15.62	2.41	48
Overall mean (Form 3) after the Student Showcase	15.70	2.28	48

Pairwise Comparisons

		Mean Difference	Std. Error	Sig.a	95% Confidence Interval for Differencea	
					Lower Bound	Upper Bound
(Form 1) after the Teacher Showcase	(Form 2) after the AR Computer Tutorial	-.229	.255	**1.000**	-.862	.403
	(Form 3) after the Student Showcase	-.313	.289	**.855**	-1.030	.405
(Form 2) after the AR Computer Tutorial	(Form 1) after the Teacher Showcase	.229	.255	1.000	-.403	.862
	(Form 3) after the Student Showcase	-.083	.269	**1.000**	-.752	.585
(Form 3) after the Student Showcase	(Form 1) after the Teacher Showcase	.313	.289	.855	-.405	1.030
	(Form 2 after the AR Computer Tutorial					

Tests of Within-Subjects Effects

Behavioral Intentions

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	2.514	2	1.257	.711	.494
	Greenhouse-Geisser	**2.514**	**1.958**	**1.284**	**.711**	**.491**
	Huynh-Feldt	2.514	2.000	1.257	.711	.494
	Lower-bound	2.514	1.000	2.514	.711	.403
Error(factor1)	Sphericity Assumed	166.153	94	1.768		
	Greenhouse-Geisser	166.153	**92.035**	1.805		
	Huynh-Feldt	166.153	94.000	1.768		
	Lower-bound	166.153	47.000	3.535		

Pearson product-moment correlation coefficients were also computed to assess the relationship(s) between the determinant Behavioral Intentions and other determinants in TAM3 (Venkatesh & Bala, 2008) which included Perceived Ease of Use, Perceived Usefulness, Perception of External Factor, Computer Anxiety, and Perceived Enjoyment. Table 4.16 displays a report of the correlation coefficients analyzed from the three forms of the questionnaire on AR acceptance collected after the Teacher Showcase, AR Computer Tutorial, and Student Showcase phases.

As evidenced in Table 4.22, after the Teacher Showcase, there was a moderate positive association between the variables Behavioral Intentions, Perceived Ease of Use ($r(48)=.571$, $p<.000$) and Perceived Enjoyment ($r(48)=.531$, $p<.000$), respectively. There was also a weak positive relationship between Behavioral Intentions, Perceived Usefulness ($r(48)=.397$, $p=.005$) and Perception of External Control ($r(48)=.303$, $p=.036$), respectively. The report, however, addressed a very weak negative correlation between Behavioral Intentions and Computer Anxiety ($r(48)=-.287$, $p=.048$).

Table 4.22

Report of the Pearson correlation coefficients of Behavioral Intentions and other determinants in TAM3 (Vankatesh & Bala, 2008), from the three forms of the questionnaire on AR acceptance (*N*=48)

		Behavioral Intentions	Perceived Usefulness	Perceived Ease of Use	Perception of External Factor	Computer Anxiety	Perceived Enjoyment
Behavioral Intentions After Teacher Showcase	Pearson Correlation	1	**.397****	**.571****	**.303***	**-.287***	**.531****
	Sig. (2-tailed)		.005	.000	.036	.048	.000
Behavioral Intentions After AR Computer Tutorial	Pearson Correlation	1	**.658****	**.451****	**.423****	-.043	**.358***
	Sig. (2-tailed)		.000	.001	.003	.772	.012
Behavioral Intentions After Student Showcase	Pearson Correlation	1	**.511****	**.420****	**.436****	**-.287***	**.492****
	Sig. (2-tailed)		.000	.003	.002	.048	.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Furthermore, based on the correlation coefficients analyzed after the AR Computer Tutorial, the statistical data similarly indicated a moderate positive association of Behavioral Intentions with Perceived Usefulness (r(48)=.658, *p*<.000), Perceived Ease of Use (r(48)=.451, *p*=.001), Perception of External Control (r(48)=.423, *p*=.003), and Perceived Enjoyment (r(48)=.358, *p*=.012). However, there was no significant relationship between Behavioral Intentions and Computer Anxiety in this phase.

Interestingly, the correlation coefficients of Perceived Usefulness and Perception of External Control increased quite apparently compared to those in the Teacher Showcase (r=.397 vs r=.658 and r=.423 vs r=.303, respectively). By contrast, the correlation coefficients of Perceived Ease of Use and Perceived Enjoyment dropped slightly during the two phases (r=.571 vs r=.451 and r=.531 vs r=.358, respectively), in relation to Behavioral Intentions. This finding may suggest that the participants gradually found AR technology relevant and useful for their productivity and learning over time, which may be driven by the fact that they gained more understanding and practical knowledge and skills about ZapWorks and Zappar during the workshop. Consequently, they tended to adopt such technology for their future use. In addition, the decrease in Perceived Ease of Use and Perceived Enjoyment may result from the operational complexity of ZapWorks and Zappar or any related technical difficulties the participants might experience during the workshop that caused them to view such technology in a less positive way.

The Pearson correlation coefficients were also subsequently analyzed from the questionnaire administered after the Student Showcase phase. Evidently, there was, again, a moderately positive relationship between Behavioral Intentions, Perceived Usefulness ($r(48)=.511$, $p<.000$), Perceived Ease of Use ($r(48)=.420$, $p=.003$), Perception of External Factor ($r(48)=.436$, $p=.002$), and Perceived Enjoyment ($r(48)=.492$, $p<.000$), whereas there was a weak negative association with Computer Anxiety ($r(48)=-.287$, $p=.048$). Nevertheless, the correlation coefficients of Perceived Usefulness and Perceived Ease of Use decreased modestly from the AR Computer Tutorial phase, while Perceived Enjoyment and Perception of External Control was elevated. When comparing all the three phases, it was quite clear that there was fluctuation, in a positive fashion, between the determinants of Behavioral Intentions, Perceived Usefulness, Perceived Ease of Use, and Perceived Enjoyment, yet Perception of External Control seemed to be the only moderator with a continually increasing association with Behavioral Intentions over the three phases.

Interview Findings of Behavioral Intentions in Using AR

As for the interview evidence regarding Behavioral Intentions, 24 interviewees reported different aspects of their willingness and interest in practically using AR technology in their future. Overall, most of the interviewees agreed mutually that they thought AR technology is highly useful for improved learning performance and/or enhanced productivity. They viewed AR as useful for several purposes, for example, as a presentational tool and as an effective supplemental learning booster that enhanced better memorization, creativity, and collaboration. Besides, the participants had fun playing with and using AR technological tools and were satisfied with their final products. Generally, they tended to have heightened self-confidence in using the technology, as discussed in the previous section. In terms of Perceived Ease of Use, the interviewees also agreed that the designated AR creator tools were easy to use with friendly user interface and operational/computational features that were similar to those in more familiar computer software, such as Microsoft Office or Adobe. Furthermore, with the provision of the AR Computer Tutorial and different resources for assistance, the participants seemed to perceive AR technology as convenient, functional, and not creating a too high learning curve, regardless of the fact that they used the technology for the first time. With very little computer anxiety that was reduced by sufficient and available facilities and technical assistance, the participants also found AR technology as a potential technology they considered adopting for their own use.

Subsequently, when asked about their projections of future adoption of AR technology, the interviewees' responses varied. Nevertheless, in a relatively similar fashion, they were likely to integrate or to apply AR in their future if opportunities allowed. The interview findings of Behavioral Intentions of using AR technology were categorized into three fundamental purposes: 1) professional preparation and presentation, and 2) personal entertainment.

Professional preparation and presentation

Surprisingly, when asked the question about what and how they would use AR technology in their future, most of the interviewees rarely mentioned prospective educational uses. That is, they did not provide much evidence of how and to what extent they would be integrating AR in their studies. This might result from the fact that all the interviewees were in their third university year, and they would generally spend considerable time with internships in their fourth year. As a result, they could not formulate vivid ideas of AR integration for learning purposes while still in university. Nevertheless, a number of interviewees shared similar thoughts when it came to applying AR for future career paths and professional development. They firmly agreed that, with adequate and appropriate resources and opportunities, they would likely use AR as an engaging career preparational and presentational tool.

S01, S03, and S07, to name a few, all indicated that AR technology would definitely make their resumes and professional video presentations unrivaled compared to other applicants. They imagined that AR multimedia interactivity would help convince organizations or employers that they were potential job candidates with outstanding digital technology skills—sought-after attributes in the more competitive job market in Thailand. S03 addressed that she would use AR "…when [she] applies for jobs because it [AR technology] makes me look 'cool' and shows that I have computer knowledge and skills that may be what the company is looking for from top candidates." Likewise, S07 was another interesting example. At first, she hesitated when asked about her AR future use. However, after a long pause, she continued:

> *"…Actually I am thinking about that* (using AR in the future)*. Not sure how I will use it but with AR skills, I think I can be more 'interesting' in other people's eyes. Suppose that I apply for a job, I can use it in my resume. If I use it for real, it surely makes me 'superior' to other applicants a little bit I guess…"*

When asked for factors or reasons why they decided to adopt AR in the future, S03 and S07 said that after all the AR activities, they felt comfortable as able AR users. They also mentioned that with existing AR skills, creating AR-enhanced resumes was not a difficult or impossible execution.

In addition to career preparation, numerous interviewees asserted that AR technology could be used as an engaging presentation tool in their future professions. This finding seemed to align well with qualitative interview data on Perceived Usefulness in that the interviewees thought that AR technology offered an affordance of multimodality and information representation. The interviewees opined that this affordance was a major attribute that influenced their likelihood of adopting AR. For instance, S12 clearly explained her reason to reap the benefit of AR as a presentational tool for her study and future career:

> *"…In the near future, let's say next year [the fourth academic year], if I have to give presentation or go work at some company, AR technology can be an interesting choice for me. This is because I can add sounds, images, videos, and create presentations that do not need screen projection via an LCD projector. It can pop up anywhere as long as you have mobile phones. I think it is exciting and new and it will make presentations exciting too."*

S14 thought similarly in the same respect. She stated that:

> *"…Like when I work and need to present something to my boss, I may have some (PowerPoint) slides while everyone else has slides with AR content. So they can watch the content simultaneously on their own. They do not even need to rely on my slides because they each have AR at their fingertips."*

Personal entertainment

A few interviewees reported that they may consider using AR technology in the future, particularly for their entertainment purposes. They said that even though AR might still be in its infancy at the moment, it may and would promise more interest and technical improvements in the very near future. These improvements or advancements could be easily and potentially applied in computer games or games consoles, such as PlayStation or Nintendo. Besides, there is an increasing number of Virtual Reality (VR) and AR equipment that is being manufactured and that is already commercially available, such as customized helmets. The increasing availability of AR equipment would allow them to access AR content more easily and more inexpensively, considering that more abundant AR content and less-costly devices would be made by technology developers to meet consumer demands. Some other interviewees projected that in the future, home entertainment or even movie advertisements might also have AR-enhanced elements. This would make AR more domestically-friendly, and the AR functionalities might be more user-friendly for the public, compared with the present time. With all these above-mentioned reasons, a large group of interviewees thought they would continue using AR in the future. For instance, S03 said that if AR reaches its anticipated potential in the future, she might create some AR work that incorporate movies for personal leisure activities. S16 remarked that she was interested in AR-enhanced games and thought "…AR can be a fun gaming experience. I actually use Nintendo and there is a camera attached to the console. There are also games cards that you have to scan with the camera and the games play will start …"

Another interesting finding from the interviews was that the respondents also anticipated their roles as prospective AR adopters. They were divided between continuing their AR technology integration as either content consumers or content creators. Although nearly all the interviewees admitted that they were likely to look for opportunities to use AR for their professional development, many of them pondered their AR skillsets and capabilities that might change over time and might affect their self-confidence in using AR. This reluctance about their abilities stemmed from an uncertainty that in the future they might not be interested in AR technology any longer, or they might forget how particular AR tools or devices worked, or their attention might shift to some other newly emerging innovations that might possibly be more captivating than AR as it is now. With these reasons, they posited that they tend to be passive AR users; that is, they preferred only to consume AR content made by developers or other users. S06, for instance, expressed her thought that she was not sure if she would be contributing any user-generated AR content in her future because it required much effort, time and energy, considering that her profession may be time-demanding, first priority over other obligations. By contrast, a very small number of interviewees reflected a different perspective. For instance, S23 indicated that she enjoyed using AR and firmly said that in the future she would certainly use AR to create new multimedia content for her personal blog about TV series and movies. She said that she was confident as an AR active user, and her level of computer self-efficacy contributed to her willingness and behavioral intentions to continue using AR.

Out of 24 interviewees, interestingly, there was only one student interviewee who practically adopted AR technology already for her personal purposes. S23 provided a narrative of her AR integration into her blog that:

> *"I made an AR presentational poster where I embedded information about a TV series character I like. It gave details about who the character was and then I posted it on my blog…It is a blog in the TV Series Lovers group…So my blog readers can read a synopsis and character information, not just simple plain webpage reading as usual, but with pop-up interactive content like what we did with ZapWorks…"*

When asked further how much time she spent on making the poster, S23 reported that she spent two whole days, starting from scratch until the finished job. She also added that she received some positive feedback from her blog followers. The researcher went on asking if this achievement encouraged her to continue adopting AR and if it elevated her computer self-efficacy, she answered firmly, “Yes, of course.”

Retention of Behavioral Intentions of AR after the Classroom Treatment

Three months after the interview, a follow-up questionnaire was administered to gather information about their existing knowledge of understanding of AR technology, as well as their existing perceptions of using AR. The questionnaire items were the same as those in the questionnaire on AR acceptance and self-efficacy. This follow-up questionnaire was made into a Google Form questionnaire and the link was emailed to all 48 participants. There were 16 respondents (*N*=16), 14 of who were females and 2 were males. However, for a reason of convenience and to avoid confusion with the previous sections, the pseudo-identify of these 16 respondents is assigned with alphanumeric codes running from R01 to R16 when referring to their selected quotes.

Based on the quantitative analysis of the four items (α=.687) that elicited students’ Behavioral Intentions, in Table 4.23, the 16 respondents reported relatively positive trends in their Behavioral Intentions of using AR technology.

Table 4.23

Descriptive statistical reports of the mean scores of respondents’ Behavioral Intentions, three months after the interviews (*N*=16)

Questionnaire items	Mean	Std. Deviation
1. Assuming I had access to the AR system, I intend to use it.	3.80	.775
2. I plan to use the AR system in the near future.	3.33	.816
3. I am determined to integrate the AR system for my future learning.	3.73	.704
4. Given that I had access to the AR system, I predict that I would use it.	4.07	.458
Cronbach’s Alpha	.687	

As for the data from the open-ended questions on their future intentions to adopt AR technology, it was quite clear that most of the respondents still found AR potential for professional integration in the future. They reported that they were still likely to use AR when time and sufficient resources, which included devices and access, allowed. Nevertheless, the evidence emerged that some of the respondents admitted that they somehow forgot about how ZapWorks operated and failed to recall important steps to create AR-mediated flashcards. They also mentioned that frequent use of AR tools or devices was one of many criteria they would have to consider in the future, and frequent or regular use of AR could also influence greater self-efficacy to sustain in the long run.

CHAPTER FIVE

DISCUSSION

Introduction

This study investigated the experiences of Thai undergraduates in activities incorporating Augmented Reality (AR) technology in a university classroom-based language learning setting. It also examined user acceptance of and self-efficacy in using the given AR technology. The research project addressed the following research questions:

1. What were participating Thai undergraduates' perceptions of the usefulness and ease of use of AR technology activities implemented in their classrooms?

2. After completing the activities, what level of self-efficacy did participating Thai undergraduates experience in using AR technology?

3. After completing the activities, what were participating Thai undergraduates' future intentions in using augmented reality technology for subject mastery and beyond?

This chapter presents discussion and reflections on the findings of the participating students' perceived usefulness, perceived ease of use, and self-efficacy in using AR technology in learning about word formation and word structures. These findings are discussed in relation to relevant research studies on AR in education and the Technology Acceptance Model 3 (TAM3), of Vankatesh and Bala (2008), the theoretical framework selected for this study. The chapter presents the limitations and implications of the research study followed by recommendations for improving pedagogical practice in utilizing AR in language education and future research investigating its effectiveness.

Discussion and Reflections of the Findings

The discussion and reflections on significant findings are organized into five categories: 1) Role of AR in Promoting Motivation, Engagement, and Enjoyment, 2) Role of AR in Promoting Digital Literacy Skills and in Reducing Computer Anxiety, 3) Strategies for Integrating AR in Instructional Design, 4) Technical and Organizational Supports for AR Implementation, and 5) Learners' Self-Satisfaction with AR-Enhanced Products.

Role of AR in Promoting Motivation, Engagement, and Enjoyment

Findings from the questionnaires and interviews showed that most participants generally perceived AR technology to heighten motivation, engagement and enjoyment in learning during and after all three phases of the AR classroom treatment. The students reported consistent viewpoints in their perceived enjoyment throughout the classroom AR treatment—a vocabulary-flashcard-making task—particularly due to instrumental values/operational features of ZapWorks and Zappar apps as effective presentational tools. The students commented that AR helped elevate their motivation and participation in the making of AR infused vocabulary flashcards. The technology offered engaging presentational features to maximize the multimodality of sensory inputs and outputs in different forms such as texts, images, videos, or even three-dimensional, computer-generated elements. Twenty two out of 24 interviewees also posited that their heightened motivation and enjoyment stemmed from the effective implementation of an AR-enhanced lesson plan and task requirements in which they were assigned to work collaboratively with peers to achieve a project-based task. These findings aligned with previous exploratory findings in which the participants' eagerness increased because they had more learning autonomy allowing them to take control of learning processes and problem-solving (Jerry & Aaron, 2010; Azuma, 1997; Klopfer, 2008; Squire & Jan, 2007; Johnson et al., 2011; Billinghurst et al., 2001). This high level of perceived usefulness of AR essentially influenced the students' expected behavioral intention to continue using AR in the future, theoretically replicating the casual relationship claimed for the TAM3 (Vankatesh & Bala, 2008). The students affirmed that they found the factor of promoting motivation and enjoyment decidedly applicable to their career preparation and development. They saw themselves using AR technology in various workplaces mostly for presentational purposes. This behavioral intention resonates with self-determination theory (Rigby & Przybylski, 2009), particularly in terms of intrinsic motivation or engagement in activities for rewards. That is, AR motivated students in part because of its benefits as a professional stepping-stone or reinforcement in attaining social status or rewards. Further, those students who reported feeling successful in the flashcard-making task also reported having greater computer self-efficacy, especially after their work was praised by peers as engagingly interactive, creative, and innovative content. Consequently, they were highly motivated to continue using the technology to their advantage. This evidence is consistent with attribution theory (Dörnyei, 2003) that describes that what a person perceives to be the cause for their past successes, or failures, will have a major impact on their expectations and hence their achievements in the future.

Nevertheless, the data suggested that the students' increased motivation and enjoyment during the classroom treatment did not result exclusively from the instrumental values or operational features of the AR tools. Rather, the pedagogic approaches and instructional design employed in the research that allowed student active, project-based, task-based, or problem-based approaches, fueled their motivation. However, a critique of these results is that they would be confined to this particular project. However, substantial literature, for example an exploratory study by Lakarnchua and Reineders (2014) on AR benefits in constructivist learning, suggests that to extend the retention of enjoyment and motivation, teachers should emphasize constructivist learning where the students are equipped with needs-based learning opportunities and interactions with peers, teachers, and surroundings in a meaningful, authentic way. Such pedagogy could contribute to learning challenges that stimulate careful collaborative planning and execution.

Role of AR in Promoting Digital Literacy Skills and in Reducing Computer Anxiety

Digital Literacy connotes a person’s ability to use information and communication technologies to find, evaluate, create and communicate information, requiring both cognitive and technical skills by allowing the students to immerse themselves in a digitally mediated environment (Cornell University Digital Literacy Resource, 2016; Klopfer, 2008; International Society for Technology in Education (ISTE), 2016). In this dissertation research, the primary aim was to examine English as Foreign Language (EFL) students’ experiences in using AR, principally their perceived usefulness, ease of use, and self-efficacy in using it. However, in addition to the findings in those areas, qualitative evidence showed that participating students also improved their digital and media literacy knowledge and skills over the period of the classroom AR treatment. In accomplishing the flashcard-making task, the students used numerous digital tools to facilitate their work progress, gradually adding technical skillsets a few participants reported they never had before. In addition, over 15 participating interviewees reported gaining awareness about the notion of Digital Citizenship that refers to the ethical and responsible use of digital resources (International Society for Technology in Education (ISTE), 2016; Partnership for 21st Century Learning, 2016). They reported that they had to check to see if the information sources they accessed were primary or secondary sources, and if those were reliable and accurate before bringing them into use.

This evidence is captivating in the sense that in incorporating a newly emerging technology, such as AR in creating learning resources, it was inevitable that the students were required to learn simultaneously about the *subject content* and the *technology*. This notion could create cognitive (over)load that may reduce the importance of the subject content by unintentionally or unnecessarily focusing on the technology. With this caution in mind, a careful instructional design is essential to create a balanced technology-integrated lesson plan that does not let the technology dominate the content pursuits. One pedagogical suggestion is that teachers start redesigning their course syllabi of any subject matter by introducing a new technology in one of the very first lessons, whose learning objective(s) can be met by the integration of the technology. Then teachers should also allocate a separate technology training session to educate students about the new technology to complete tasks/assignments. That is, using the new technology should facilitate or supplement their carrying out assigned tasks in meaningful ways. Later in the course, teachers can and should occasionally bring back the same technology into classrooms. This can allow students to re-practice their technological skills, accustoming them to using the technology more confidently and competently.

Furthermore, the data showed that in this study, the participating students took the matter of digital literacy learning quite seriously, alongside their pursuit of linguistic knowledge (word structures and word formation). For instance, some participants mentioned that they had to check to see if the images they took from the online Google Images search engine were actually copyrighted. They also had to check if the pronunciation audios were accurate and if the word definitions and other relational information were correct as defined in trustworthy dictionaries. This demonstrated that the students achieved their language task with increasing awareness and development of digital literacy skills that could be regarded as an advantage incidental to this study. A recommendation for further research that follows from these findings would be to further investigate the learners' development and improvement of their digital literacies along with their skill in integrating emerging technologies. This recommendation emerges from the findings in that approximately half of the 24 interviewees posited a concern about copyright infringement issues. They addressed that they were cautious about downloading, using, or manipulating digital materials they had taken from the Internet sources; they were concerned that they may have violated any copyright or intellectual properties law. Many of them even decided not to use available online sources for their flashcards, but to re-create their own versions of multimedia elements, such as self-recorded audios of word pronunciations. However, some students chose to rely on using online materials made by others, primarily due to constraints of time and other academic-related obligations. This phenomenon offers a promising opportunity for teachers to strategically implement issues of cyberethics or copyright into curricula or lesson plans, enabling students to embrace the essence of digital citizenship in a practical and analytical way. Further studies on students' development of mindsets about digital citizenship via using emerging technologies are also worth investigating.

Because most of the participants had some background in using computers and the Internet prior to the study, and that most owned personal laptops and/or smartphones, their introduction to an emerging AR technology did not seem to pose chronic computer or digital-technologies apprehension. Throughout the three-phase classroom treatment, the students indicated both qualitatively and quantitatively, very rare feelings of fear or frustration in using AR. This was deemed partially thanks to the AR tools' instrumental values and features that were similar to the Microsoft Office Suite, with which most participants were already familiar. This perceived ease of use of the tools, then, reduced or obviated computer anxiety and increased the students' computer self-efficacy simultaneously. With the absence of computer anxiety, and with the heightened computer self-efficacy, most students reported positive likelihood of adopting AR in the future if opportunities and resources allow. Nevertheless, it was interesting to note that a few students who reported some computer apprehension during the AR Computer Tutorial also stated that they gradually were able to overcome that frustration over the period of pair-work and finally came to terms with demands of AR technology.

Evidence from this research suggests that those participants with some technology background may acquaint themselves with new technological innovations relatively rapidly and seamlessly, with initial difficulties easily fixed by teacher or peer assistance. Moreover, aligning well with studies by Saettler (1990) and by Cuban (2001), this finding suggests that the introduction of new technologies to a group of first-timers or novice users should be strategically accompanied by a technical, hands-on training/workshop where they are taught about the features of the tools, step-by-step procedures to do a given task, and necessary tutorial resources for their future reference. This recommendation is heavily supported by the findings in which the students agreed that the AR Computer Tutorial, YouTube-hosted video recordings of the tutorial, and troubleshooting via e-mail correspondence with the researcher who was also the tutorial presenter, were useful and assistive.

Strategies in Integrating AR in Instructional Design

Cuban (1986, 2001) posited that new technologies usually conflicted with traditional age-old instruction beliefs and systems. That is, teachers long-held teaching practices and overloaded obligations do not readily allow flexibility or room for the employment of emerging educational technologies and media. This may be because they fear that new technologies would overtake their classrooms and reduce their importance to the educational system. Even worse, there were several teachers, as Annetta et al. (2012) reported, who were concerned that they receive proper professional training in strategies for using technologies effectively in their pedagogy. With this constraint in mind, this research study was initially grounded in the premise that the classroom treatment be planned, designed, and executed by the researcher in close and continuing collaboration with the course teacher a year prior to the main data collection. This strategy led to the creation of an effective syllabus-based, student-needs-based learning activity, in an attempt to compensate for the lack of collaborative work between a triad of media producers, instructional designers, and teachers found to be important in previous decades (Saettler, 1990). Furthermore, to reduce the complexity of the technology-enhanced learning activities, which, as Dunleavy et al. (2009) and Dunleavy and Dede (2004) cautioned may cause learners' overwhelming mental effort, mental fatigue, and an unnecessarily consuming cognitive load, the designated classroom treatment was then based on the first two fundamental lessons of the course in Analytical Reading. These lessons centered on learning about word formation and word structures as review. Additionally, a pair work, project-based approach was adopted to allow the learners to work as a team in problem solving and making their own decisions in an inquiry-based process of learning (Klopfer & Squire, 2008; Klopfer, 2008).

Findings from the research questionnaires and interviews produced interesting evidence that the students found the flashcard treatment as an enjoyable and facilitative experience and a useful supplementary resource for vocabulary learning and review. After the completion of the AR Computer Tutorial and the Student Showcase, the students reported that they incidentally learned about word structures more comprehensively during the pair-work phase with repetition of vocabulary review. They also were exposed to their peers' flashcards showcasing sets of words and affixes different from their own works, which many participants also found instructive and even inspiring. The students also commented that the flashcard activity was not too complicated given that a training workshop was provided, teacher's assistance was offered on-site and e-mail correspondence and tutorial documentation and videos were also available. They also appreciated that the opportunity to allow them to create their own tangible pieces of work as part of the learning process enabled them to shift their role from passive to active learners. This finding aligned with and tapped into many years of research showing positive results between the pedagogical use of technology and a constructivist learning approach (See Saettler, 1990; Cuban, 1986, 2001).

These supporting, external factors assisted or influenced their perception of AR technology; participants found it easy to operate, leading to their high computer self-efficacy and the likelihood or behavioral intent to adopt AR technology when necessary access and resources are allocated. This evidence suggests clearly that AR technology integration could succeed when implemented strategically and seamlessly in pedagogy, not in isolation. That is, it is not just bringing AR technology *into classrooms* in a mere physical sense, but *into a course syllabus* by using the technology to facilitate achieving the pre-determined learning goals or learning objectives (Ogle, et al., 2002). This evidence also aligns well with the notion that there is a need for systematic instructional design. For instance, Saettler (1990) emphasized the notion:

> *"…technologies do not mediate learning, but the knowledge is mediated by the cognitive process produced by technologies. Consequently, the function of educational technology involves the development of powerful instructional design*

> *that generates the most productive cognitive processes required for particular learning tasks."*

Nevertheless, a noteworthy shortcoming emerged in the findings. Some students posited that in the end they did not learn extensively about word structures from the flashcard activity. They reported that, even though the activity was well intentioned, useful, and enjoyable and helped them to memorize more new words, they wondered why they did not acquire long-term retention of the newly acquired knowledge. One of the reasons was that after the Student Showcase, they rarely came back to review the flashcards because they were obliged to move on to the next lessons. Another reason was that oftentimes, selections of words on the student-made flashcards were common or too easy, often words they knew already. A few other students observed that a single project was inadequate to sustain a lasting effect of technology integration in a language course. These findings help shed light on a future course of action that the integration plans should be carefully tailored to suit a certain learning context, and teaching and learning activities should be *sustained* throughout a sufficient period of time to yield observable and quantifiable positive changes. In addition, the cooperation between teachers, instructional designers, and educational technologists is highly valued. It was also clear that the task of materials development was not solely in the hands of any particular individual; it was shared through a division of labor. More importantly, a successful AR implementation is supposed to empower students to learn independently, constructively, and collaboratively, within a carefully constructed environment. This issue about better instructional integration of emerging technologies, particularly AR technology, needs further investigation in future research.

Technical and Organizational Supports for AR Implementation

As Cuban (1986, 2001) and Sattler (1990) asserted, access to technological equipment, services, and assistance is a crucial factor in weighing up whether new technologies would be smoothly and productively implemented within school walls. This notion of technology and curriculum integration has been one of the long-standing issues surrounding the field of educational media and technology. Provision of training and development programs that tackle various dimensions of departmental, managerial, and various practical levels would help teachers and students alike to gain pedagogical control over technology, enabling everyone to learn content and gain technological knowledge and skills (UNESCO, 2011; Shuler, 2009; Mishra & Koehler, 2006).

This studies' findings revealed that students' notion of Perception of External Control, which refers to the degree to which an individual believes that organizational and technical support and resources facilitate their use of the technology (Venkatesh, Speier, & Morris, 2002), emerged frequently when the students were asked to reflect on their computer self-efficacy and their perceived ease of use of AR technology. In both qualitative and quantitative findings, the participating students agreed that the AR Computer Tutorial session together with other enabling resources, YouTube video-recordings, printed manuals, online tutorials, and e-mail troubleshooting assistance, was extremely helpful and useful. These technical supports influenced the students' perception of ease of use in integrating AR technology. The students thought that without prior training, they would have encountered difficulties that eventually hindered them in completing the task. Moreover, the interview data showed that their positive perception of ease of use seemed to be closely associated with how the students regarded themselves as confident AR active learners/users. They found the AR tools were easy to use, were equipped with sufficient instrumental features and researcher-prepared and web-available resources for references, which helped promote their confidence in using AR. Accordingly, with computer self-efficacy and with the impression of being given necessary resources, the students regarded themselves as continuing AR users and that they were likely to explore the uses of AR in their future for both educational and professional purposes.

Nonetheless, another captivating piece of evidence indicated that in terms of equipment support, a number of the participating students found that the computer labs and Internet access were reasonably reliable and adequate. However, many also expressed a preference for mobility in completing the task, meaning that they worked on the project primarily by using their personal technological devices at convenient locations, such as dorms or private residences. This was evidence of constructive learning taking place both in and out of classrooms. Traxler (2007) posited that this kind of ubiquitous learning could facilitate teaching and learning independent of time and location. This highlights a kind of mobile or dynamic learning in which learners use handheld computers and other devices to transform their path and discourse in learning. Such learning can still be constructive, and it enables students to have some control over *when* to learn, *where* to learn, and *how* to learn, all of which have been found to contribute to their processes of acquiring and building new knowledge at their own pace (Cobcroft, Towers, Smith, & Bruns, 2006). Besides, these millennial learners are increasingly familiar with mobile and digital technologies that pervade many aspects of their lives and influence their digital consumption. This paradigm exhibits an importance of mobile and digital technologies to maintain social networks, resulting in that the younger generation tends to seek greater use, devices, and services of technologies that facilitate their shifting and varying social needs (Eastman, Iyer, Troth, Williams, & Griffin, 2014). This evidence suggests that organizational and technical support schemes plan to suit the learners' shifting learning preferences and flexibility relative to technology integration.

Another interesting finding regarding perception of external control and, additionally, computer self-efficacy and behavioral intentions, was the element of time. The time allocated to the assigned task appeared to be a significant indicator of how students perceived their work as well achieved. Many participating students reported that they experienced temporary frustration during pair-work due to a limited three-week time frame. This frustration resulted from the fact that the students were afraid they might not be able to finish the task by the deadline, considering that they also had assignments from other courses. This time factor played an important role as part of perceived external control, particularly in terms of organizational support. The students needed extensive time, not directly as *support*, but more substantially as an add-on *amenity* when being introduced to a new technology. This finding suggests that to tailor a course-syllabus-based activity, sufficient time allocation should be taken seriously. This is because the students do not only invest in their cognitive learning process, but also in coping with new technologies introduced in the required task. Sufficient time would provide the students with room for mental adjustment to stabilize cognitive overload or to lower a new learning curve (Dunleavy & Dede, 2004; Klopfer & Squire, 2008). In addition, from the interview data regarding behavioral intentions in using AR technology, the majority of the students agreed that they would continue incorporating AR applications to improve their productivity as long as they were given enough time. This evidence, therefore, clearly suggests that for AR technology, and other educational innovations, to be productively integrated into training schools or colleges, ample time must be given for both teachers and students to get gradually accustomed to innovations.

Learners' Self-Satisfaction with AR-Enhanced Products

Bandura's (1982) concept of self-efficacy strongly influences the construct of perceived ease of use of a given technology. Bandura (1982) defined self-efficacy as "judgments of how well one can execute courses of action required to deal with prospective situations" (p. 122). That is, self-efficacy is simply people's perception that they are capable of successfully performing a behavioral action. On the other hand, computer self-efficacy connotes the degree to which individuals believe that they possess the ability to perform a specific task using a computer (Compeau & Higgins, 1995). In investigating the students' perceptions and perspectives toward their computer self-efficacy and the extent to which they used AR technology, the questionnaires revealed that the students reported possessing high levels of confidence. From the interview data, the students also perceived themselves as capable AR users and content creators whose computer self-efficacy was fundamentally driven by their feelings of ease when operating user-friendly ZapWorks software. Most participating interviewees reported they were confident in operating AR technology effectively.

Participating students reported being quite satisfied with their levels of and extent of self-efficacy. They expressed their computer self-efficacy levels essentially through their particular lens of satisfaction with their overall performance in the flashcard-making task, not solely on whether they felt generally confident. They substantially identified themselves as able AR users after they had satisfactorily accomplished the research task, not just believing they could do it. Further analysis showed that participants reported two types of satisfaction or contentment. The interviewees opined that their self-satisfaction sprang from their perception of accomplishment, in terms of both *product-based* and *process-based* achievement. For process-based satisfaction, contentment emerged as a result of a sense of fulfillment of necessary technical procedural steps. Product-based satisfaction was brought about because they were happy their flashcards, *the product*, because they were in good shape and worked properly as planned. This is significant because both notions of contentment contributed accordingly to how the interviewees reflected on their perceived computer self-efficacy and eventually on their behavioral intention to continue using AR technology in the future. Further, these notions of self-satisfaction were not part of the construct in the Technology Acceptance Model 3 (Vankatesh & Bala, 2008) theoretical framework adopted in this study, but nevertheless emerged from the data as playing a critical role in shaping some individual's level of computer self-efficacy. Determining if levels of process and product satisfactions should be included in a Technology Acceptance Model is a recommendation for further research that results from this dissertation.

Consequently, it is somewhat imperative to draw attention as to whether computer self-efficacy on the one hand and self-satisfaction on the other should be distinguished from each other as separate factors that to varying degrees contribute to an individual's level of self-confidence in utilizing the AR technology. The interview data also revealed stimulating evidence that the interviewees with high computer self-efficacy reporting being subsequently content with their final form of their vocabulary flashcards. That is, their outcome expectancies were firmly aligned with their self-efficacy judgments. Nevertheless, those interviewees with relatively lower levels of computer self-efficacy did not necessarily report lower self-satisfaction with their work. This finding may suggest that the computer self-efficacy proportionately influences self-satisfaction, but not vice versa. Because of the limited scope and findings of this pioneering research, it is premature to conclude that differentiating computer self-efficacy and self-satisfaction is productive but it is a promising area for further research.

Personal Reflections on the Findings

Throughout the journey of conducting this dissertation, there were predispositions and surprising outcomes, on which I, as the researcher, would like to mention for the benefits of future replication studies on AR implementation as well as other emerging technologies. First of all, due to that this research was to explore how students experienced innovative AR technology, assumptions had been made that the technical infrastructure, that is Internet access, at a research setting might play an important role. It was thought at first place that on-campus Internet may be less accessible and/or unreliable that it caused inconvenience for the participants in successfully carrying out the assignment. Yet, it turned out that the Internet access was highly reliable and accessible throughout campus. Moreover, to provide infrastructure and facilities, a computer lab was reserved and available both at the Faculty of Liberal Arts and the university's learning center for the participants to gather and work collaboratively on the assignment. However, what surprised the researcher, which was also previously discussed in this chapter, was that the students were likely to shift from classroom-based learning to anywhere-anytime learning. They preferred to collaborate via online platforms, e-mail correspondence and social media, instead of meeting face-to-face. This phenomenon could suggest that the nature of emerging technologies and the students' learning styles and individual preferences might play a major role in how these technologies would be integrated into curriculum and how instructional design should be revamped to facilitate a variety of learning preferences.

Second, reflecting on what I should or could have done better in the research, I personally think there are two things. To begin with, in the research there was only one classroom AR treatment which was implemented at the first two weeks of the course Analytical Reading on the lessons of word formation and word structures. However, I came to ponder that a singular activity might be insufficient to allow us to gather abundant of data on how students actually perceived and experienced the use of AR technology in depth. Possibly, more AR activities were needed throughout the course so that the participants could be reinforced to revisit their knowledge and skills of AR technology. More frequent implementations of AR-enhanced activities may possibly yield different sets of information concerning the students' perceptions of and their experiences in using AR technology.

Third, another aspect I wish I could improve was about the knowledge retention tasks for the participants. Some of the participants pondered that the AR classroom activity was well-intentioned that it was aimed to assist them in learning English vocabulary in a more interactive way via AR technology. However, after the Student Showcase in which the students experienced each pair's AR products, it was unlikely for them to have an opportunity to revisit those flashcards products after the completion of the task. One of the reasons was that they were to move on to next lessons, resulting in that those AR-enhanced flashcards were left unexploited. A few participants even regretted that it was shame to have created such an innovative piece of work but they never went back to use those flashcards for their learning anymore due to other tightly-scheduled academic obligations that allowed them no time. Also, a few other students thought that while creating AR flashcards helped them learn new words effectively, they found little relevance of the task with the rest of the Analytical Reading course. This was because other lessons of the course Analytical Reading were about practicing critical and analytical reading abilities and comprehension of long academic texts which required high cognitive processing of inferential reading abilities. This was drastically different from and more demanding than when they took the first two lessons on word formation and structures. I, therefore, thought that it would have been more interesting to see how AR technology could extend to facilitate the students' high demands in other areas of the course. For instance, instead of creating AR-enhanced flashcards, the students could have produced an AR presentation of a text in which they summarized, critiqued, or discussed ideas worth spreading. These presentations could be digitally made into embedded videos or audios and could be superimposed on to the text so that other students could read, listen and/or watch to gain better insights or understandings.

Implications

Even though this study aimed at investigating Thai EFL undergraduates' experiences in using given AR technology in a language education classroom, the roles of teachers and departmental and institutional stakeholders as key agents in initiating changes in the practices of technology adoption emerged as significant at a very fundamental level. Thus, the findings of this study generate important implications at four major levels that should be viewed as closely interdependent, not standing separately on their individual merit. These implications include 1) policy decision-makers and stakeholders, 2) teacher practices and collaboration, 3) departmental support and professional development schemes, and 4) technical and facilities support. These are discussed in the next section.

Policy Decision-Makers and Stakeholders

The findings of this study demonstrate that most of the participating students found AR very educationally and professionally useful in improving performance and productivity. The research demonstrated that AR facilitated student engagement, heightened motivation, and encouraged collaboration, communication, and problem-solving in carrying out a classroom-based task and injected a sense of the joy of learning as a communal enterprise. These are necessary 21st century soft skills in an evolving world of interconnectedness through technology. Hence, university policies should emphasize curricula that accentuate student-centered learning with emerging technologies and provide education and technical training in the form of courses, workshops, curricular programs or seminars in which learners are educated about information communication and Digital Citizenship (International Society for Technology in Education (ISTE), 2016) as integrated with teaching of content objectives. The provision of digital literacy education will not only serve the learning needs of the students, but will also prepare them for the pursuit of career opportunities and career development in an increasingly competitive job market. Policy decision-making authorities should reconsider regulations or protocols in integrating education of digital literacy skills in exciting multidisciplinary schemes, not separately as an isolated computer course or part of one. In sum, it is critical for institutional policymakers to re-envision long-term plans and schemes in which technologies are strategically and imaginatively incorporated.

Teacher Practices and Collaboration

At the level of teacher practices, instructional re-design and materials re-development should occupy a place at the center of instruction. The present research suggests that EFL teachers and their students will benefit from incorporating the use of AR into their instructional practices and goals. AR alongside other kinds of emerging technologies, when integrated with important learning objectives, will advance interaction, collaboration, and engagement both educationally and societally. In the specific case of English language education and curricula, technology practices and learning goals can be reformulated in course syllabi. Learning objective-based technology integration may provide more opportunities for student-student, student-teacher, and student-technology interactions in a more facilitative socio-constructive language learning environment (Laire, Casteleyn, & Mottart, 2012). Moreover, newly-trained teachers may be eager and able to revamp their course syllabi to include a wide variety of teaching approaches and methods. Problem-based, scenario-based, or project-based teaching approaches are some of the recommendations in which students learn constructively with peers, with teacher guidance, and with surrounding resources assisted and re-enforced by appropriate use of technologies. It is a crucial factor that teachers should strive to embed technology-related content and digital literacy skills into classroom practices and homework assignments, not isolating or relegating technology to the role of a faddish add-on. There should be some degree of technology use in one of, or even each of, the lesson plans, that allows students to learn *with* and *by* technologies. These skills involve students' abilities to use digital technologies for the purposes of not only producing learning resources but also for researching, organizing, and evaluating online information in order to create new bodies of knowledge and to communicate with others successfully, responsibly, and ethically (Partnership for 21st Century Learning, 2016; The New Media Consortium (NMC), 2015). Consequently, teachers can reimagine their role from being authoritative to being facilitative. Teachers will then emerge, in part, as organizers and managers of cooperative tasks that encourage students to embark on a quest of knowledge discovery. In the same way, with strategic integration of AR and other emerging technologies, students can be motivated to take charge of their learning more independently with assistance from teachers as needed. That is, technology-integrated course syllabi may promote active learners, more meaningful classroom tasks, and heightened classroom participation in a more joyful environment.

In terms of teacher collaboration, teachers would also be expected and encouraged to form a professional community of shared pedagogic practices and technological knowledge and skills with fellow teachers (Lave & Wenger, 1991). This could be organized as a departmental unit where teachers of the same or different subject matter gather to exchange and share successful—or failed—technology pedagogic techniques, discuss advantages and constraints arising from using technological software and hardware, and organize some professional development training to help colleagues gain better understanding, knowledge, and skills important for successful and effective incorporation of technology.

Departmental Supports and Professional Development Schemes

Implications for departmental support and professional development schemes are closely associated with the recommended teacher practices and collaboration. For teachers to effectively and successfully utilize technologies in classrooms, institutional and/or departmental support must be secured, continuously maintained, and improved. Such support elements may include 1) building a faculty support system/unit, 2) organizing on-going training sessions on topics surrounding technology integration, and 3) funding for professional conferences.

Departments and institutions should invest in conducting regular and on-going needs analysis/assessment among their faculty members to understand their emerging or changing needs in learning about educational technologies and media so that a faculty support unit could be organized accordingly. Data collected from faculty needs analysis would help form a needs-based support system/unit. Within this support unit, together with the teachers' community of practice, the faculty's needs are brought into account in organizing a departmental *help desk*. This help desk would be comprised of a group of educational technologists whose responsibilities are to assist in-service teachers across disciplines in troubleshooting technical problems, in practically incorporating appropriate innovative technologies into existing course syllabi, and in demonstrating how new digital technologies could be used in practice. That said, according to the literature, as Saettler (1990) and Mishra and Koehler (2006) asserted, it is recommended that educational technologists and faculty members work collaboratively to merge their technological knowledge and pedagogical practices in generating effective technology-integrated instructional design. Making technology such as AR productive to learning will involve hiring trained personnel and should be taken into consideration in fiscal planning.

Apart from providing on-site troubleshooting assistance for the faculty, this support unit could serve to provide on-demand professional development programs or workshops conducted by experts in the field of educational media and technology. These professional development schemes include an education in *what* tools, both software and hardware, could be brought into pedagogy, *how* and *why* to use the tools technologically and pedagogically. In addition to on-site training, the faculty should also have opportunities to secure short-term funding or scholarships to expand their technological-pedagogical knowledge and skills by attending regional, national, and international conferences. These proposals are believed to equip teachers with intellectual instruments to keep themselves up-to-date and well-informed about educational technologies that may be advantageous in and out of classrooms. Establishing blogs or user-groups exchanges online or as YouTube talks would bring teachers and information together online and reduce the sense of teacher isolation as well.

Technical Facilities and Organizational Support

As evidenced in the findings of this study, participants reported that organizational and technical support enhanced their perceptions of the usefulness and the ease of use of Augmented Reality technology. Likewise, to launch successful professional development planning and execution, readiness in technical and technological infrastructure, access, and facilities must be ensured in a given institution. Reliable and high-speed Internet access and coverage must be set up, and routine access monitoring should be done to ensure that the problem of low-coverage spots is removed. It is evident from the findings that emerging digital technologies require reliable Internet access and speed to encourage a smoother and seamless implementation of technologies. Furthermore, institutions should invest in the improvement or renovation of its available infrastructural facilities such as computer labs and laptops/mobile devices for student and faculty use. The provision of such hardware devices would promote more equality and access for those who are socio-economically-marginalized and facilitate digital technology use when necessary equipment is made widely available. Not only is hardware important, the availability of software is also crucial. Augmented Reality technology is relatively new and existing Augmented Reality applications in the market at this time are generally expensive. If Augmented Reality technology were to be adopted now in classrooms, it would incur extensive financial cost on the departmental end. Taking this factor into account, it would be wise for an institution to add this budgetary matter into its future fiscal policy agenda. Doubtless, in the foreseeable future, more inexpensive Augmented Reality tools will be introduced into the market for end-users with fewer or no computer programming skills. As is typically the case, these tools will presumably come with several more affordable pricing subscription plans, particularly for education customers. Based on the history of the rapid reduction in the price of other computer hardware and software, AR expenses can be expected to follow the same trend and near-term planning and budgeting should keep this in mind and move ahead into the future accordingly.

Limitations

There are three limitations that emerged in this study. Firstly, the findings are contextually confined to the interpretations of a relatively small sample group of 48 Thai EFL undergraduates in a state-run university in Thailand. Consequently, it is uncertain as to what extent the findings, both quantitative and qualitative, may be generalized for the whole population of EFL learners in higher-education settings in Thailand or in any other educational contexts. In addition, while one of the aims of the study was to investigate student experience in integrating Augmented Reality technology in a language classroom, only 24 out of 48 students participated in one-on-one interviews, and only 16 out of 48 participated in the post-AR-activity, follow-up questionnaire (three months after the AR classroom treatment). Also, this research is from a limited span of time, and students' experiences and future behaviors in utilizing Augmented Reality technology will no doubt change and evolve over time. As a result, the data gathered from the questionnaires, the interviews, as well as classroom observations, though sufficiently rich to answer all the research questions, they are limited in holistically interpreting the EFL learners' sustainable integration of Augmented Reality technology over longer periods of time.

Second, the research instruments of this study, for example, the questionnaires and the interview protocol, were originally devised in English and then translated into Thai for convenience in data collection with a sample group whose first language was Thai. That is, Thai-translated questionnaires were administered to the students; the interviews were conducted in Thai; and the AR Computer Tutorial workshop was delivered in Thai. This was to allow the participants to fully express their experiences, insights and perspectives to reduce communication difficulties or anxiety that might have been caused by English as their non-native language. The process of translating English questionnaires into Thai versions, despite a translation review and approval by an expert, may still leave parts of the English vocabulary that have no absolute equivalent in Thai. These linguistic subtleties may render a very minor misunderstanding or inaccurate interpretation of the questionnaire items that could cause the participants to fill out the questionnaires imprecisely, in particular the English notions of "self-satisfaction" and "self-efficacy."

Lastly, this research study employed only a single classroom Augmented Reality treatment, with three sequential phases of Teacher Showcase, AR Computer Tutorial and Student Showcase. This overall classroom treatment spanned approximately ten to eleven weeks, including the administration of four questionnaires and one-on-one interviews. Even though the length of the treatment was sufficient to gather in-depth data to answer the research questions, the absence of multiple format treatments over a semester or an academic year may be regarded as a drawback in an attempt to investigate the students' long-term AR acceptance and self-efficacy.

Recommendations for Future Research

This study provides valuable insights into the integration of AR technology into an EFL classroom, intertwined with the student experiences, their perceived usefulness, perceived ease of use, and related self-efficacy in using AR technology for their language learning performance and digital skills learning. That said, future research may examine some or all of the following recommendations.

First of all, a future study could focus on examining EFL teacher experiences in pedagogically incorporating AR technology. Because the present study is about student experience, it would be useful to combine it with an investigation into how teachers perceive AR technology, its usefulness, ease of use, and other emergent factors. To be more specific, in a future study a sample group of teachers could be introduced to AR technology and trained and taught how to use AR creator tools to produce instructional resources for their own classroom use. This future research could extend to multiple higher-education settings in different regions of Thailand. This would shed light on the comparison of how diverse socio-cultural, socio-economic and even organizational factors in certain settings unfold in the process of educational adoption of AR technology. Such future research could be assistive in increasing teachers' comfort levels, knowledge of and skillsets in emerging educational technologies with different instructional approaches and methods in language education. The promise of insightful findings and implications could possibly be tailored to appropriate professional development schemes to enhance teacher facility in employing technologies more effectively, successfully, and responsibly so as to ingrain digital literacy skills in their students.

Second, a future study could be conducted in other subject disciplines, not only limited to language education. It would be interesting and useful to examine diverse techniques or approaches in pedagogic adoption of AR technology in higher education settings with the students and/or teachers in, for example, engineering, medical science, science, architecture, or special education for those learners with learning limitations. Considering this recommendation for a study in multidisciplinary fields, data collection procedures could then be differentiated to suit certain settings and sample groups. Case studies or comparative studies across contexts could also yield interesting prospective findings and implications to fill in the gaps in the existing literature.

Third, a future study could be extended by employing a quasi-experimental research design in which the students' learning performances are assessed or evaluated before and after the intervention of one or more AR-mediated classroom treatments/tasks. This future study could concentrate on the associations of implementing AR technology with how much the students improve in their learning performances or proficiencies, both objectively and subjectively. The premise of this dimension of future research could provide more quantitative data on the potential of AR technology to promote better learning outcomes. The expected findings and implications would then be highly useful for policymaking, instructional design and materials development. Teachers, educators and educational technologists could then join forces in customizing appropriate AR-mediated resources that successfully enrich student learning processes.

Lastly, a future study could be replicated in different contexts, geographically, socio-culturally, socio-economically, and educationally, across different age groups of learners. As Augmented Reality technology is currently in its infancy in the academic arena, ample opportunities to explore its possibilities and shortcomings are quite promising and challenging considering the expected ongoing development of such technology in terms of hardware and software. It seems that it would be tremendously useful if replicated studies of different research design techniques were to be conducted in an attempt to examine other forms of Augmented Reality that would help promote a better understanding of how it may be deployed to enhance teaching and learning in the increasingly competitive and uncertain 21st century.

Conclusion

The emergence of new technological innovations, specifically AR technology, has prompted fortunate teachers and other educators to improve their subject-content knowledge, technological and pedagogical knowledge, and skillsets that enable them to educate students more effectively, ethically and responsibly in the 21st century. The introduction and increasing adoption of AR in higher-education settings across contexts can and do improve teaching and learning as well as facilitate globalization. In this sense, the effective use of AR in learning environments does not primarily lie in what tools to use and how novel the instrumental value of those tools is. Instead, this research supports the conclusion that key factors for a successful and effective implementation of AR technology requires that teachers and/or related departmental or university authorities be strongly encouraged to take into account the socio-economic, cultural, political and schooling challenges of the present and projected educational setting. Using technologies typically affects the long-time beliefs, routines and practices of people and organizations involved in education in the broadest sense. Further, successful AR integration success will depend on strategically intertwining such technology into curricula and course-syllabus levels and faculty development. Teachers and institutional authorities are fundamentally responsible for tailoring age and proficiency appropriate learning environments and lesson plans, teaching and learning materials development, and organizational and technical resources. As a result, AR technology can be blended into and/or supplement teaching and learning for promoting digital literacy skills among the students, and for equipping them with necessary knowledge and skills to thrive in the 21st century. This study not only answers the a priori research questions surrounding the classroom adoption of AR as a newly emerging innovation, it also stimulates an ambitious quest of further discovery of new possibilities and informed uses of such technology for the benefit of teachers and students alike.

APPENDICES

Appendix 1: Approval Letter of Boston University IRB Exemption

Boston University Charles River Campus Institutional Review Board

25 Buick Street
Room 157
Boston, Massachusetts 02215
T 617-358-6115
www.bu.edu/irb

BOSTON UNIVERSITY

Notification of IRB Review: Exemption Request

June 15, 2017

Payungsak Kaenchan
Curriculum and Teaching
School of Education
Two Silber Way
Boston, MA 02215

Protocol Title:	Examining Thai Students' Experiences of Augmented Reality Technology in a University Language Education Classroom
Protocol #:	4547X
Funding Agency:	Unfunded
IRB Review Type:	Exempt (2)

Dear Mr. Kaenchan:

On June 15, 2017, the IRB determined that the above-referenced protocol meets the criteria for exemption in accordance with CFR 46.101(b)(2). Per the protocol, the purpose of this study is to investigate Thai undergraduates' experiences and perceptions about using the augmented reality (AR) technology. The exempt determination includes the use of: recruitment email, consent form, questionnaire on internet use, Questionnaire on the Acceptance of Augmented Reality Technology, Questionnaire on the Acceptance of Augmented Reality Technology, Questionnaire on the Acceptance of Augmented Reality Technology, interview protocol, classroom observation protocol, reading passage and AR vocabulary cards.

Additional review of this study is not needed unless changes are made to the current version of the study. Any changes to the current protocol must be reported and reviewed by the IRB. If you have any changes, please submit the ***Clarification Form*** located at http://www.bu.edu/irb/. No changes can be implemented until they have been reviewed by the IRB.

In approximately six months, you will receive an inquiry from the IRB to ascertain whether your study still meets the requirements for exempt review

If you have any questions, please contact me at 617-358-6922.

Sincerely,

Mary McCabe

Mary McCabe
Senior IRB Analyst
Charles River Campus IRB

Appendix 2: Approval Letter of Boston University IRB Clarification of Translation

Boston University Charles River Campus Institutional Review Board

25 Buick Street
Room 157
Boston, Massachusetts 02215
T 617-358-6115
www.bu.edu/irb

BOSTON UNIVERSITY

Notification of IRB Review: Clarification 1

August 2, 2017

Payungsak Kaenchan
Curriculum and Teaching
School of Education
Two Silber Way
Boston, MA 02215

Protocol Title:	Examining Thai Students' Experiences of Augmented Reality Technology in a University Language Education Classroom
Protocol #:	4547X
Funding Agency:	Unfunded
IRB Review Type:	Exempt

Dear Mr. Kaenchan:

On August 2, 2017, the Charles River Campus IRB reviewed the **Clarification** for the above-referenced protocol. This does not change the exempt status of this protocol.

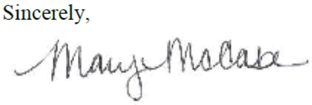
This clarification includes the following:

- Study documents have been translated to Thai

Additional review of this study is not needed unless changes are made to the current version of the study. Any changes to the current protocol must be reported and reviewed by the IRB. If you have any changes, please submit the ***Clarification Form*** located at http://www.bu.edu/irb/. No changes can be implemented until they have been reviewed by the IRB.

If you have any questions, please contact me at 617-358-6922.

Sincerely,



Mary McCabe
Senior IRB Analyst
Charles River Campus IRB

Appendix 3: Completion Report of CITI Program in Human Subjects Research

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COMPLETION REPORT - PART 1 OF 2

COURSEWORK REQUIREMENTS*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Payungsak Kaenchan (ID: 3747649)
- **Institution Affiliation:** Boston University (ID: 1797)
- **Institution Email:** payungie@bu.edu
- **Institution Unit:** School of Education Boston University
- **Phone:** 18572105117

- **Curriculum Group:** Human Subjects Protection Training: Social & Behavioral Focus
- **Course Learner Group:** Same as Curriculum Group
- **Stage:** Stage 2 - Refresher Course

- **Record ID:** 19967848
- **Completion Date:** 20-Feb-2017
- **Expiration Date:** 20-Feb-2020
- **Minimum Passing:** 80
- **Reported Score*:** 95

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED	SCORE
SBE Refresher 1 – Instructions (ID: 943)	19-Feb-2017	No Quiz
SBE Refresher 1 – History and Ethical Principles (ID: 936)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Defining Research with Human Subjects (ID: 15029)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Privacy and Confidentiality (ID: 15035)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Assessing Risk (ID: 15034)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Research with Children (ID: 15036)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – International Research (ID: 15028)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Federal Regulations for Protecting Research Subjects (ID: 937)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Informed Consent (ID: 938)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Research with Prisoners (ID: 939)	20-Feb-2017	2/2 (100%)
SBE Refresher 1 – Research in Educational Settings (ID: 940)	20-Feb-2017	1/2 (50%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: www.citiprogram.org/verify/?k9df843b8-713e-4052-9ed1-5cc18638bae0-19967848

Collaborative Institutional Training Initiative (CITI Program)
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

Appendix 4: Approval Letter of Mahidol University IRB in Social Sciences

Certificate of MUSSIRB Approval

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Certificate of Approval No.:	2017/151.1107
MUSSIRB No.:	2017/181 (B1)
Student ID:	U74782723
Title of Project:	EXAMINING THAI STUDENTS' EXPERIENCES OF AUGMENTED REALITY TECHNOLOGY IN A UNIVERSITY LANGUAGE EDUCATION CLASSROOM
Principal Investigator:	MR.PAYUNGSAK KAENCHAN
Major Advisor:	LECT.DR. LAURA JIMENEZ
Name of Institution:	SCHOOL OF EDUCATION, BOSTON UNIVERSITY
Approval includes:	1) MUSSIRB Submission Form version received date 11 July 2017 2) Participant Information sheet version date 11 July 2017 3) Informed Consent Form version date 11 July 2017

The Committee for Research Ethics (Social Sciences) is in full compliance with International Guidelines of Human Research Protection such as Declaration of Helsinki, The Belmont Report, and CIOMS Guidelines.

Date of Approval: July 11, 2017
Date of Expiration: July 10, 2018

Chairman | **Head of the Institute**

(Emeritus Professor Dr.Santhat Sermsri)

(Assoc.Prof.Dr.Luechai Sri-Ngernyuang)
Dean of Faculty of Social Sciences and Humanities

Office of The Committee for Research Ethics (Social Sciences), Faculty of Social Sciences and Humanities, Mahidol University
Phuttamonthon 4 Rd., Salaya, Phuttamonthon District, Nakhon Pathom 73170. Tel.(662) 441 9180 Fax.(662) 441 9181
Website: www.mussirb.com ; e-mail: mussirb310@gmail.com

Appendix 5: Questionnaire on Computer and the Internet Use

Questionnaire on Computer and the Internet Use

This screening questionnaire consists of three parts: About You, Computer and Internet Use, and Knowledge about Augmented Reality Technology. The purpose is to elicit the student participants' general accounts of their experience, competency, and use of computers and the Internet, prior to the main data collection and implementation of augmented reality enhanced learning activities. The questionnaire is expected to take approximately 20 minutes or less to complete.

Part 1: About you

1.1 Your gender

- ☐ Male
- ☐ Female

1.2 Your age

- ☐ 17
- ☐ 18
- ☐ 19
- ☐ 20
- ☐ Other: Please specify _______

1.3 Your class status

- ☐ Freshman (first year)
- ☐ Sophomore (second year)
- ☐ Junior (third year)
- ☐ Senior (fourth year)
- ☐ Other: Please specify ________

1.4 Self-reported level of English proficiency (Please put an X in the box)

Skills	Self-reported proficiency				
	Novice	Intermediate	Upper-intermediate	Advanced	Expert
Writing					
Reading					
Listening					
Speaking					

Part 2: Computer and Internet Use

2.1 Do you have a desktop personal computer (PC) or laptop?

- ☐ Yes
- ☐ No (Go to 2.3)

2.2 On average, how often do you use your desktop personal computer (PC) or laptop?

- ☐ 1-4 hours per day
- ☐ 5-8 hours per day
- ☐ 9-12 hours per day
- ☐ Other: Please specify ______

2.3 Do you have a tablet device (e.g. iPad, Samsung Galaxy Tab, etc.)?

- ☐ Yes
- ☐ No (Go to 2.5)

2.4 On average, how often do you use your tablet device?

- ☐ 1-4 hours per day
- ☐ 5-8 hours per day
- ☐ 9-12 hours per day
- ☐ Other: Please specify ______

2.5 Do you have a smartphone (e.g. iPhone, Samsung Galaxy, etc.)?

- ☐ Yes
- ☐ No (Go to 2.7)

2.6 On average, how often do you use your smartphone?

- ☐ 1-4 hours per day
- ☐ 5-8 hours per day
- ☐ 9-12 hours per day
- ☐ Other: Please specify ______

2.7 On average, how many hours per day do you spend on the Internet?

- ☐ 1-4 hours per day
- ☐ 5-8 hours per day
- ☐ 9-12 hours per day
- ☐ Other: Please specify ______

2.8 **FOR PERSONAL USE**, how often do you use your computer(s), mobile device(s) or the Internet for? Please put an X in the box of your choice.

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	All of the Time (5)
2.8.1 Games and entertainment (e.g. movies and music listening)					
2.8.2 Graphic design and editing					
2.8.3 Microsoft Office (e.g. Word, Excel, PowerPoint, etc.)					
2.8.4 E-mail					
2.8.5 File sharing and storage					
2.8.6 E-commerce and online shopping					
2.8.7 E-banking and online financial transactions					
2.8.8 Social media and social networking (e.g. Facebook, Twitter, Instagram, YouTube etc.)					
2.8.9 Other: Please specify					

2.9 **FOR LEARNING AND STUDY USE**, what do you typically use your computer(s), mobile device(s) or the Internet for? (Choose all that apply).

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	All of the Time (5)
2.9.1 Information or media search					
2.9.2 Use Microsoft Office (e.g. Word, Excel, PowerPoint, etc.) and other offline applications to complete assignments					
2.9.3 Use online tools/applications to complete assignments					
2.9.4 E-mail					
2.9.5 File sharing and storage					
2.9.6 Social media and social networking (e.g. Facebook, Twitter, Instagram, YouTube etc.) to connect with classmates and teachers					
2.9.7 Other: Please specify					

2.10 Have you ever used computers, mobile devices, and/or the Internet as part of learning activities in any other course subjects? If yes, please explain briefly.

- ☐ Yes
- ☐ No (Go to 2.11)

Please explain:

____

____

____

____

Part 3: Knowledge about Augmented Reality Technology

3.1 Do you know or have you ever heard about augmented reality technology?

- ☐ Yes (Please answer items 2.12 and 2.13)
- ☐ No

3.2 If you answer Yes to item 2.11, please explain your understanding about augmented reality technology. You can also provide examples of computer applications or any other forms of examples in which augmented reality technology has been applied.

____
____
____
____
____
____
____
____

3.3 If you answer Yes to item 2.11, please provide a brief explanation about how, in your opinion, augmented reality technology can be beneficial in improving your learning performance if it is employed in education or in classrooms?

____
____
____
____
____
____
____
____

Appendix 6: Questionnaire on the Acceptance and Self-efficacy of Augmented Reality Technology

Questionnaire on the Acceptance and Self-efficacy of Augmented Reality Technology

This post questionnaire consists of two parts: Part 1: About You and Part 2: Acceptance of Augmented Reality Technology. The purpose is to elicit the student participants' general accounts of their experience and perception about augmented reality technology after the implementation of augmented reality enhanced learning activities. The questionnaire is expected to take approximately 30 minutes or less to complete.

Part 1: About you

Identification code/number (assigned by researcher): ______________________

After the completion of this questionnaire, you are invited to participate in an individual interview in which you elicit your retrospective experiences when using the AR technology in the learning activities. This interview is voluntary. The interview will take place at your convenient time as scheduled and agreed with the researcher. The interview can be in person or via audio conferencing, and it will be audio-recorded for further transcription.

If you are willing to participate in the interview session, please provide your contact information as listed below. The researcher will contact you accordingly.

If you are not willing to participate, please skip this part and complete Part 2.

1.1 Your e-mail address ____

1.2 Your contact number ____

Part 2: Acceptance and Self-Efficacy of Augmented Reality Technology

2.1: Acceptance of Augmented Reality Technology

In this section, please read each of the following statements carefully and choose the best response by putting an X in the box.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
2.1.1 I find the AR system to be useful for my learning.					
2.1.2 Interacting with the AR system does not require a lot of my mental effort.					
2.1.3 Assuming I had access to the AR system, I intend to use it.					
2.1.4 I have control over using the AR system.					
2.1.5 Working with the AR system makes me nervous.					

2.1.6 I find using the AR system to be enjoyable.					
2.1.7 Using the AR system for my learning increases my productivity.					
2.1.8 I find the AR system to be easy to use.					
2.1.9 Given that I had access to the AR system, I predict that I would use it.					

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
2.1.10 I had the resources necessary to use the AR system.					
2.1.11 The AR system makes me feel uncomfortable.					
2.1.12 The actual process of using the AR system is pleasant.					
2.1.13 Using the AR system enhances my effectiveness for my learning.					
2.1.14 I find it easy to get the AR system to do what I want them to do.					
2.1.15 I plan to use the AR system in the near future.					

2.1.16 Given the resources, opportunities and knowledge it takes to use the AR system, it would be easy for me to use the system.					
2.1.17 The AR system makes me feel uneasy.					
2.1.18 I had enjoyment while using the AR system.					

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
2.1.19 Using the AR system improves my learning performance.					
2.1.20 My interaction with the AR system is clear and understandable.					
2.1.21 I am determined to integrate the AR system for my future learning.					
2.1.22 Resources needed to use the AR systems are sufficient for me.					
2.1.23 Using the AR system scares me.					
2.1.24 I had fun using the AR system.					

2.2: Self-Efficacy of Augmented Reality Technology

The following questions ask you to indicate whether you could use this unfamiliar, emerging augmented reality technology under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the augmented reality technology. Then for each condition that you answered "YES," please rate your confidence about your first judgement, by putting and X in the number box from 1 to 10, where 1 indicates "Not at all confident," 5 indicates "Moderately confident," and 10 indicates "Totally confident."

	Not at all confident (1)	(2)	(3)	(4)	Moderately confident (5)	(6)	(7)	(8)	(9)	Totally confident (10)
I COULD COMPLETE THE TASK USING THE AUGMENTED REALITY TECHNOLOGY…										
2.2.1 I …if there was no one around to tell me what to do as I go with the AR system. ☐ YES ☐ NO										
2.2.2 …if I had never used the AR system before. ☐ YES ☐ NO										
2.2.3 …if I had only the AR system manuals for reference. ☐ YES ☐ NO										
2.2.4 …if I had seen someone else using the AR system before trying it myself. ☐ YES ☐ NO										

	Not at all confident (1)	(2)	(3)	(4)	Moderately confident (5)	(6)	(7)	(8)	(9)	Totally confident (10)
I COULD COMPLETE THE TASK USING THE AUGMENTED REALITY TECHNOLOGY…										
2.2.5 …If I could call or ask someone else for help if I got stuck. ☐ YES ☐ NO										
2.2.6 …if someone else had helped me get started. ☐ YES ☐ NO										
2.2.7 …if I had a lot of time to complete the task for which the AR system was provided. ☐ YES ☐ NO										
2.2.8 …if I had the built-in help facility for assistance. ☐ YES ☐ NO										
2.2.9 …if someone showed me how to do it first. ☐ YES ☐ NO										
2.2.10 …if I had used similar system(s) before this one to do the same task. ☐ YES ☐ NO										

Appendix 7: Interview Protocol

Interview Protocol

The purpose of this interviews is to collect student participants' personal reflections, perspectives, and accounts of their experience in using AR enhanced language learning activities. This interview protocol is used as a guideline to elicit the participant's experience. The interview questions will be constructed based on the Technology Acceptance Model (TAM) by Davis, Bagozzi, and Warshaw (1989) and the Technology Acceptance Model 3 (TAM3) by Venkatesh and Bala (2008).

Interview Overview

This interview is expected to take typically 30-45 minutes. Each invited/selected research participant will spend this time to elicit his/her personal information, learning experience, and how (s)he has used AR enhanced language learning activities in English classrooms.

Part 1: Introduction by interviewer

Say to the interviewee:

Thank you very much for your time to participate in my research study. My name is Payungsak Kaenchan, the researcher of this study. Before we start the interview, I would like to explain the objective of this study and this particular interview to you first. The purpose of the study is to investigate your perceptions, attitudes and acceptance of augmented reality technology in language classrooms. This also includes the investigation of your own judgment of how well you manage to do what you want to do with technology; your beliefs and how they influence your learning practice.

The interview will take about 30-45 minutes. If my interview questions are not clear to you at any point, please do not hesitate to ask for clarification. You can also request to withdraw from the interview session at any time if you feel uncomfortable. Do you, as of now, have any question before we start?

Part 2: Interviewee's experience towards the use of augmented reality

1. Personal information and experience about using technologies

1.1 Could you briefly introduce yourself?

1.2 Could you explain your personal experience of using computers and the Internet?

1.3 Do you have any experience using mobile technology? Please explain.

1.4 Do you know about or have any experience using augmented reality, prior to this research? Please explain.

1.5 Has there been any non-AR technology that you have felt you are successful with? What is it? Please explain.

1.6 Has there been any non-AR technology that you have felt you are unsuccessful with? What is it? Please explain.

2. Attitude, acceptance, and perception about augmented reality technology

2.1 Prior to the course, you attended an AR orientation. Could you please explain what AR or augmented reality is, based on your understanding?

Perceived Usefulness

2.2 How do you perceive the use of augmented reality technology in particular? Do you think it is important in your learning? If yes, how and to what extent? (Perceived Usefulness)

2.3 Please explain some benefits you can find in integrating augmented reality technology in language learning activities in the classroom. (Perceived Usefulness)

2.4 Please explain some disadvantages you can find in integrating augmented reality technology in language learning activities in the classroom. (Perceived Usefulness and Perceived Ease of Use)
2.5 How do you find augmented reality technology useful in education? Do you think augmented reality technology can be beneficial for your future? (Job Relevance)

Perceived Ease of Use
2.6 Do you think you are successful in using augmented reality technology in your classrooms? How would you rate yourself as a user of such technology in general? From a scale of 1 to 10 point, how many points would you rate yourself as a confident or competent user of augmented reality? (Computer Self-efficacy)
2.7 What technical constraints/ difficulties you have faced when using augmented reality technology in your classroom? Do you have enough support and resources? What kind of support and resources you think are important? Please explain. (Perception of External Control)
2.8 Do you feel any frustration or anxiety while using augmented reality technology? Do you feel nervous or fear that you would not be able to use it effectively? Please explain. (Computer Anxiety)
2.9 Do you think using augmented reality technology in language learning or language classrooms is fun and enjoyable? Please explain. (Perceived Enjoyment)
2.10 If you could provide suggestions/comments for future development of this particular AR application (ZapWorks), what would you tell the development team?

3. Future adoption of augmented reality
3.1 How do you think augmented reality technology can be adopted in education in the future? Please explain.

4. Additional questions regarding learning performances?

4.1 After getting to know AR and after working on an AR activity, does AR technology help you with improved learning in general? How?

4.2 After getting to know AR and after working on an AR activity, does AR technology help you with improved English language learning? How?

References

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, 35*(8), 982-1003.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences, 39*(2), 273-315.

Appendix 8: Thai Translation of Questionnaire on Computer and the Internet Use

แบบสอบถามการใช้งาคอมพิวเตอร์และอินเทอร์เน็ต

Questionnaire on Computer and Internet Use

แบบสอบถามเบื้องต้นฉบับนี้ประกอบไปด้วยสามส่วน คือ ข้อมูลส่วนตัว การใช้งานคอมพิวเตอร์และอินเทอร์เน็ตและความรู้ความเข้าใจเกี่ยวกับเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) วัตถุประสงค์ของแบบสอบถามนี้เพื่อสอบถามข้อมูลทั่วไปของผู้เข้าร่วมวิจัยเกี่ยวกับประสบการณ์ ความสามารถและพฤติกรรมการใช้งานคอมพิวเตอร์และอินเทอร์เน็ตก่อนการเก็บข้อมูลวิจัยขั้นตอนหลักและการประยุกต์กิจกรรมการเรียนรู้ที่ใช้เทคโนโลยีชนิดความจริงเสริมในห้องเรียนวิชาภาษาอังกฤษ โดบแบบสอบถามชุดนี้จะใช้เวลาทำประมาณ 10 ถึง 15 นาทีหรือน้อยกว่านั้น

ส่วนที่ 1 ข้อมูลส่วนตัว

1.1 เพศสภาพ ☐ ชาย ☐ หญิง

1.2 อายุ ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ อื่นๆ โปรดระบุ ________

1.3 ระดับชั้นเรียน ☐ ชั้นปีที่ 1 ☐ ชั้นปีที่ 2 ☐ ชั้นปีที่ 3 ☐ ชั้นปีที่ 4 ☐ อื่นๆ โปรดระบุ ________

1.4 อีเมลติดต่อ: ____

1.5 เบอร์โทรศัพท์เคลื่อนที่ที่ติดต่อสะดวก: ____

1.6 ระดับความสามารถในการใช้ภาษาอังกฤษโดยประเมินจากตนเอง

1.6.1 คุณได้คะแนนวิชาภาษาอังกฤษกี่คะแนนจากข้อสอบเพื่อสอบเข้ามหาวิทยาลัย

GAT2: ____________ | ภาษาอังกฤษ O-Net:__________| ภาษาอังกฤษสามัญ: ___________

1.6.2 โปรดประเมินความสามารถในการใช้ภาษาอังกฤษของคุณโดยการใส่เครื่องหมาย X ในช่องที่ท่านเลือกตามลักษณะทักษะการใช้ภาษา

ทักษะ	ผลประเมินความสามารถการใช้ภาษาอังกฤษ				
	เบื้องต้น	ระดับกลาง	ระดับกลางกึ่งสูง	ระดับสูง	ระดับเชี่ยวชาญ
การเขียน					
การอ่าน					
การพูด					
การฟัง					

ส่วนที่ 2 การใช้งานคอมพิวเตอร์และอินเทอร์เน็ต

2.1 คุณมีคอมพิวเตอร์ส่วนบุคคล (Desktop PC) หรือคอมพิวเตอร์แบบพกพาหรือไม่

☐ มี ☐ ไม่มี (ข้ามไปตอบข้อ 2.3)

2.2 โดยเฉลี่ย คุณใช้งานคอมพิวเตอร์ส่วนบุคคลหรือคอมพิวเตอร์แบบพกพาบ่อยแค่ไหนต่อวัน

☐ 1 ถึง 4 ชั่วโมงต่อวัน ☐ 5 ถึง 8 ชั่วโมงต่อวัน

☐ 9 ถึง 12 ชั่วโมงต่อวัน ☐ อื่นๆ โปรดระบุ

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2.3 คุณมีอุปกรณ์ชนิดแทบเล็ต เช่น)iPadหรือไม่ (

☐ มี ☐ ไม่มี (ข้ามไปตอบข้อ 2.5)

2.4 โดยเฉลี่ย คุณใช้งานอุปกรณ์ชนิดแทบเล็ตบ่อยแค่ไหนต่อวัน

☐ 1 ถึง 4 ชั่วโมงต่อวัน ☐ 5 ถึง 8 ชั่วโมงต่อวัน

☐ 9 ถึง 12 ชั่วโมงต่อวัน ☐ อื่นๆ โปรดระบุ

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2.5 คุณมีอุปกรณ์ชนิดสมาร์ทโฟน เช่น)iPhone หรือ Samsung Galaxyหรือไม่ (

☐ มี ☐ ไม่มี (ข้ามไปตอบข้อ 2.7)

2.6 โดยเฉลี่ย คุณใช้งานอุปกรณ์ชนิดสมาร์ทโฟนบ่อยแค่ไหนต่อวัน

☐ 1 ถึง 4 ชั่วโมงต่อวัน ☐ 5 ถึง 8 ชั่วโมงต่อวัน

☐ 9 ถึง 12 ชั่วโมงต่อวัน ☐ อื่นๆ โปรดระบุ

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2.7 โดยเฉลี่ย คุณใช้งานอินเทอร์เน็ตกี่ชั่วโมงต่อวัน

☐ 1 ถึง 4 ชั่วโมงต่อวัน ☐ 5 ถึง 8 ชั่วโมงต่อวัน

☐ 9 ถึง 12 ชั่วโมงต่อวัน ☐ อื่นๆ โปรดระบุ

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2.8 **หากพิจารณาถึงการใช้งานส่วนตัว** คุณใช้คอมพิวเตอร์ อุปกรณ์เคลื่อนที่ต่างๆ หรืออินเทอร์เน็ตบ่อยแค่ไหน โปรดใส่เครื่องหมาย X ในช่องที่คุณเลือก

	ไม่เคย(1)	แทบจะไม่ (2)	บางครั้ง (3)	บ่อย (4)	ตลอดเวลา (5)
2.8.1 เล่นเกม โปรดระบุชนิดเกมหรือชื่อเกมที่คุณเล่น ____________________ ____________________ ____________________ ____________________ ____________________ ____________________					
2.8.2 ชมภาพยนตร์และฟังดนตรี					
2.8.3 ออกแบบและแก้ไขกราฟฟิก					
2.8.4 ใช้ซอฟต์แวร์ Microsoft Office (เช่น Word, Excel, PowerPoint, และอื่นๆ)					
2.8.5 รับส่งอีเมล					
2.8.6 แบ่งปันและเก็บข้อมูลดิจิตอล					
2.8.7 ซื้อขายสินค้าออนไลน์หรือธุรกรรมอีคอมเมิร์ซ					
2.8.8 ทำธุรกรรมการเงินออนไลน์หรืออีแบงค์กิ้ง					

2.8.9 เล่นสื่อโซเชียลมีเดีย หรือสื่อสังคมออนไลน์ เช่น Facebook, Twitter, Instagram, Youtube หรืออื่นๆ					
2.8.10 อื่นๆ นอกเหนือจากระบุมา โปรดระบุ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________					

2.9 **หากพิจารณาถึงการใช้งานเพื่อการศึกษาและการเรียนรู้** คุณใช้คอมพิวเตอร์ อุปกรณ์เคลื่อนที่ต่างๆ หรืออินเทอร์เน็ตบ่อยแค่ไหน โปรดใส่เครื่องหมาย X ในช่องที่คุณเลือก

	ไม่เคย(1)	แทบจะไม่ (2)	บางครั้ง (3)	บ่อย(4)	ตลอดเวลา (5)
2.9.1 เพื่อการสืบค้นข้อมูลและสื่อชนิดต่างๆ					
2.9.2 เพื่อการใช้งานซอฟต์แวร์ Microsoft Office (เช่น Word,					

Excel, PowerPoint, etc.) และโปรแกรมหรือซอฟต์แวร์อื่นๆ ที่ไม่ต้องเชื่อมต่ออินเทอร์เน็ตเพื่อทำการบ้านหรืองานที่ได้รับมอบหมาย					
2.9.3 เพื่อใช้อุปกรณ์ ซอฟต์แวร์หรือโปรแกรมออนไลน์เพื่อทำการบ้านหรืองานที่ได้รับมอบหมาย					
2.9.4 เพื่อการรับส่งอีเมล					
2.9.5 เพื่อการแบ่งปันหรือเก็บข้อมูลดิจิตอล					
2.9.6 เล่นสื่อโซเชียลมีเดียหรือสื่อสังคมออนไลน์เช่น Facebook, Twitter, Instagram,					

Youtube หรือ อื่นๆ					
2.9.7 อื่นๆ โปรดระบุ ______________ ______________ ______________ ______________ ______________ ______________ ______________ ______________ ______________					

2.10 คุณเคยใช้อุปกรณ์คอมพิวเตอร์หรืออุปกรณ์ขนาดพกพาต่างๆ เช่นโทรศัพท์มือถือ สมาร์ทโฟนหรือแท็บเลต ตลอดจนเคยใช้อินเทอร์เน็ตเพื่อเป็นส่วนหนึ่งในการทำกิจกรรมเพื่อการเรียนรู้ในรายวิชาอื่นๆ ที่เคยศึกษาหรือกำลังศึกษาอยู่หรือไม่ หากเคยใช้ โปรดอธิบายเป็นภาษาไทยคร่าวๆ

☐ เคย ☐ ไม่เคย (ไปที่ข้อ 2.11)

หากท่านเคยใช้ โปรดอธิบายคร่าวๆ เป็นภาษาไทยในพื้นที่ด้านล่าง

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ส่วนที่ 3 ความรู้และความเข้าใจเบื้องต้นเกี่ยวกับเทคโนโลยีชนิดความจริงเสริม (Augmented Reality)

3.1 คุณรับทราบหรือเข้าใจเกี่ยวกับเทคโนโลยีชนิดความจริงเสริมมาก่อนหรือไม่

☐ รับทราบ (โปรดข้ามไปตอบคำถามข้อ 3.2 และ 3.3) ☐ ไม่เคยรับทราบมาก่อน

3.2 หากคุณตอบว่า ในข้อ ”รับทราบ“3.1 โปรดอธิบายความเข้าใจหรือความรู้ของคุณเกี่ยวกับเทคโนโลยีชนิดความจริงเสริม (Augmented Realityเป็นภาษาไทยอย่างคร่าวๆ ในพื้นที่ด้านล่าง คุณ (สามารถยกตัวอย่างซอฟต์แวร์หรือโปรแกรมต่างๆ หรือตัวอย่างของผลงาน ชิ้นงานในแขนงต่างๆ ที่ผสมผสานหรือประยุกต์เทคโนโลยีชนิดความจริงเสริมเข้าไปเพื่อเสริมคำอธิบายของท่าน

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จบแบบสอบถาม

โปรดตรวจทานและส่งแบบสอบถามคืนผู้วิจัย

Appendix 9: Thai Translation of Questionnaire on the Acceptance and Self-efficacy of Augmented Reality Technology

แบบสอบถามการยอมรับเทคโนโลยีชนิดความจริงเสริม (Augmented Reality)

Questionnaire on the Acceptance and Self-efficacy of Augmented Reality Technology

แบบสอบถามนี้ประกอบด้วยสองส่วน ส่วนที่ 1 ข้อมูลส่วนตัวและคำยินยอมเพื่อสัมภาษณ์เชิงลึก ส่วนที่ 2 การยอมรับและความมั่นใจในการใช้งานเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) วัตถุประสงค์ของแบบสอบถามนี้เพื่อเก็บข้อมูลเกี่ยวกับประสบการณ์ของนักศึกษาในการผสมผสานหรือประยุกต์ใช้เทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมเพื่อการเรียนรู้ในรายวิชา Analytical Reading ซึ่งเป็นหนึ่งในรายวิชาบังคับของนักศึกษาเอกวิชาภาษาอังกฤษ คณะศิลปศาสตร์ มหาวิทยาลัยมหิดล แบบสอบถามนี้ใช้เวลาประมาณ 15-20 นาทีในการตอบ เมื่อทำแบบสอบถามเสร็จ กรุณาส่งคืนผู้วิจัย

ส่วนที่ 1 : **ข้อมูลส่วนตัวและคำยินยอมเพื่อสัมภาษณ์เชิงลึก**

รหัสผู้ให้ข้อมูลวิจัย (ระบุโดยผู้วิจัย): ____________________

หลังจากที่ท่านกรอกแบบสอบถามนี้เสร็จแล้ว ท่านอาจได้รับการเชิญให้ร่วมในการสัมภาษณ์เชิงลึกต่อเนื่อง ซึ่งการสัมภาษณ์เชิงลึกจะสอบถามเกี่ยวกับประสบการณ์การใช้เทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมเพื่อการเรียนรู้ในห้องเรียนรายวิชา Analytical Reading การยินยอมเข้าร่วมการสัมภาษณ์ขึ้นอยู่กับความสมัครใจของท่าน หากท่านยินยอมเข้าร่วม โปรดกรอกข้อมูลติดต่อเช่นอีเมลหรือเบอร์โทรศัพท์ที่สะดวก หลังจากนั้นผู้วิจัยจะติดต่อท่านเพื่อนัดหมายสถานที่และเวลาในการสัมภาษณ์ ทั้งนี้การสัมภาษณ์อาจ

ดำเนินการผ่านระบบประชุมทางไกลหากท่านไม่สะดวกเดินทาง โดยการสัมภาษณ์จะถูกบันทึกเสียงเพื่อการถอดเสียงสำหรับการวิเคราะห์ต่อไป

หากท่านยินยอมเข้าร่วมการสัมภาษณ์เชิงลึกในขั้นตอนต่อไป โปรดกรอกข้อมูลเพื่อการติดต่อกลับ ผู้วิจัยจะติดต่อท่านในลำดับต่อไป

หากท่านไม่ยินยอมเข้าร่วมการสัมภาษณ์เชิงลึก โปรดข้ามไปตอบแบบสอบถามส่วนที่ 2

1.1 อีเมล: ____ หรือ

1.2 เบอร์โทรศัพท์: ____

ส่วนที่ 2 การยอมรับและความมั่นใจในการใช้งานเทคโนโลยีชนิดความจริงเสริม (Augmented Reality)

2.1: การยอมรับการใช้งานเทคโนโลยีชนิดความจริงเสริม (Augmented Reality)

โปรดอ่านประโยคต่อไปนี้ให้ถี่ถ้วนแล้วเลือกคำตอบที่ท่านคิดว่าตรงกับประสบการณ์ของท่านมากที่สุด โดยกากบาท X ในช่องที่ท่านเลือก

	ไม่เห็นด้วยอย่างยิ่ง (1)	ไม่เห็นด้วย (2)	ตัดสินใจไม่ได้ (3)	เห็นด้วย (4)	เห็นด้วยอย่างยิ่ง (5)
2.1.1 ฉันคิดว่าเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) หรือเรียกสั้นๆ ว่า AR เป็นประโยชน์ต่อการเรียนรู้ของฉัน					
2.1.2 ฉันไม่ต้องใช้ความพยายามการใช้งานหรือการทดลองเล่นเทคโนโลยี AR จนเกินไป					
2.1.3 ฉันตั้งใจจะใช้เทคโนโลยี AR หากฉันมีอุปกรณ์และเทคโนโลยีพร้อม					
2.1.4 ฉันสามารถควบคุมการใช้งานหรือการทดลองเล่นเทคโนโลยี AR ได้					
2.1.5 ฉันรู้สึกประหม่าเมื่อต้องใช้งานหรือทดลองเล่นเทคโนโลยี AR					
2.1.6 ฉันคิดว่าการใช้งานหรือการทดลองเล่นเทคโนโลยี AR มีความสนุกสนาน					
2.1.7 การใช้งานเทคโนโลยี AR ช่วยเพิ่มประสิทธิผลในการเรียนรู้ของฉัน					
2.1.8 ฉันคิดว่าเทคโนโลยี AR ง่ายในการใช้งาน					
2.1.9 ฉันคิดว่าฉันจะใช้งานเทคโนโลยี AR หากฉันมีอุปกรณ์และสามารถเข้าถึงเทคโนโลยีชนิดนี้ได้					

	ไม่เห็นด้วยอย่างยิ่ง (1)	ไม่เห็นด้วย (2)	ตัดสินใจไม่ได้ (3)	เห็นด้วย (4)	เห็นด้วยอย่างยิ่ง (5)
2.1.10 ฉันมีแหล่งข้อมูลและอุปกรณ์ที่จำเป็นต่างๆ ในการใช้งานหรือการทดลองเล่นเทคโนโลยี AR					
2.1.11 ฉันรู้สึกไม่สะดวกสบายเมื่อต้องใช้เทคโนโลยี AR					
2.1.12 ขั้นตอนการใช้งานหรือทดลองเล่นเทคโนโลยี AR เป็นที่น่าพึงพอใจ					
2.1.13 การใช้งานหรือการทดลองเล่นเทคโนโลยี AR ช่วยให้ประสิทธิภาพในการเรียนรู้ของฉันดีขึ้น					
2.1.14 ฉันคิดว่าการใช้เทคโนโลยี AR ในการทำสิ่งที่ต้องทำเพื่อการเรียนรู้เป็นเรื่องง่ายดาย					
2.1.15 ฉันวางแผนที่จะใช้งานเทคโนโลยี AR ในอนาคตอันใกล้					
2.1.16 ฉันคิดว่าจะเป็นเรื่องง่ายในการใช้งานเทคโนโลยี AR หากมีแหล่งข้อมูล ทรัพยากร โอกาสและองค์ความรู้ที่จำเป็นในการใช้งาน					
2.1.17 การใช้เทคโนโลยี AR ทำให้ฉันรู้สึกเป็นกังวลและไม่สบายใจ					
2.1.18 ฉันรู้สึกสนุกสนานตอนใช้งานหรือทดลองเล่นเทคโนโลยี AR					
2.1.19 การใช้งานหรือการทดลองเล่นเทคโนโลยี AR ช่วยส่งเสริมสมรรถภาพการเรียนรู้ของฉัน					
2.1.20 กระบวนการใช้งานและการมีปฏิสัมพันธ์ของฉันกับเทคโนโลยี AR มีความชัดเจนและเข้าใจได้ง่าย					
2.1.21 ฉันมีความมุ่งมั่นที่จะประยุกต์ใช้เทคโนโลยี AR ในกระบวนการเรียนรู้ในอนาคต					
2.1.22 แหล่งข้อมูลและทรัพยากรจำเป็นในการใช้งานเทคโนโลยี AR มีปริมาณเพียงพอสำหรับฉัน					

2.1.23 การใช้งานหรือการทดลองเล่นเทคโนโลยี AR ทำให้ฉันหวาดกลัว					
2.1.24 ฉันสนุกตอนใช้งานเทคโนโลยี AR					

2.2: ความมั่นใจในการใช้เทคโนโลยีชนิดความจริงเสริม (Augmented Reality)

ข้อความในประโยคต่อไปนี้จะสอบถามเพื่อชี้วัดว่าคุณมีความมั่นใจและสามารถใช้งานเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) ซึ่งอาจเป็นเทคโนโลยีที่คุณไม่คุ้นเคยมาก่อน ได้ดีในระดับใดภายใต้เงื่อนไขต่างๆ วิธีการตอบแบบสอบถามส่วนนี้คือโปรดอ่านประโยคด้านล่างอย่างถี่ถ้วน จากนั้นให้เลือกตัดสินใจว่าคุณจะตอบว่า "ใช่" หรือ "ไม่ใช่" หากคุณตอบว่า "ใช่" ในประโยคใด ให้กากบาทระดับความมั่นใจในการใช้เทคโนโลยีชนิดความจริงเสริมโดยประเมินจากประสบการณ์ของตนเองที่ผ่านมาหลังจากทำกิจกรรมในห้องเรียน โดยระดับความมั่นใจจะมีตั้งแต่หมายเลข 1 ถึง 10 โดยหมายเลข 1 หมายถึง "ไม่มั่นใจเลย" หมายเลข 5 หมายถึง "ค่อนข้างมั่นใจ" และหมายเลข 10 หมายถึง "มั่นใจที่สุด"

	ไม่มั่นใจเลย (1)	(2)	(3)	(4)	ค่อนข้างมั่นใจ (5)	(6)	(7)	(8)	(9)	มั่นใจที่สุด (10)
ฉันใช้งานหรือทดลองเล่นเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) หรือ AR ได้ …										
2.2.1 … ถ้าไม่มีใครคอยบอกว่าต้องทำอย่างไรตอนที่ฉันกำลังใช้เทคโนโลยีดังกล่าวอยู่ ☐ ใช่ ☐ ไม่ใช่										
2.2.2 … ถ้าฉันไม่เคยใช้งานเทคโนโลยีดังกล่าวมาก่อน ☐ ใช่ ☐ ไม่ใช่										
2.2.3 … ถ้าเพียงฉันมีคู่มืออ้างอิงการใช้งานเทคโนโลยีดังกล่าว ☐ ใช่ ☐ ไม่ใช่										
2.2.4 … ถ้าฉันได้ดูคนอื่นใช้งานเทคโนโลยีดังกล่าวก่อนที่จะลงมือใช้จริงด้วยตนเอง ☐ ใช่ ☐ ไม่ใช่										

	ไม่มั่นใจเลย (1)	(2)	(3)	(4)	ค่อนข้างมั่นใจ (5)	(6)	(7)	(8)	(9)	มั่นใจที่สุด (10)
ฉันใช้งานหรือทดลองเล่นเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) หรือ AR ได้ …										
2.2.5 … ถ้าฉันสามารถโทรหาหรือขอความช่วยเหลือจากคนอื่นเมื่อฉันเจอปัญหาติดขัดตอนใช้งานเทคโนโลยีดังกล่าว ☐ ใช่ ☐ ไม่ใช่										
2.2.6 … ถ้ามีคนคอยแนะนำว่าต้องทำอย่างไรในขั้นต้น ☐ ใช่ ☐ ไม่ใช่										
2.2.7 … ถ้าฉันมีเวลามากพอที่จะทำชิ้นงานที่ต้องใช้เทคโนโลยีดังกล่าว ☐ ใช่ ☐ ไม่ใช่										
2.2.8 … ถ้าฉันมีทรัพยากรและอุปกรณ์ที่จำเป็นพร้อมสรรพเมื่อต้องการความช่วยเหลือ ☐ ใช่ ☐ ไม่ใช่										
2.2.9 … ถ้ามีคนสาธิตวิธีการหรือขั้นตอนให้ฉันดูก่อน ☐ ใช่ ☐ ไม่ใช่										
2.2.10 … ถ้าฉันเคยใช้งานเทคโนโลยีที่คล้ายคลึงกับเทคโนโลยี AR มาก่อนในการทำชิ้นงานแบบเดียวกัน ☐ ใช่ ☐ ไม่ใช่										

Appendix 10: Thai Translation of Interview Protocol

ชุดคำถามสัมภาษณ์เชิงลึก

Interview Protocol

วัตถุประสงค์ของชุดคำถามเพื่อการสัมภาษณ์เชิงลึกชุดนี้เพื่อเก็บข้อมูลจากผู้เข้าร่วมวิจัยซึ่งเป็นนักศึกษาในรายวิชา Analytical Reading ประจำคณะศิลปศาสตร์ มหาวิทยาลัยมหิดล โดยจะสอบถามเกี่ยวกับประสบการณ์ มุมมอง ทัศนคติและคำบอกเล่าถึงการใช้งานเทคโนโลยีชนิดความจริงเสริม (Augmented Reality) เพื่อการทำกิจกรรมการเรียนรู้ในรายวิชาดังกล่าว คำถามที่ใช้ในการสัมภาษณ์เชิงลึกนี้ได้รับการพัฒนาขึ้นมาโดยอ้างอิงจาก Technology Acceptance Model (TAM) โดย Davis, Bagozzi และ Warshaw (1989) และ Technology Acceptance Model 3 (TAM3) โดย Venkatesh และ Bala (2008)

ข้อมูลการสัมภาษณ์เบื้องต้น

การสัมภาษณ์เชิงลึกนี้คาดว่าจะใช้เวลาประมาณ 30 ถึง 45 นาทีต่อคน โดยผู้เข้าร่วมวิจัยที่ยินยอมเข้าสัมภาษณ์จะใช้โอกาสนี้บอกเล่าประสบการณ์ ทัศนคติ มุมมองและความคิดส่วนตัวอื่นๆ อันเกี่ยวข้องกับการใช้งานเทคโนโลยีชนิดความจริงเสริมในการเรียนรายวิชา Analytical Reading

ส่วนที่ 1: คำแนะนำตัวโดยผู้วิจัย

พูดกับผู้ให้สัมภาษณ์*:*

ก่อนอื่นขอขอบคุณที่ท่านสละเวลาเข้าร่วมการวิจัยในครั้งนี้ ผมชื่อนายพยุงศักดิ์ แก่นจันทร์ เป็นผู้ดำเนินการวิจัย ก่อนที่เราจะเริ่มสัมภาษณ์เชิงลึก ผมขอเวลาอธิบายวัตถุประสงค์ของการสัมภาษณ์ให้ท่านทราบอีกครั้ง วัตถุประสงค์หลักของการวิจัยครั้งนี้เพื่อศึกษา

ทัศนคติ การรับรู้ การยอมรับ ความมั่นใจในการใช้ตลอดจนประสบการณ์การใช้งานเทคโนโลยีชนิดความจริงเสริมหรือ Augmented Reality การสัมภาษณ์ครั้งนี้จะใช้เวลาทั้งสิ้นประมาณ 30 ถึง 45 นาที หากท่านสงสัยหรือไม่แน่ใจในความหมายของคำถามข้อใด ท่านสามารถขอให้ผู้วิจัยอธิบายได้ตลอดเวลา หรือหากระหว่างการสัมภาษณ์ ท่านรู้สึกไม่สบายใจที่จะให้ข้อมูลต่อ ท่านสามารถขอถอนตัวจากการสัมภาษณ์ได้ทุกเมื่อ ท่านมีคำถามอื่นใดเกี่ยวกับการสัมภาษณ์เชิงลึกครั้งนี้หรือไม่ ถ้าไม่มี ผมจะขอเริ่มสัมภาษณ์ครับ

ส่วนที่ 2: ประสบการณ์ของผู้ให้สัมภาษณ์ในการใช้งานเทคโนโลยีชนิดความจริงเสริม

1. ข้อมูลส่วนตัวและประสบการณ์การใช้งานเทคโนโลยี

1.1 โปรดแนะนำตัวคร่าวๆ ครับ

1.2 โปรดเล่าประสบการณ์และความสามารถในการใช้คอมพิวเตอร์และอินเทอร์เน็ตในชีวิตประจำวันครับ

1.3 คุณมีประสบการณ์การใช้งานอุปกรณ์สื่อสารชนิดพกพาหรือไม่ โปรดอธิบายเพิ่มเติม

1.4 คุณมีประสบการณ์การใช้งานเทคโนโลยีชนิดความจริงเสริมมาก่อนหรือไม่ โปรดอธิบายเพิ่มเติม

1.5 คุณเคยใช้เทคโนโลยีชนิดใดหรือไม่ที่ไม่ใช่เทคโนโลยีชนิดความจริงเสริม ที่คุณรู้สึกว่าใช้งานได้อย่างมีประสิทธิภาพและคุณพอใจ

1.6 คุณเคยใช้เทคโนโลยีชนิดใดหรือไม่ที่ไม่ใช่เทคโนโลยีชนิดความจริงเสริม ที่คุณรู้สึกว่าไม่สามารถใช้งานได้อย่างมีประสิทธิภาพ เกิดข้อผิดพลาด ขัดข้อง หรือทำให้คุณไม่สบายใจและไม่อยากใช้งานอีก โปรดอธิบาย

2. ทัศนคติ การยอมรับ การรับรู้เกี่ยวกับเทคโนโลยีชนิดความจริงเสริม

2.1 ก่อนเรียนวิชา Analytical Reading คุณได้รับข้อมูลเบื้องต้นเกี่ยวกับเทคโนโลยีชนิดความจริงเสริมโดยผู้วิจัย ช่วยบรรยายหรืออธิบายได้ไหมว่าเทคโนโลยีชนิดความจริงเสริมคืออะไร มีคุณสมบัติหรือลักษณะโดดเด่นอะไร โดยบรรยายจากความเข้าใจของคุณ

Perceived Usefulness

2.2 คุณพิจารณาหรือรับรู้การใช้งานเทคโนโลยีชนิดความจริงเสริมอย่างไรบ้าง คุณคิดว่าเทคโนโลยีชนิดนี้มีความสำคัญต่อการเรียนรู้ของคุณหรือไม่ อย่างไร โปรดอธิบายขอสังเขป (Perceived Usefulness)

2.3 โปรดอธิบายถึงประโยชน์หรือข้อดีที่คุณคิดว่าได้รับจากการใช้งานเทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมการเรียนรู้ในรายวิชา Analytical Reading (Perceived Usefulness)

2.4 โปรดอธิบายโทษหรือข้อเสีย ตลอดจนปัญหาขัดข้องหรืออุปสรรคในการใช้เทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมการเรียนรู้ในรายวิชา Analytical Reading (Perceived Usefulness และ Perceived Ease of Use)

2.5 คุณคิดว่าเทคโนโลยีชนิดความจริงเสริมมีประโยชน์ในการศึกษาหรือไม่ อย่างไร คุณคิดว่าเทคโนโลยีชนิดนี้จะเป็นประโยชน์สำหรับคุณในอนาคตหรือไม่ (Job Relevance)

Perceived Ease of Use

2.6 คุณคิดว่าคุณประสบความสำเร็จในการใช้งานเทคโนโลยีชนิดความจริงเสริมหรือไม่ในการทำกิจกรรมในชั้นเรียน คุณจะประเมินระดับความสามารถในฐานะผู้ใช้เทคโนโลยีชนิดนี้ในระดับใด หากระดับความมั่นใจเริ่มตั้งแต่ 1 ถึง 10 โดยที่ 1 หมายถึงมั่นใจน้อยที่สุด และ 10 หมายถึงมั่นใจมากที่สุด คุณจะประเมินคะแนนตนเองในระดับใด เพราะเหตุใด (Computer Self-efficacy)

2.7 คุณเผชิญปัญหา ข้อขัดข้อง อุปสรรคใดบ้างในการใช้งานเทคโนโลยีชนิดความจริงเสริมในชั้นเรียน คุณได้รับการสนับสนุนหรือความช่วยเหลือเพียงพอหรือไม่ในการใช้งานเทคโนโลยีดังกล่าว การสนับสนุนหรือความช่วยเหลือใดบ้างที่คุณคิดว่าสำคัญหรือจำเป็น โปรดอธิบาย (Perception of External Control)

2.8 คุณรู้สึกกระสับกระส่าย ประหม่า กังวลใจหรือไม่สบายใจใดๆ หรือไม่ขณะใช้งานเทคโนโลยีชนิดความจริงเสริม คุณรู้สึกกลัวหรือไม่มั่นใจว่าจะใช้งานเทคโนโลยีชนิดดังกล่าวหรือไม่ โปรดอธิบาย (Computer Anxiety)

2.9 คุณคิดว่าการใช้งานเทคโนโลยีชนิดความจริงเสริมในการเรียนรู้ภาษาอังกฤษเป็นกิจกรรมที่สนุกสนานหรือไม่ โปรดอธิบาย (Perceived Enjoyment)

2.10 หากคุณสามารถให้คำแนะนำหรือคำวิจารณ์แก่คณะผู้พัฒนาเทคโนโลยีชนิดความจริงเสริมที่ท่านใช้งานในการทำกิจกรรมการเรียนรู้ในห้องเรียน คุณอยากจะแนะนำหรือบอกอะไรบ้าง

3. การใช้งานเทคโนโลยีชนิดความจริงเสริมในอนาคต

3.1 คุณคิดว่าเทคโนโลยีชนิดความจริงเสริมสามารถนำไปประยุกต์ใช้งานในการศึกษาในอนาคตได้หรือไม่ อย่างไร โปรดอธิบาย

4. คำถามเพิ่มเติมเกี่ยวกับศักยภาพและสมรรถภาพการเรียนรู้

4.1 หลังจากที่คุณได้รู้จักและใช้งานเทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมในชั้นเรียน คุณคิดว่าเทคโนโลยีชนิดนี้ช่วยให้คุณพัฒนาการเรียนรู้หรือไม่ โปรดอธิบาย

4.2 หลังจากที่คุณได้รู้จักและใช้งานเทคโนโลยีชนิดความจริงเสริมในการทำกิจกรรมในชั้นเรียน คุณคิดว่าเทคโนโลยีชนิดนี้ช่วยให้คุณพัฒนาการเรียนรู้ภาษาอังกฤษหรือไม่ โปรดอธิบาย

อ้างอิง

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, 35*(8), 982-1003.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences, 39*(2), 273-315.

Appendix 11: Classroom Observation Protocol

Classroom Observation Protocol

This Classroom Observation Protocol is used for a purpose of indicating and observing a lesson/class in which a particular technology is being used. It is based on the International Society for Technology in Education (ISTE)'s Classroom Observation Tool (ICOT) (2008), in combination with the concept of Critical Events in classroom observation by Wragg (1999, p.67).

Background Information & Setting	
Teacher Name	
Observation date	DD ______ MM _______ YY ______
Observation time	From _______ to ________
Length (minutes)	
Subject	
Number of students	
Other (e.g. student diversity)	
Classroom physical arrangement/ description	
Grouping of students	_____ Individual _____ Pairs/small groups _____ Whole class

Events of Technology Use by Students
Event 1 Technology tools (hardware and/or software): What led up to the technology use event? What happened in class? How do students interact among themselves and with the technology? What were the outcomes?
Event 2 Technology tools (hardware and/or software): What led up to the technology use event? What happened in class? How do students interact among themselves and with the technology? What were the outcomes?
Event 3 Technology tools (hardware and/or software): What led up to the technology use event?

What happened in class? How do students interact among themselves and with the technology?   What were the outcomes?
Event 4 Technology tools (hardware and/or software):   What led up to the technology use event?   What happened in class? How do students interact among themselves and with the technology?   What were the outcomes?

References:

ISTE Classroom Observation Tool (ICOT). (2008). *ISTE Classroom Observation Tool (ICOT).* Retrieved December 30, 2016, from International Society for Technology in Education: www.iste.org/docs/excel-files/icot.xlsm?sfvrsn=2

Wragg, E. C. (1999). *An introduction to classroom observation.* New York: Routledge.

Appendix 12: Course Syllabus of the course Analytic Reading

Course Syllabus

1. Program of Study	English
Faculty/Institution/College	Faculty of Liberal Arts
2. Course Title:	Analytical Reading
Course Code:	LAEN 304
3. Number of Credits:	3 (3-0-6)
4. Prerequisite:	None
5. Type of course:	Core course
6. Semester:	First semester
Academic year	2016

7. Course Condition

Students must have attended at least 80% of the total class hours and participate in class activities.

8. Course Description:

Practicing reading skill in various types, reading for main idea, supporting details, and drawing conclusions from the reading materials; presenting ideas and discussing in groups based on various types of the readings.

9. Course Objectives:

After successful completion of this course, students will be able to

- reason out the meanings of the unknown words
- determine the topic, main ideas, and supporting details; and write a summary
- apply the advanced reading skills in both discussion and written forms

10. Course Outline

Week	Topics	Hours		
		Lecture	Lab	self-study
1 18/19 Aug	- Introduction to the course - Determining the meaning of an unfamiliar word (I) - Word structure (I)	3		6
2 25/26 Aug	- Determining the meaning of an unfamiliar word (II) - Word structure (II) - Submission of group members and number of the selection	3		6
3 1/9 Sep	- Topic, main idea, and supporting details of a paragraph (I)	3		6
4 15/16 Sep	- Topic, main idea, and supporting details of a paragraph (II)	3		6
5 22/23 Sep	- Topic, main idea, and supporting details of a paragraph (III)	3		6
6 29/30 Sep	- Writing's patterns	3		6
7 6/7 Oct	- Writing a summary - Discussion on report progress	3		6
8 10-14 October	MID-TERM EXAMINATION			
9 20/21 Oct	- Distinguishing facts from opinions	3		6
10 27/28 Oct	- Making inferences	3		6
11 3/4 Nov	- Determining author's purpose, tone, point of view, and intended audience (I) - Evaluation of author's argument (I)	3		6
12 10/11 Nov	- Determining author's purpose, tone, point of view, and intended audience (II) - Evaluation of author's argument (II)	3		6
13 17/18 Nov	- Interpreting graphic aids	3		6
14 24/25 Nov	- Revision of all the advanced skills (I)	3		6
15	- Revision of all the advanced skills (II)	3		6

1/2 Dec	- Full report submission			
16 6-16 Dec	FINAL EXAMINATION			

11. Teaching Method:

Lecture and discussion, pair-work/ group-work discussion, report

12. Teaching Media:

Textbook, supplementary sheets, LCD projector, computer, whiteboard, visualizer

13. Measurement and Evaluation of Student Achievement

Students are evaluated throughout the course based on the criteria as follows:

Attendance and participation	10%
Quizzes	10%
Report	20%
Mid-term	30%
Final	30%

Student achievement will be graded according to the faculty and university standard using the symbols: A, B+, B, C+, C, D+, D, and F as follows:

A	80-100
B+	75-79
B	70-74
C+	65-69
C	60-64
D+	55-59
D	50-54
F	0-49

15. Instructor

Ajarn Suchaniya Wongwiwattana
Email: suchaniya.won@mahidol.ac.th
Faculty of Liberal Arts, Mahidol University

17. Reference

Elder, J. (2008). *Exercise Your College Reading Skills: Developing More Powerful Comprehension*. Second edition. Singapore: The McGraw-Hill Companies.

18. Instructions for group report (200 marks)

In a group of about 5 students, choose one of the twelve selections on page 394-460 and analyze it as directed below:

1 Find 5 words that you can guess meaning from context. Write down the meanings (Dictionary is not allowed). Identify the strategies that help you determine the meanings.
2 Find 3 sentences telling facts and 3 sentences telling opinions.
3 Determine the author's purpose and intended audience of the selection.
4 Analyze the author's argument as follows:
4.1 Identify the assumptions.
4.2 Identify the types of support.
4.3 Determine the relevance of support.
4.4 Evaluate the objectivity.
4.5 Check the completeness.
4.6 Determine if the argument is valid and credible.

Note: **Students will be informed if there is any change**

Appendix 13: Letter to Institution for Research Permission

LETTER TO INSTITUTION

BOSTON UNIVERSITY
SCHOOL OF EDUCATION

Two Silber Way, Boston, MA 02215
www.bu.edu/sed
Dissertation supervisor:
Dr. Laura M. Jimenez
Tel: +1(617)358-1945

March 31, 2017

Dear Dean of the Faculty of Liberal Arts, Mahidol University,

My name is Payungsak Kaenchan, a doctoral student in Curriculum and Teaching with a specialization in Educational Media and Technology at School of Education Boston University. I am carrying out a research study into Thai learners' experiences and technology acceptance towards the use of Augmented Reality (AR) technology in classrooms. The study also investigates the learners' assumed levels of self-efficacy in using AR. I am interested in the way that Thai learners perceive, accept, and practically use AR technology particularly in their learning. Therefore, I would like to invite some of your faculty members and English-major undergraduates to participate in this this study during the academic semester 1/2017 (August – November, 2017). Data collection will span over a course of two months or less.

Conceptually, AR is defined as a type of human-computer interaction which adds virtual objects to real senses. That is, AR could be described as an experience in which a wide range of technologies project digital sensory input which may include texts, images, videos, audios or three-dimensional components onto real-world environments. This augmented experience gives users immersive perceptions through various types of technological devices. The technology superimposes interactive, computer-generated visuals and other multimedia elements onto real-life surroundings, allowing simultaneous viewing and interacting between the virtual and real objects in attempt to enhance users' perceptive experiences.

This study examines to what extent Thai learners perceive such technology as learning materials will be examined in depth and answered. It will be advantageous to understand how learners perceive the benefits and the glitches in integrating this emerging technology so that the understanding of their perceptions and related self-efficacy toward the technology can be obtained. The results may provide useful insights into the learners' reported affordances and constraints in the integration of AR for their learning purposes.

My research study has three main phases. In Phase One, I will administer a questionnaire seeking information on demographics and computer and the Internet use to approximately 15-20 student participants in the course Analytical Reading. In Phase Two, I will organize an introductory workshop about AR technology, implement a teacher-led lesson plan in which the participants learn about English word structures. Subsequently, the participants will also attend an AR tutorial workshop in which they are taught and trained about how to use a designated AR application to complete a pair-work learning activity about English word structures. Later in Phase Three, I will administer a questionnaire on AR technology acceptance and self-efficacy to the participants. I will also conduct an individual interview with the participants. They will be asked to retrospectively elicit their experience in integrating AR technology in their lessons. They will be asked questions regarding their perceptions about the usefulness, the constraints, and the level of self-efficacy in using AR technology. This interview will be audio-recorded and digitally stored and transcribed. After data transcription, the participants will be invited to comment on the fidelity of the transcriptions.

I do hope that you, your faculty members, and students will find this research project valuable for instructional and professional development and improvement. Participation would, of course, be entirely voluntary. The participants would be free to withdraw from the study at any time without giving a reason, and all personal information would be kept strictly confidential and anonymous. Neither your faculty members nor your school/faculty would be identifiable in my doctoral dissertation or in any publications or presentations that might follow. I would not share my transcriptions with you, only with each individual participant and my dissertation committee members.

If you think you might be willing for your faculty members and students to participate in this study, I would be very happy to discuss it with you or designated persons further by email (payungie@bu.edu) or by Skype via Mryungie. Though I am currently based in Boston, Massachusetts, USA, I am traveling to collect research data at your faculty by myself in the academic semester (1/2017) which is from August to November, 2017. That is, the whole data collection process will take approximately 2-3 months, or less. In addition, the appointments with your faculty members and students to collect data will be depending on their convenient, or agreed, teaching schedules and time.

Please feel free to contact me if you have any questions regarding the study. Thank you for taking the time to read this and I hope that I may have the opportunity to collaborate in the near future.

Yours sincerely,

Payungsak Kaenchan
Researcher

Dissertation supervisor: Dr. Laura M. Jimenez

Appendix 14: Information Letter for Participants

INFORMATION LETTER FOR PARTICIPANTS

BOSTON UNIVERSITY
SCHOOL OF EDUCATION

Two Silber Way, Boston, MA 02215
www.bu.edu/sed
Dissertation supervisor:
Dr. Laura M. Jimenez
Tel: +1(617)358-1945

March 31, 2017

EXAMINING THAI STUDENTS' EXPERIENCES OF
AUGMENTED REALITY TECHNOLOGY
IN A UNIVERSITY LANGUAGE EDUCATION CLASSROOM

Information for Participants

Dear participant,

My name is Payungsak Kaenchan, a doctoral student in Curriculum and Teaching with a specialization in Educational Media and Technology at School of Education Boston University. I am carrying out a research study into Thai learners' experiences and technology acceptance towards the use of Augmented Reality (AR) technology in classrooms. The study also investigates the learners' assumed levels of self-efficacy in using AR. I am interested in the way that Thai learners perceive, accept, and practically use AR technology particularly in their learning. Therefore, I would like to invite some of your faculty members and English-major undergraduates to participate in this this study during the academic semester 1/2017 (August – November, 2017). Data collection will span over a course of two months or less.

Introduction to AR

AR can be defined as a type of human-computer interaction which adds virtual objects to real senses. That is, AR could be described as an experience in which a wide range of technologies project digital sensory input which may include texts, images, videos, audios or three-dimensional components onto real-world environments. This augmented experience gives users immersive perceptions through various types of technological devices. The technology superimposes interactive, computer-generated visuals and other multimedia elements onto real-life surroundings, allowing simultaneous viewing and interacting between the virtual and real objects in attempt to enhance users' perceptive experiences.

Invitation

I would like to invite you to take part in this research project. Before you decide whether to participate, it is important that you understand why the project is being conducted and what your participation would involve. Please take time to read the following information and the consent form carefully. Please contact me if there are any aspects of the project that are unclear, or if you would like more information.

What is the purpose of the project?

The aim of this study is to examine Thai higher-education students' experiences towards the use of AR technology in learning. The study also investigates the students' perceptions and the level of self-efficacy in using AR. It is, therefore, interesting to see how and to what extent the Thai students perceive, accept, and integrate these technologies to facilitate their learning, and how confident they feel about using the technology.

Why have you been chosen?

For this study, I am seeking participants who are English-major undergraduates in a higher-education setting in Thailand. Also, you should be enrolled as full-time students, and should have English proficiency levels of intermediate to upper-intermediate levels, based on your self-reported information or the English score from your Admission Examination. Moreover, it is preferable that you are students in the course Analytical Reading, one of the required courses for English-major students at the Faculty of Liberal Arts. The rationale is that a portion of the course sessions align with the learning objective of the AR activity which is designed in collaboration of the researcher and the teacher of the course.

What will happen during the study?

If you agree to participate in this study, here is what will happen. The research study has three phases. In Phase One, you will be completing a questionnaire that seeks information on your demographics and computer and the Internet use, at the beginning of the course. This is to gather necessary information concerning technological resources and/or devices that may be needed in the study. In Phase Two, you will be studying the first two sessions of the course which are word formation and structures. The session will be taught by your course teacher. A required assignment/activity of this session is that you will be working in pair to create an AR-based product. In order to complete this activity, you will be attending an AR introductory and tutorial workshop organized by the researcher. You will be taught, trained, and assisted in using a designated AR application to complete the pair-work activity. You will have an opportunity to showcase your products with classmates. Later in Phase Three, you will fill out a questionnaire on AR technology acceptance and self-efficacy. Also, you will be joining an interview in which you retrospectively elicit you experience in integrating AR technology in classroom. You will be asked questions regarding your perceptions about the usefulness, the constraints, and the level of self-efficacy in using AR technology. This interview will be audio-recorded and digitally stored and transcribed. After data transcription, you will be invited to comment on the fidelity of the transcriptions.

Do you have to take part? What are the risks and benefits of taking part?

You are under absolutely no obligation to take part in this study. Filling out the questionnaires does not oblige you to agree to the workshops, observation, and interview if you are invited. If you do choose to participate, you can decide to stop at any time without giving a reason, and without any consequences – see the consent form for how to do this. There are no known risks to participating in the study. The study may also contribute generally to knowledge about learners' experience of the integration of AR technology in language instruction and learning. It may help you to reflect upon your own learning process.

What will happen to the results of this research?

The results of this research will be analyzed for Boston University doctoral dissertation. None of the transcripts will be shared with anyone else in your institution besides yourself and dissertation committee members. The results of the analyses may be published in academic publications or presented at academic conferences in the future. You will not be identifiable in any of the publications or presentations. No one but my supervisor, Dr. Laura M. Jimenez, and I will have access to your name. All paper materials will be kept in a locked filing cabinet to which only I have the key, and all electronic data will be password-protected. All paper materials, and any electronic data where you are identifiable, will be destroyed once the materials have been analyzed. Anonymized electronic data, with any potentially identifying words removed, will be kept indefinitely in order to be used for later research by me or other researchers, unless you indicate on the consent form that you wish the anonymized data to be destroyed. However, please note that the confidentiality of your data is subject to normal legal requirements.

Who is organizing the research?

This research is organized as a doctoral research study under the supervision of School of Education Boston University, USA.

Contact for Further Information or Follow-up

Should you have any further questions about this research, please do not hesitate to contact me via my primary Boston University email address at: payungie@bu.edu, or by phone at +66 99-330-9692 or my Skype ID: Mryungie. Should you have any comments or concerns about this study at any time, and you are not satisfied with the answers I have given you, you can contact my supervisor, Dr. Laura M. Jimenez, jimenez1@bu.edu.

Sincerely,

Payungsak Kaenchan
Researcher
Tel: +66 99-330-9692
Skype: Mryungie
Email address: payungie@bu.edu

Appendix 15: Participant Consent Form

PARTICIPANT CONSENT FORM

BOSTON UNIVERSITY
SCHOOL OF EDUCATION

BOSTON UNIVERSITY

Two Silber Way, Boston, MA 02215
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Dissertation supervisor:
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March 31, 2017

EXAMINING THAI STUDENTS' EXPERIENCES OF
AUGMENTED REALITY TECHNOLOGY
IN A UNIVERSITY LANGUAGE EDUCATION CLASSROOM

Participant Consent Form

This study aims to examine higher-education learners' self-reported experiences and perceptions towards the use of Augmented Reality technology in classroom learning; and their acceptance and self-efficacy in the integration of the technology. This is a study undertaken by Mr. Payungsak Kaenchan, a doctoral student in Curriculum and Teaching with a specialization in Educational Media and Technology, School of Education Boston University.

1. I have understood the information about and procedures in this study in the information letter. I have considered all the risks involved. I have had an opportunity to ask questions, and any questions have been answered satisfactorily.
2. I have decided to participate in filling out the two questionnaires, and upon consent, I am willing to participate in interview(s) and classroom observation(s). I also agree to have the interview audio-recorded and stored.
3. I have understood that participation in this study is voluntary and that I can withdraw from the study at any time, without consequence and without having to give a reason. If I decide to withdraw, I will let Mr. Payungsak Kaenchan know as soon as possible.
4. I have understood that there is a certain party of people—researcher, research assistants, and dissertation committee members—who will have access to my information or data provided, and to how the data will be stored and what will happen to the data at the end of the project.

5. I have understood that confidentiality of information is subject to normal legal requirements.
6. I am aware of who to contact should I have questions or concerns during or following my participation in this study.
7. I have understood that this project has been reviewed by and received ethical clearance through Institutional Review Board (IRB) of Boston University and Mahidol University.

Informed of the aforementioned,

I agree / I disagree to participate in this study.

[Underline or circle your choice]

Name (print) : ____

Signature : ____

Date : ____

Email address : ____

Contact no. : ____

Researcher : **Payungsak Kaenchan**

Signature : ____

Date : ____

Contact no. : +(66)99-330-9692

Email address : payungie@bu.edu

Skype : Mryungie

Appendix 16: Adapted Reading Passage and the AR Flashcards for the Teacher Showcase

An adapted reading passage with a set of 12 teacher-made AR vocabulary flashcards

The following passage was adapted from an online source to be used in the teacher showcase where participating undergraduates work in small groups to read the passage and guess the meanings of the 12 underlined words. Those words are then brought into the creation of 12 AR-mediated vocabulary flashcards. These AR vocabulary flashcards can be viewed by using a mobile application called Zappar which can be downloaded from Google Play or Apple Store for free.

Reading passage

Galaxy-Exploring Camera to Be Used in the Operating Room

ScienceDaily (July 11, 2012) — **Neurosurgeons** and researchers at Cedars-Sinai Medical Center and the Maxine Dunitz Neurosurgical Institute are adapting an ultraviolet camera to **possibly** bring planet-exploring technology into the operating room.

If the system works when focused on brain tissue, it could give surgeons a real-time view of changes **invisible** to the naked eye and unapparent even with magnification of current medical imaging technologies. The pilot study seeks to determine if the camera provides visual detail that might help surgeons distinguish areas of healthy brain from deadly tumors called gliomas, which have **irregular** borders as they spread into normal tissue.

"Our goal is to **revolutionize** the way neurological disorders are treated. Ultraviolet imaging is one of several intraoperative technologies we are pursuing," commented Keith L. Black, MD, chair of the Department of Neurosurgery.

The tumors' far-reaching tentacles pose big challenges for neurosurgeons: Taking out too much normal brain tissue can have catastrophic consequences, but stopping short of total **removal** gives remaining cancer cells a head start on growing back. Delineating the margin where tumor cells end and healthy cells begin never has been easy, even with recent advances in medical imaging systems, said Black, director of the Maxine Dunitz Neurosurgical Institute and the Johnnie L. Cochran, Jr. Brain Tumor Center and the Ruth and Lawrence Harvey Chair in Neuroscience

But the ultraviolet camera might be able to see below the surface, he said. Because tumor cells are more active and require more energy than normal cells, a specific chemical (nicotinamide adenine dinucleotide hydrogenase or NADH) accumulates in tumor cells but not in healthy cells. NADH emits ultraviolet light that may be captured by the camera and displayed in a high-resolution image. The camera, on loan from NASA's Jet Propulsion Laboratory, employs the ultraviolet technology used in space to study planets and distant galaxies.

"The ultraviolet imaging technique may provide a 'metabolic map' of tumors that could help us **differentiate** them from normal surrounding brain tissue, providing useful, real-time, intraoperative information," said Ray Chu, MD, a neurosurgeon leading the study with co-principal **investigator** Babak Kateb, MD, research scientist at Cedars-Sinai's Maxine Dunitz Neurosurgical Institute and chairman of the board of the Society for Brain Mapping and Therapeutics.

Kateb observed: "This study and equipment-sharing **arrangement** represents the leading edge of an effort by Cedars-Sinai to develop the next generation of solutions for brain tumors, injuries and other neurological disorders right here at Cedars-Sinai's Maxine Dunitz Neurosurgical Institute by introducing paradigm-shifting technologies into the field."

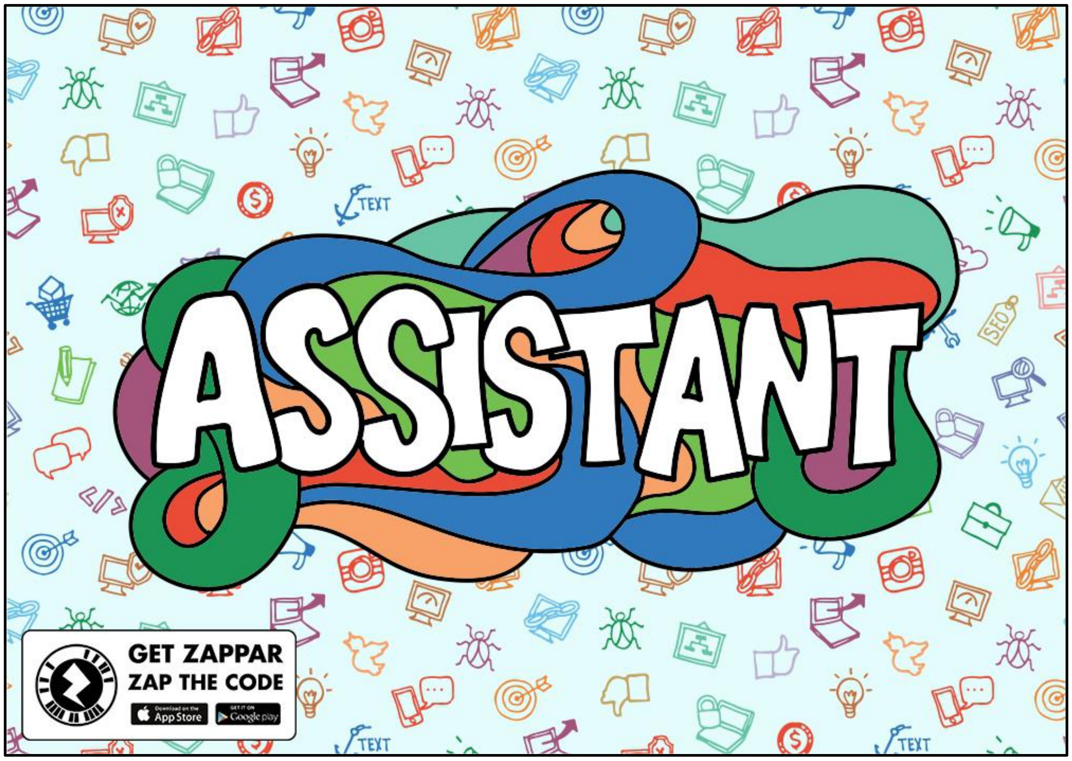
In the clinical trial, the highly sensitive camera is placed near the surgical field, recording images as the neurosurgeon exposes and removes the tumor. Images are not used in decision-making or surgical technique but later are correlated with tumor **appearance**, laboratory findings, and MRI and CT scans to assess the ultraviolet technology's value in the operating room.

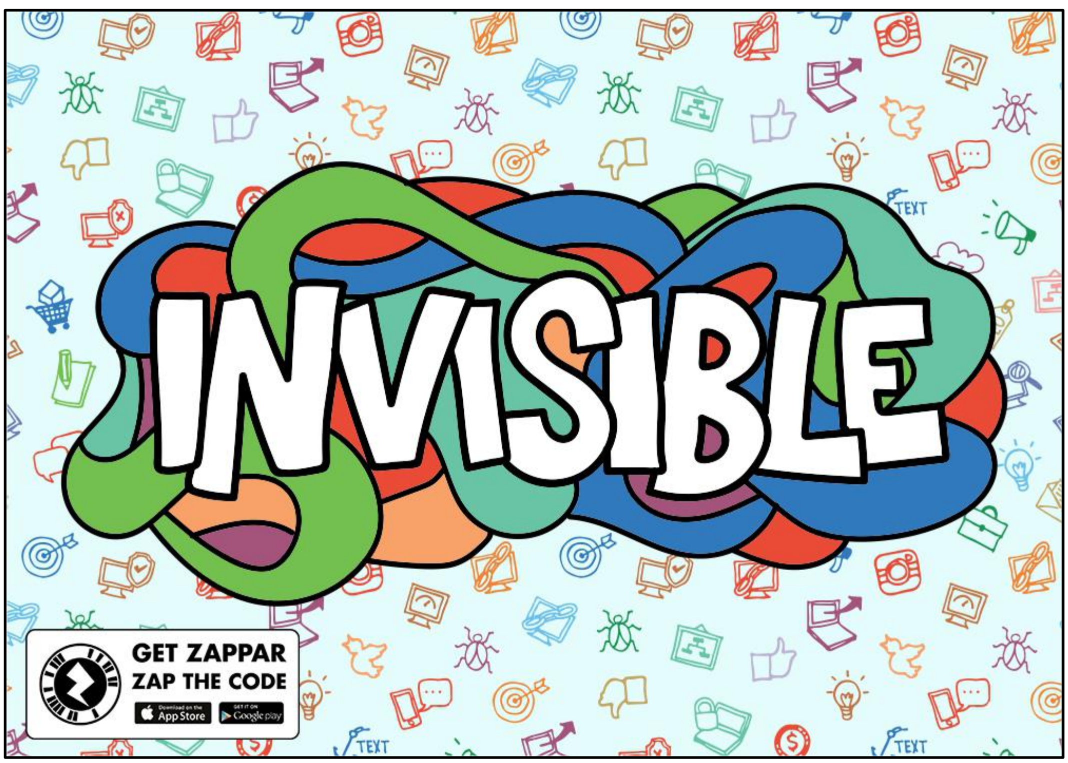
John S. Yu, MD, vice chair of the Department of Neurosurgery, and Adam N. Mamelak, MD, neurosurgeon and co-director of Cedars-Sinai's Pituitary Center, also are participating in the study.

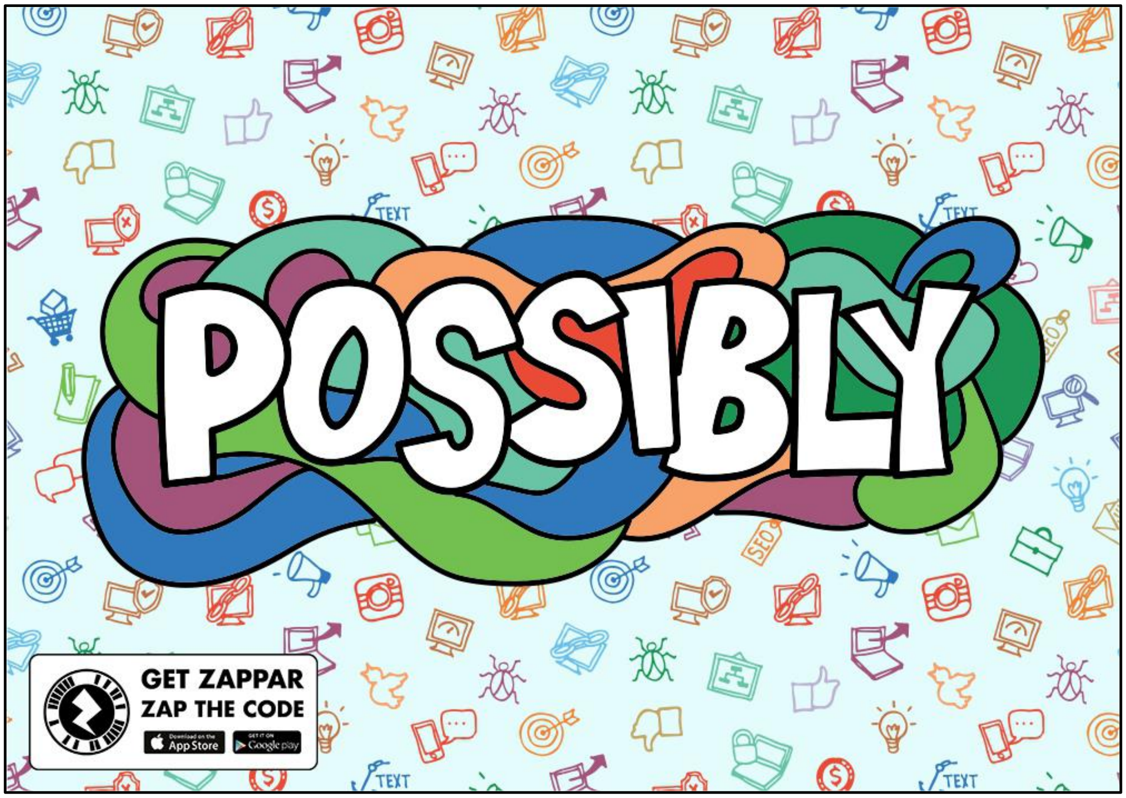
The ultraviolet imaging study, which will include 20 patients, is open to adults undergoing open-skull surgery **treatment** for any brain tumor that is within range of the camera lens. Enrollment information is available by contacting Suzane Brian, study research **assistant**, in the Department of Neurosurgery.

Adapted from:
https://www.sciencedaily.com/releases/2012/07/120712092234.htm

12 AR-mediated vocabulary flashcards



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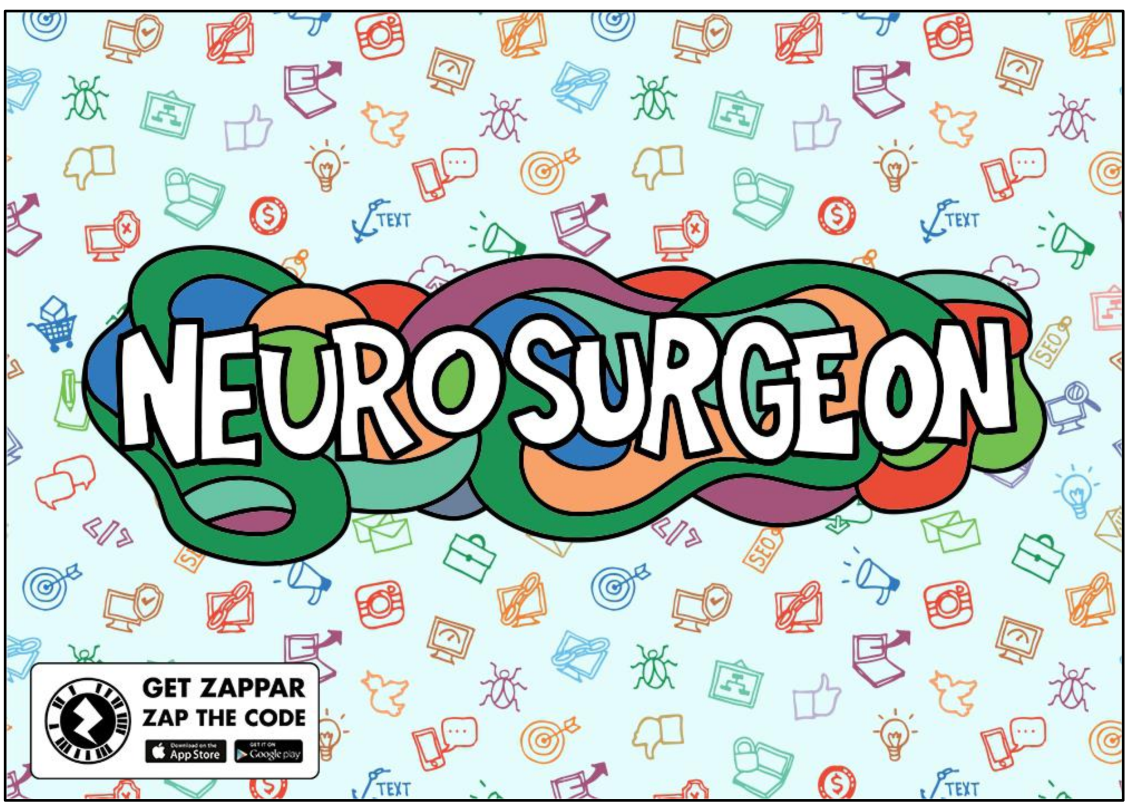
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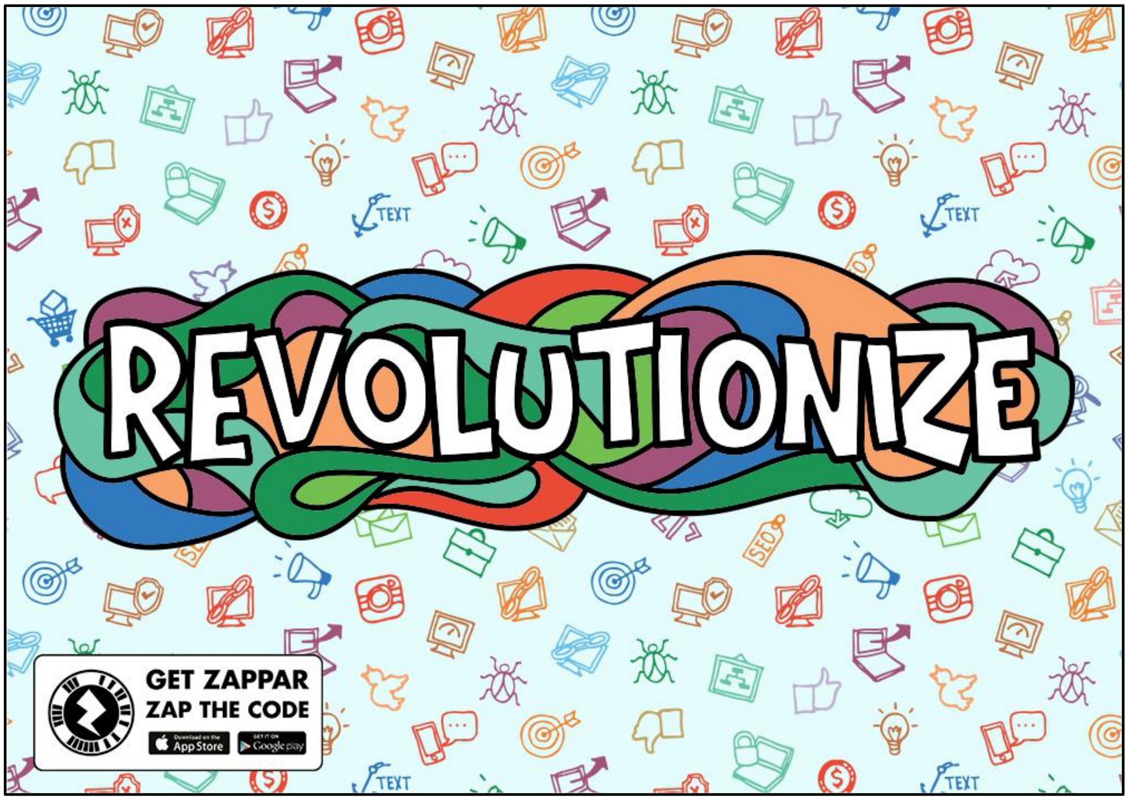
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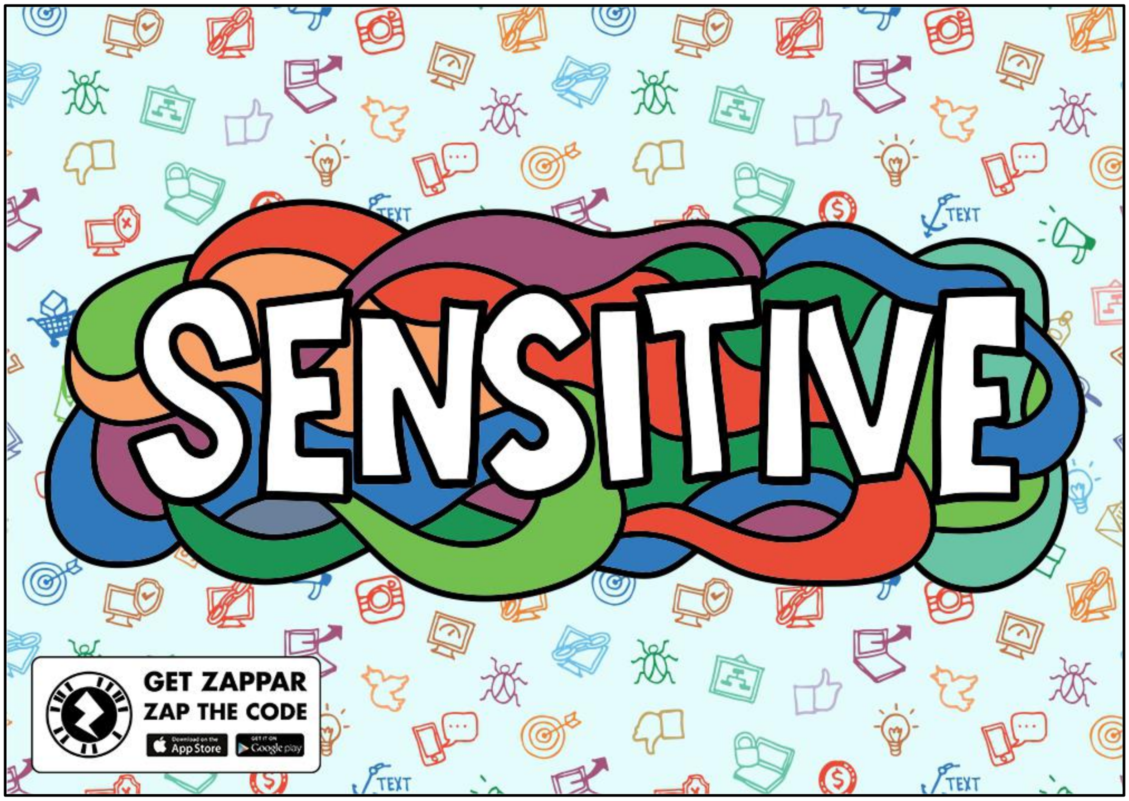
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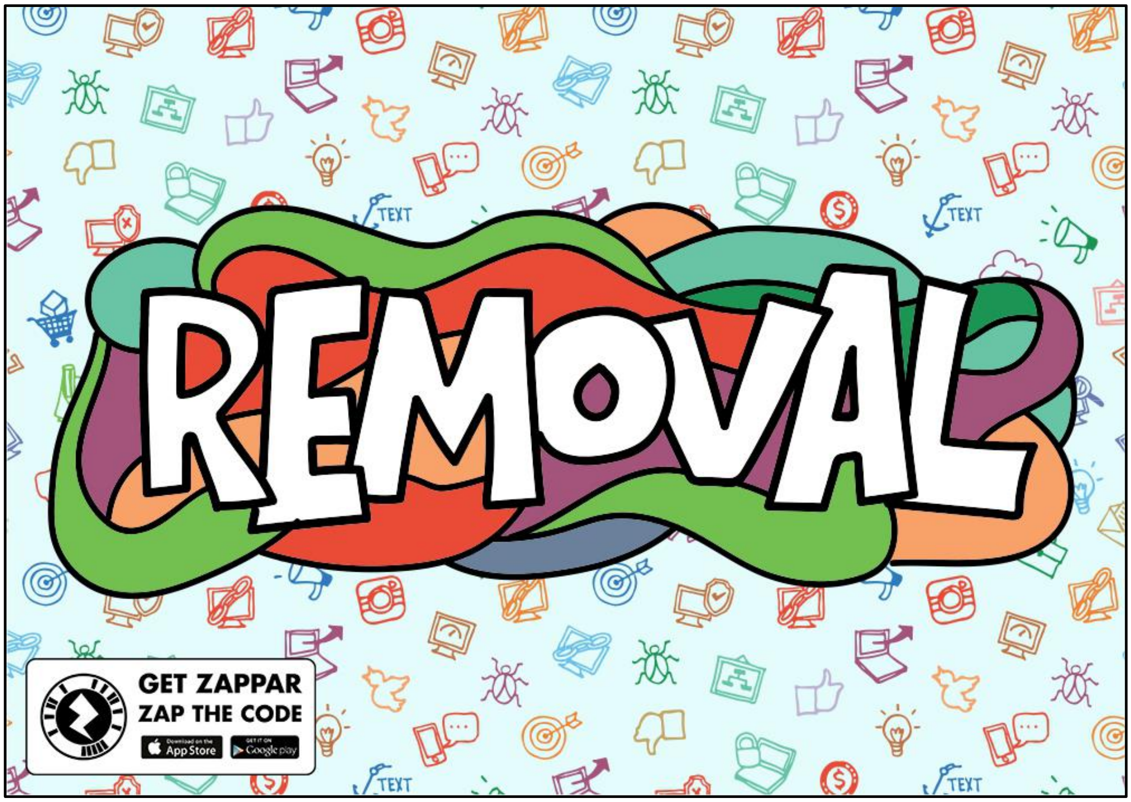
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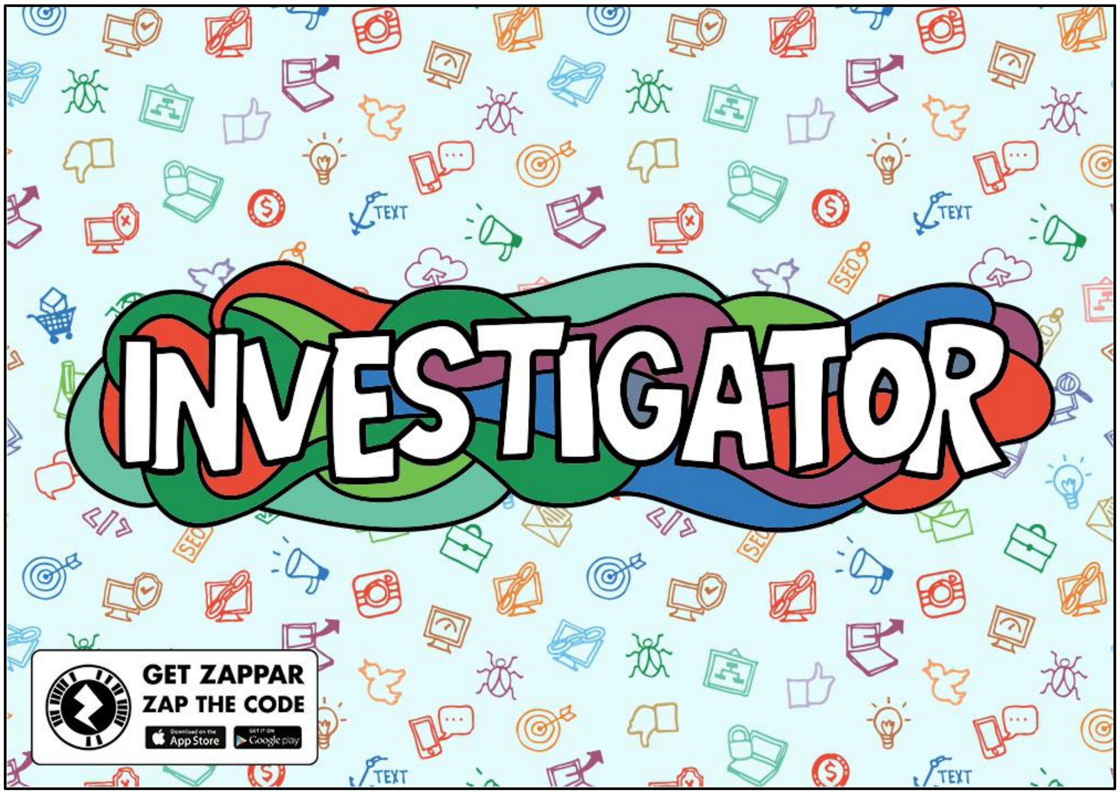
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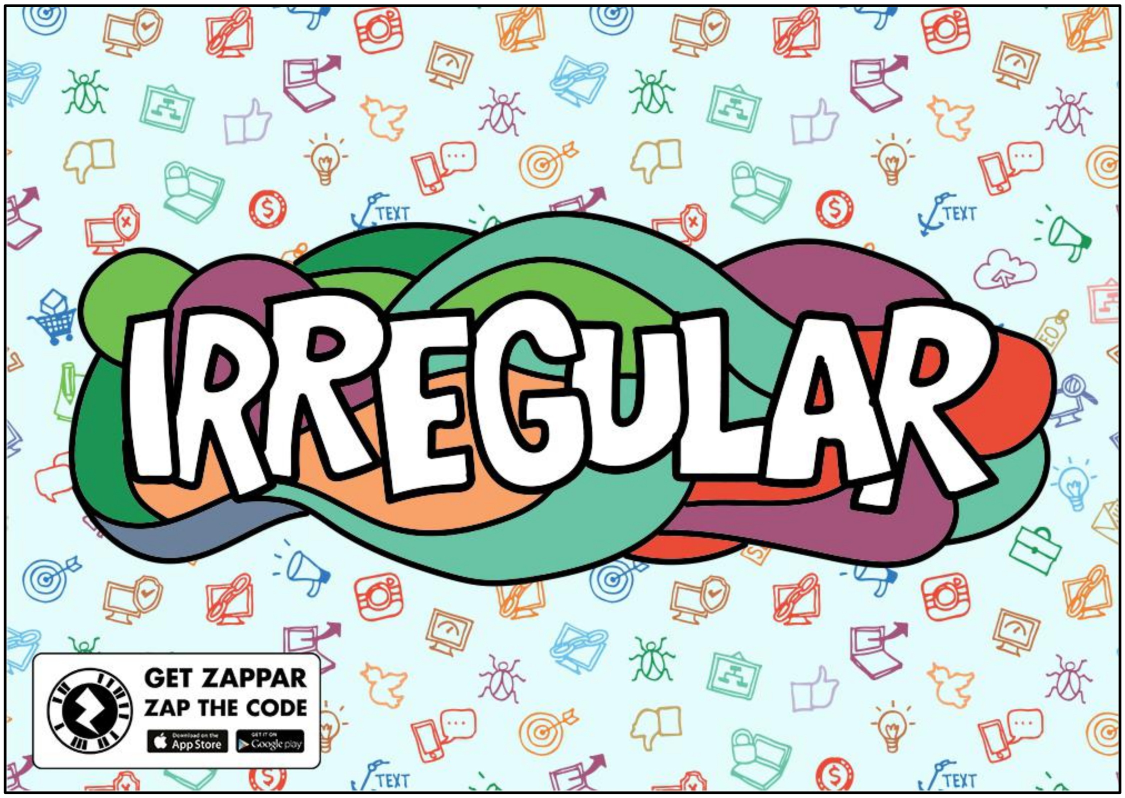
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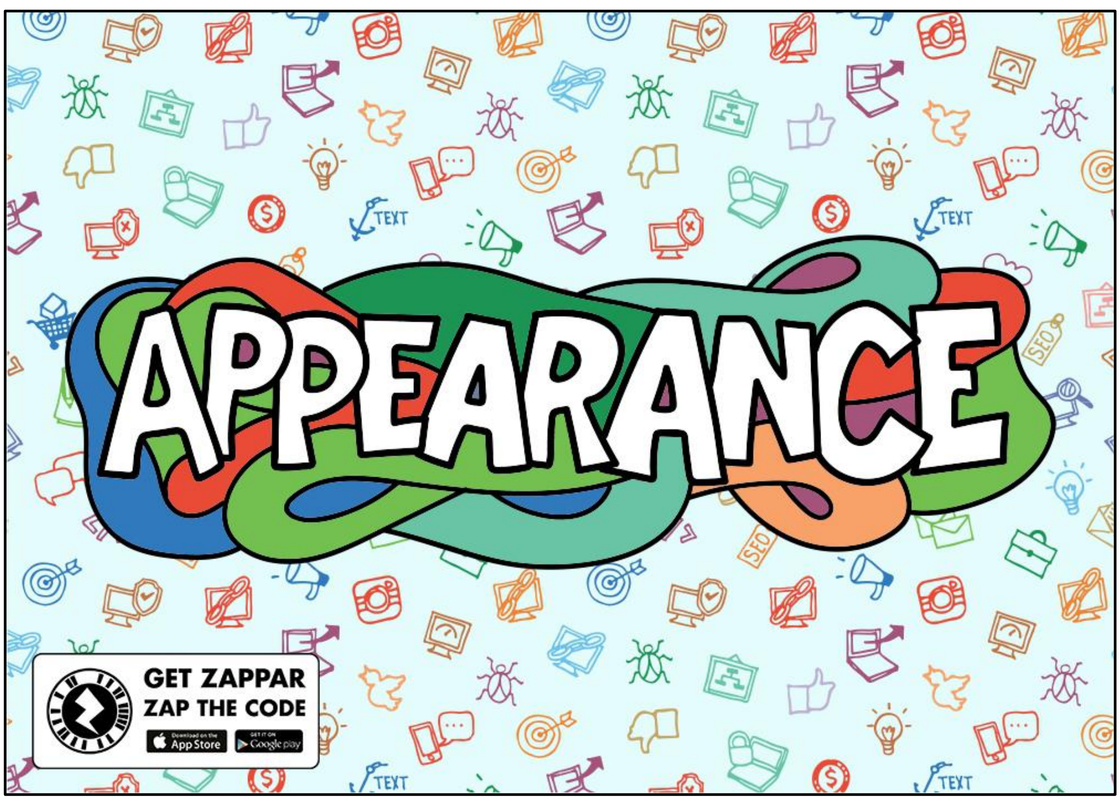
APPEARANCE
GET ZAPPAR
ZAP THE CODE
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