Chapter 23
An Investigation of the Effects of Individual Differences on Mobile-Based Augmented Reality English Vocabulary Learning

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Abstract Mobile devices are now widely owned and available to the majority of people. While the affordances of mobile learning include supporting a more personalized, authentic, situated learning based on the findings of many studies, it is crucial and urgent to start rethink pedagogy and learning using mobile devices. Additionally, as the concept of augmented reality (AR) enables learners to receive additional, valuable information in a real setting, this study, thus, aims to investigate the effects of a mobile-based augmented reality simulation learning system for English vocabulary acquisition on learners of different learning styles (field independence/dependence, FI/FD) and English proficiency (high/low) in terms of learning outcome and motivation. An experimental research design was used in this study to identify any differences between FI, FD students and high/low English proficiency learners. The results showed that FD learners benefitted significantly from the mobile AR instruction on learning outcome; there was a borderline significant difference between high and low English proficiency learners on learning outcome; and neither learning styles nor English proficiency affected learning motivation after the mobile AR instruction was applied. From the findings of the present study, individual differences should be considered when a new instructional approach is applied in order to make learning more effective and motivating.

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23.1 Introduction

English is significant when it comes to cross-cultural, international exchanges, ranging from political, business, scientific, communications, and academic issues (Chang 2011). Accordingly, learning English as a foreign language (EFL) has become a critical matter for both educators and learners. Vocabulary learning, in particular, has always played an important role in laying a solid foundation for the acquisition of a foreign language (Beck et al. 2002; Bormuth 1966; Davis 1944, 1968). As the basic building blocks of English sentences, vocabulary acquisition is necessary for second language (L2) learners to make correct inferences or to understand the content, or even to avoid being diagnosed as learning disabled (Gu 2003; Huang 2007; Nation 2001; August et al. 2005). Furthermore, as Wilkins (1972) noted, "without vocabulary nothing can be conveyed (p. 111)." Thus, constant, numerous researches into vocabulary learning for English as a foreign language have been conducted, showing a keen, urgent interest in finding out how words can best be learned.

Vocabulary learning is crucial for EFL learners to master English; however, both instructors and L2 learners are now encountering difficulties among English vocabulary learning. Aside from the problems of formal English education in Taiwan, such as lack of teaching hours, teacher shortage, and different required vocabulary size resulting in a huge gap between learners' English proficiency (Chang 2011), Barab (2002) stated the main problems in traditional schooling practices are that information becomes decontextualized, knowledge appears to be more indirect, abstract, and experiences are second-handed confined in classroom context. That is, instructions tend to be more fragmented, teacher-centered and irrelevant to student's needs and interests (Cullen 1994). To be more specific, acquiring vocabulary from abstract, textual definitions from a dictionary results in problems when using language in real situations (Brown et al. 1989).

Learners' individual differences also play an essential role in the effectiveness of learning. For example, Oxford and Anderson (1995) suggests that there is a need for language instructors to understand students' learning style to achieve optimal language progress. Furthermore, in the field of learning styles, field independence/dependence (FI/D), in particular, has been considered potentially important in second language acquisition (Chapelle and Green 1992). In addition to learning styles, learners' initial English proficiency may also make a difference in terms of learning outcome. However, previous studies that treated learners' English proficiency as an independent variable were mostly about their usage of learning strategies rather than the effect of a particular instructional method (Su 2005; Lai 2009).

The effects of individual differences, such as learning style, prior knowledge, and competencies, are also widely investigated in technology-supported learning, as the aid of technology in educational settings enables learning to be personalized and creates learning environments that support learners' diversity and individual needs (Chen and Tsai 2012; Wade and Ashman 2007; Kraus et al. 2001); however, the

results whether individual differences affect learning outcome with an technology-enhanced instruction are unclear.

It is also noticeable that there has been a gradual shift of learning approach from behaviorist to contextualized, situated approaches (Chuo 2004). Situated learning theory, proposed by Lave and Wenger in the 1990s, posits that knowledge should be constructed in an authentic context and that learning requires social interaction and collaboration (1990). As technology advances, augmented reality (AR) incorporating with the use of mobile devices then provides a solution to support situated learning theory, since AR has the affordances of the real world setting by offering additional and contextual information to support learning, blending learner's learning environment into their real-life contexts (Squire and Klopfer 2007). That is, with mobile devices, wireless connection and location-based technology, a mobile AR learning system then enables and enhances learning by making it ubiquitous, collaborative, personalized, and situated while at the same time bridging formal and informal learning (Wu et al. 2013).

23.2 Literature Review

23.2.1 English Vocabulary Learning

Vocabulary learning is a primary, endless, and indispensable task for English learners (Schmitt 2008). When it comes to the acquisition of L2 vocabulary, Nation (2001) categorized the methods of learning and teaching high frequency words as four main approaches, "direct teaching," "direct learning," "incidental learning," and "planned encounters." To be more specific, "high frequency words" with a commonly agreed coverage of 2,000 English words, refer to vocabulary other than that of academic, technical, and low-frequency words (Nation 2001). As for the learning strategies which learners use to acquire vocabulary, Gu and Johnson (1996) listed six major strategies commonly employed by EFL learners–guessing, dictionary, note-taking, rehearsal, encoding, and activation strategies.

Among the abovementioned four ways of learning/teaching high-frequency words and six vocabulary learning strategies, incidental learning, or the "guessing strategies," which means to guess word meanings from context, has been acknowledged to result in vocabulary growth (Krashen 1989). However, drawbacks of incidental vocabulary learning are also addressed. According to Hunt and Beglar (2002), guessing strategies may only be more beneficial to learners of higher proficiency and it may also be time-consuming. Furthermore, there are risks that learner take wrong guesses or make incorrect inference resulted from the ambiguous information presented in contexts (Shahrokni 2009; Yoshii and Flaitz 2002).

Aside from the drawbacks such as wrong guessing and incorrect inferences, there is a certain degree of difficulty to practice incidental vocabulary learning,

since many learners do not have the environment that are needed for this kind of learning to happen (Nation 2001). And while incidental vocabulary learning is often regarded as opposed to the direct intentional learning and teaching, Nation (2001) proposed that the two should be complementary activities, enhancing each other simultaneously, and that a well-designed language learning program should have a proper balance between meaning-focused activities (e.g., incidental learning through reading and speaking activities) and language-focused activities (e.g., the direct study of language items).

As for "dictionary strategies," Brown et al. (1989) pointed out that dictionary-based learning might result in problems when learners try to use the language in real situations. Barab (2002) also argued that the main problems while practicing traditional teaching methods are that information becomes decontextualized, knowledge becomes more indirect, abstract, and experience are second-handed confined in classroom context. Thus, the present study proposed a learning system that aimed to realize the idea of "recognizing a word automatically in natural contexts" (Gu and Johnson 1996, p. 660) by enabling learners to learn in a physical context, which is the actual environment, while at the same time, also providing learners with glosses (i.e., the direct study of language items) through the aid of augmented reality technology.

When it comes to learning styles, there is no one universally acknowledged definition. Keefe (1979, p. 4) described learning styles as "cognitive, affective, and physiological traits that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (as cited in Park et al. 2006)." It is necessary for language instructors to understand how students perceive and approach learning tasks, that is, students' distinct learning styles, in order to achieve optimal language learning progress (Oxford and Anderson 1995). Among different classifications of learning styles, field independence/dependence (FI/D) in particular, has been extensively investigated and acknowledged to be potentially important in second language acquisition (Alptekin and Atakan 1990; Chapelle and Green 1992; Wyss 2002; Dörnyei and Skehan 2003). Nonetheless, the results of the empirical studies motivated by the FI/D conducted in the field of second language acquisition showed that the correlation between FI/D and language learning achievement is usually low, and that the FI/D interpretation is simply a measure of intelligence in disguise, which in turn means FI stylists are often the ones showing significant positive correlations (Dörnyei and Skehan 2003).

Regardless of the criticisms, Chapelle and Green (1992) provided a powerful defense that knowing learners' FI/D is still significant to offer a better L2 learning experience, since the measure of FI/D of previous studies only tackles one of the three major constructs, the "cognitive restructuring skills," and ignoring the two other components, "interpersonal competencies" and "reliance on internal versus external referents" (Witkin and Goodenough 1981, p. 54).

The success of second language acquisition is associated with both ends of the FI/D continuum. For instance, FI learners are claimed to be more intense in focusing "on the language stimuli relevant to the language learning task at hand" (Naiman et al. 1978, p. 30) and thus excel in classroom learning which involves

analysis, attention to details and mastering in exercises such as being better at tracking grammatical correctness, acquiring linguistic rules, and scoring better on classroom-oriented language tests like cloze test (Chapelle and Green 1992; Wyss 2002). In terms of the personality dimension, Seliger (1977) and Day (1984) denoted that FI learners tend to be the more confident language learners as they depend more on internal reference, and thus may speak out actively and take risks in class. As for FD learners, Chapelle and Roberts (1986) and Brown (1987) suggested that the preference for social interaction of field dependents assists them to acquire language through contextualized practice with native speakers. That is, according to Wyss (2002), FD learners tend to achieve a higher degree of success in everyday language situations beyond the constraints of the classroom, and tackle problems by utilizing interpersonal communication skills. The theory of FI/D, as described by Witkin, is "an ever-changing framework, continuously incorporating new discoveries and new insights about the nature of the dimension" (Goodenough 1986, p. 6).

There are several differences between learners of different English proficiency levels when it comes to English learning. For example, students with higher English proficiency are generally more confident, and hold relatively positive language learning beliefs in language acquisition, while learners of lower English proficiency show passive attitudes, shyness and fear due to students' smaller vocabulary size (Hong-Nam and Leavell 2006; Huang and Tsai 2003). Studies have found that explicitly teaching English vocabulary, in other words, direct teaching benefitted both high and low English proficiency learners (Huang and Tsai 2003; Carlo et al. 2004). Furthermore, to reach a prevalent success in both high and low English proficiency learners, August et al. (2005) suggested that vocabulary definitions and contextual information should be provided and actively involving students through student-directed activity would help reach the goal. Moreover, learners of higher English proficiency tend to use a greater amount of vocabulary learning strategies and they prefer to learn vocabulary in its natural contexts (O'Malley et al. 1985; Gu and Johnson 1996; Lai 2009; Su 2005). Accordingly, the present study, based on situated learning theory, aims at investigating how FI/FD learners differ in learning performance and motivation when vocabulary is acquired in a real setting.

23.2.2   Situated Learning

Situated learning theory, or situated cognition, which has a significant impact on educational thinking, was first proposed by Brown et al. in 1989, asserting that knowledge is constructed in an authentic context requiring social interaction and collaboration and that learning is the outcome of interactions among the people, places, objects, processes, and culture within the given context (Brown et al. 1989; Lave and Wenger 1990). Implementing these ideas in instructional design can cause difficulties as the model of situated learning continue to evolve and develop with new research and technology. In order to incorporate new technology into situated

instructional design, it is necessary to pay careful attention to some of the critical characteristics, such as providing authentic context that reflects the way knowledge would be used in reality, providing authentic activities, access to expert performances, multiple roles, perspectives, supporting collaborative construction of knowledge, and so on (Herrington and Oliver 1995).

Augmented reality, AR, refers to the concept to augment virtual information to the reality. Azuma (1997) defined AR to be able to reveal the three following features: a combination of real and virtual world, real-time interaction, and accurate 3D registration of virtual and real objects. As for the implementation of AR, varied technologies can be used, such as PC, handheld devices, head-mounted computers, and so on. According to Squire and Klopfer (2007), AR has the affordances of the real-world setting by offering additional and contextual information to support situated learning.

A number of empirical studies have implemented AR in educational settings and have been proved to enable situated learning. However, most of the proposed AR-facilitated learning systems to date are developed for science and mathematics education, because learning such subjects require visualization of abstract concepts (Wu et al. 2013). Still, there are a few learning systems that incorporated AR or other contextual technology (e.g., mobile technology, RFID, GPS) to support situated learning for other disciplines like language education. The following are three empirical studies of context-aware learning applied specifically in vocabulary acquisition (Wong and Looi 2010; Chen and Li 2010; Ogata and Yano 2004). Wong and Looi (2010) conducted a learner-created, design-oriented, mobile-assisted language learning (MALL) study that required primary students to take photos outside the classroom using mobile devices to demonstrate their knowledge of English prepositions (in, on, over, under, in front, and behind), and were subsequently asked to share, describe their photos in the classroom to illustrate the spatial relationship of the prepositions by making sentences. The researchers discovered that students were excited, engaged, and became "active knowledge builders" rather than passively receiving knowledge in a formal learning setting during the activities (Wong and Looi 2010). According to the teachers, the photo-taking and sentence-making activity helped students to "internalize and enhance the ability to apply the prepositions" with the aid of mobile technology that made learning seamless and thus bridging the gap between formal and informal learning (Wong and Looi 2010). Chen and Li (2010) proposed the idea that 'context' is an essential factor in vocabulary learning which also enhances learners' learning interest and efficiency, and thus came up with an English vocabulary learning system called PCULS (personalized context-aware ubiquitous learning system) that personalizes learning by sending learners location-based English vocabulary through positioning techniques. The results indicated that incorporating context-awareness into the learning system increases learning performance. One of the studies conducted by Ogata and Yano (2004) used a system called TANGO (Tag Added learNinG Objects) that enables learners to acquire vocabulary through authentic objects in the environment with their mobile devices and with the aid of RFID (radio frequency identification) technology. Learners were asked to complete

tasks assigned by the system through scanning the RFID tag attached to a specific object, and they reported that relating vocabulary to authentic objects helps them understand the words with greater ease, interest, and engagement. The significance of Ogata and Yano's study lies in its corporation of context-awareness and self-pacedness into vocabulary learning.

23.2.3 The Present Study

Based on the theoretical foundation of situated learning, the present study proposes a learning system that incorporates the technology of augmented reality into English vocabulary learning with the use of mobile devices, enabling learners to acquire vocabulary in an authentic context by actually seeing and interacting with the environment. Learning motivation and learning outcome will then be measured and analyzed to find out whether there is a difference between FI and FD learners. This study aims to describe early research into augmented reality-based mobile learning that attempts to assess its effect on students of different learning styles' learning outcome and perceived motivation in English vocabulary learning of elementary students, by enabling students to actually see, touch and interact with the "vocabulary" in a real setting. The research objective of this study is to investigate whether there is a difference among learning motivation and learning outcome of students of different learning styles exposed to a mobile-based AR simulations learning system proposed in this study. Accordingly, the three primary research questions are:

RQ1 Is there a significant difference between FD and FI learners in the mobile augmented reality-supported English vocabulary instruction?
RQ2 Is there a significant difference between FD and FI learners in learning motivation while the mobile augmented reality instruction was applied?
RQ3 Is there a significant difference between learners of high and low English proficiency levels in the mobile augmented reality-supported English vocabulary instruction?
RQ4 Is there a significant difference between learners of high and low English proficiency levels in learning motivation while the mobile augmented reality instruction was applied?

23.3 Methods

This study employed a quasi-experimental design, a pretest–posttest design, to examine the difference in learning motivation and outcome of participants of two different learning styles (field independence/dependence) and two English proficiency levels (high/low). Before the experiment, a pilot test was conducted to discover problems before the main experiment and thus to ensure the validity of the experimental design. Then, all the participants would take the Group Embedded

Figures Test to distinguish field independent and field dependent learners, followed by a pretest on English vocabulary. After the pretest, participants would then use mobile devices to learn vocabulary in a real setting, which would be their classroom. Finally, they were then given questionnaires and vocabulary tests to measure their learning motivation and learning outcome, respectively. A semi-structured student interviews were also conducted at the end of the experiment in order to provide an in-depth understanding of the lived experience of the third graders regarding their opinions and learning attitude toward the usage of the proposed learning system.

23.3.1 Participants

In order to align the learning system with the existing curriculum guidelines, the participants in this study were 52 third-grade students, from two different classes, class 303 and class 308, at an elementary school in XiZhi District, New Taipei City. Students from both classes used the mobile-based AR simulations learning system in a real setting. As for the participants in the pilot test, a total of 26 third-grade students from the same elementary school were assigned using a convenience sampling method. These students, aged between 9 and 10 year-old have at least received 2 years of formal English education at school for 80–120 min a week. As for the usage of mobile devices, 84 % of the students have the experience of using mobile devices, such as tablets and smartphones or iPods; while 44 % possess their own mobile devices; and 44 % of the participants indicate that they have used mobile devices as learning tools. In brief, from the survey, it can be concluded that participants are fairly familiar with mobile devices to a certain degree, and would not have encountered major problems in terms of operation.

23.3.2 Mobile-Based AR Simulations Learning System Overview

The mobile-based AR simulations learning system requires learners to collaborate with teammates to complete the assigned task using an augmented reality platform called *Aurasma*, a free mobile application enabling users to generate their own augmented reality content and is available for both iPhones and Android phones. With wireless Internet connection and the built-in video camera on, additional information in the form of images, videos, animations, and audio can be shown on users' screen when recognizing the objects one wishes to augment more information to, see Fig. 23.1 for a demonstration of this concept. When participants turn on the *Aurasma* application with their tablets, SAMSUNG Note 2, and found the assigned items in the classroom, relevant digital content would appear on their screen, showing the English word, Chinese equivalent, and English pronunciation, which was previously recorded by a native English speaker who is also a professional EFL teacher.

Fig. 23.1 User screen

23.3.3 Procedure

Before the activity using the proposed mobile AR English vocabulary learning system, students were given pretests on their prior knowledge, namely, their English vocabulary knowledge, see Fig. 23.2. Group Embedded Figures Test (GEFT) was also administrated to all 52 participants to research into their learning styles, field dependence or field independence. An instruction on how the test works was given before participants took it, as shown in Fig. 23.3, depicting one of the participants demonstrating how to locate a simple geometric shape embedded in a more complex one. The activity began with the anticipatory set, where students were asked if they had hands-on experience of using a particular item in a classroom, and to contribute to a discussion about their personal experiences and knowledge of a classroom vocabulary, which they had showed great interest in sharing their own thoughts (as depicted in Fig. 23.3), since the topic was closely related to every student's daily life.

After a pre-information and instruction of the activity explaining what they need to do in the classroom, students were randomly divided into nine sub groups with three members in one group, given a mobile device, and began with the activity. In the classroom, they were assigned to a task: First, they were given a clue for the first item. Second, when they successfully found out the first item, additional

Fig. 23.2 Participants taking pretests on English vocabulary (on the *left*) and a participant demonstrating how GEFT works (on the *right*)

Fig. 23.3 Students actively participating

information of the item, the English vocabulary, Chinese equivalent, and audio pronunciation would appear on their screen when scanning the right item. Then, they had to return to the control center to show the screenshot proving they had successfully discovered the assigned item and utter the Chinese and English pronunciation of the vocabulary to get the next clue. In order to accomplish the task, participants need to collect every required item. After all groups had finished the task, the group who spent the least time possible would be awarded.

To ensure grouping (i.e., the composition of group members) would not have an effect on students' learning outcome, learners were asked to take turns using the tablets to eliminate possible confounding factors caused by grouping. Finally, after the activity, they were asked to answer questions on the motivation questionnaire and English vocabulary posttest to gauge their learning outcome

23.3.4 Variables and Instruments

Two independent and two dependent variables were examined in this study, which are learning styles (FI/FD), English proficiency level, learning outcome, and learning motivation, respectively. As for the two independent variables, learning styles and English proficiency levels, students' previous English (midterm and final) exam scores were used to indicate their proficiency in English, dividing them into two groups: high English proficiency (top 27 % among 52 students) and low English proficiency (lowest 27 %); while the Group Embedded Figures Test (GEFT) was used to measure their learning style, field dependence/independence. As for the two dependent variables, learning outcome and learning motivation, to investigate participants' learning outcome, an English vocabulary pre and posttests were used; while a motivation survey was conducted to measure the learning motivation.

The Group Embedded Figures Test (GEFT), developed by Witkin and his associates in 1971, is one of the most widely used measures of field independence/dependence (FI/D), especially in second language acquisition research (Khatib and Hosseinpur 2011). The test requires subjects to locate and trace simple geometric figures embedded in a more complex figure. For example, the participants are asked to identify the simple figure labeled "x," see Fig. 23.4 (Witkin et al. 1971), from a more complex one below, and outline the shape out of it.

The Group Embedded Figures Test used in this study, based on Witkin et al. (1971), was a modified, Chinese version with Mandarin phonetic symbols, zhuyin, to ensure the third-grade participants could fully comprehend the instructions on the test paper. Several geometric figures were also re-illustrated due to some of its undistinguishable features. The test consists of three sections/pages: the first page comprising seven simpler geometric questions serves as a warm-up exercise for students to get familiarize with the test; while the second and third part containing nine questions each with more complex figures are the part where students are given a limited time and get scored to determined whether they are FI or FD stylist.

In general, FI/D is determined by the numbers of the correct answers given by the test takers. That is, those who scored higher are labeled as FI, while those who score lower are branded as FD learning stylists. There are two common ways of

Fig. 23.4 An example of the inquiries in the GEFT (Adapted from "A Manual of Embedded Figures Tests," by Witkin et al. 1971)
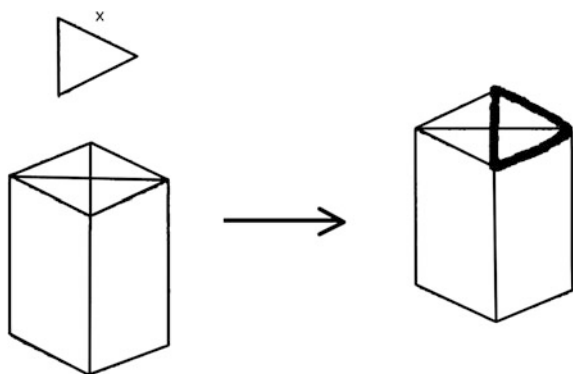
determining FD and FI learners. The first method assumes learners who score above the median of the overall scores as FI learners, while those below as FD learners. The second method labels the upper 25 % of the subject as FI learners, while the lower 25 % as FD learners.

Taking the present study's relatively smaller sample size into account, the first method was adopted to determine FI and FD learners. In the present study, a total number of 52 students were examined. The median score was four, and those who scored four and below were categorized as FD learners, consisted of 30 persons; while students who scored above four were deemed to be FI learners, consisted of 22 persons.

The questionnaire (see Appendix A) used in the present study to measure learning motivation was adapted from Liu and Chu (2010), which the two researchers aimed to investigate if their proposed ubiquitous English instructional approach would affect learning outcome and motivation, a research topic similar to the present study. That is, both studies probed into the impact of a more innovative, mobile, context-aware instructional approach on learning outcome and motivation, and particularly in the field of English as foreign language learning. Thus, this motivation scale is best suited for this study since the two studies shared similar learning method, learning topic and variables.

The motivation questionnaire developed by Liu and Chu (2010) applied Keller's attention, relevance, confidence and satisfaction (ARCS) motivation model, which is a model well used in student-centric instructional tasks (Keller 1987; Keller and Suzuki 2004). The core values of this motivation model were also practiced in the design of the proposed mobile AR instruction. That is, with an eye to building an effective learning environment with interesting activities, the present study aimed at stimulating students' visual and auditory senses to draw their *attention*, providing opportunities for self-learning, and cooperation with teammates at the same time. As the proposed mobile AR instruction was designed to be closely related to students' daily life, such as "items one encounters in a classroom," students could also be able to find *relevance* when they were involved in this learning activity. What is more, the activity offered students opportunities to accomplish challenging tasks, and thus providing the possibility of building self-*confidence* and gaining a sense of *satisfaction* afterwards.

The motivation questionnaire used in the present study was composed of 16 questions in total, 4 questions for each dimension, *attention*, *relevance*, *confidence,* and *satisfaction.* The level of motivation will be indicated on a five-point Likert scale from (1) strongly disagree, to (5) strongly agree. English vocabulary tests for the pre and posttests used to examine students after the experiment were designed with a focus on word recognition. In the first section, students were asked to match the English vocabulary and the pictures of that item. For the second section, students had to match the English vocabulary with its Chinese equivalents. The target words of this learning activity were selected from the basic 2000 English word list at elementary school level, issued by Taiwan's Ministry of Education. The English vocabulary pre and posttests were also validated in advance by three experts in related field, mobile-assisted learning and EFL education.

At the end of the experiment, semi-structured interviews with the students were conducted in order to gain in-depth understanding of the participants' live experience in using the proposed mobile AR vocabulary learning system. The interviews contained a predetermined set of questions as follows:

- Do you think the method of English learning employed in this course is interesting? Why or Why not?
- Do you think the method of English learning employed in this course is attractive? Why or Why not?
- Do you think the method of English learning employed in this course is useful? Why or Why not?
- Do you think this course improved your confidence in learning English? Why or Why not?
- Are you satisfied with your English learning achievement? Why or Why not?

23.3.5 Data Analysis

The overall performance, students' English vocabulary test scores, and scores of the questionnaire used to measure learning motivation were collected and analyzed using ANCOVA and independent *t*-test to identify any significant differences between learners of the two different learning styles, FI/FD, and those of high/low English proficiency levels. Pre and posttest designs are widely adopted and considered well suited to investigate the effects of educational innovations. ANCOVA on posttest and pretest as a covariance is a more appropriate and informative analysis (Dugard and Todman 1995).

As for the qualitative data, all interviews were audio-taped and transcribed by the researcher and analyzed with the procedure by first organize the data, generate categories, themes, and patterns; search for alternative explanation for the data, and write the report, as proposed by Marshall and Rossman (1989). Five interviewees from three different classes were chosen and coded according to the class they belong; capital letters, A, B, C for the class code, and the numeric numbers, 1–5 representing their identity.

23.4 Results

23.4.1 Research Question 1

To investigate whether there is a significant difference in the improvement of scores between students of Field Dependence and Field Independence on learning outcome while the proposed mobile AR instruction was applied, analysis of covariance

(ANCOVA) was conducted to analyze the data. The descriptive statistics of FI and FD learners' performance are showed in Table 23.1.

Before ANCOVA, the first step is to analyze the homogeneity of regression coefficients. The result, $F = 0.464$, $p = 0.499 > 0.05$, does not reach the significant level, thus meaning the regression slope of FI and FD groups is equivalent. This result confirms the assumption of homogeneity of regression coefficients; ANCOVA could then be further executed. The ANCOVA evaluation results of FI and FD learners' learning outcome are presented in Table 23.2. The results, $F = 10.010$, $p = 0.003 < 0.005$, indicate that learning styles, FI and FD, do make a difference when students received the proposed mobile AR instruction.

Table 23.3 displayed the estimated posttest score after removing the effect of covariance, showing FD learners' posttest scores (9.602) higher than that of FI learners (8.543). Thus, it can be concluded that FD learners benefitted more than FI learners while a mobile augmented reality English vocabulary learning approach was applied.

23.4.2 Research Question 2

To examine whether there is a statistical difference in learning motivation between FI and FD learners, independent samples t-test was conducted. The mean and SD of FI were 70.68 and 13.40, respectively; the mean and SD of FD were 68.80 and 6.91, respectively. The t-test results further showed that there is no statistical difference, $p = 0.51$, in motivation between learners of two different learning styles.

Table 23.1 Descriptive statistics of FI and FD's learning outcome

Learning styles	Mean		Std. deviation		N
	Pretest	Posttest	Pretest	Posttest	
FI	7.68	8.86	3.153	1.457	22
FD	5.41	9.50	3.232	1.102	30

Table 23.2 ANCOVA evaluation results

Source	SS	df	MS	F	p
Styles (FI/FD)	12.732	1	12.732	10.010	0.003
Error	62.322	49	1.272		
Total	4456.000	52			

Table 23.3 The estimated score of FI and FD learners after adjusting the dependent effect with respect to the covariance

	Mean	SD	Lower bound	Upper bound
FI group ($N = 22$)	8.543	0.248	8.044	9.042
FD group ($N = 30$)	9.602	0.211	9.178	10.062

That is, learning motivation of both FI and FD learners is more or less similar after they received the proposed mobile AR English vocabulary instruction.

23.4.3 Research Question 3

To investigate whether there is a difference between students of different English proficiency levels after receiving the mobile AR English vocabulary instruction, students were first classified as two groups, higher English proficiency level and lower English proficiency level. Students whose average exam scores among the top 27 % ($N = 14$) were categorized as high English proficiency group; while the lowest 27 % ($N = 14$) were deemed as low English proficiency group. The descriptive statistics of the two groups' learning performance are showed in Table 23.4.

Before the ANCOVA test to explore whether English proficiency level has an impact on learners' learning outcome, the first step is to analyze the homogeneity of regression coefficients. The result, $F = 0.789$, $p = 0.383 > 0.05$, does not reach the significant level, thus meaning the regression slope of high English proficiency and low English proficiency groups is equivalent. In other words, this result confirms the assumption of homogeneity of coefficients; ANCOVA could then be further executed. The ANCOVA evaluation results of high and low English proficiency learners' learning outcome are presented in Table 23.5. The results, $F = 4.179$, $p = 0.052 > 0.005$, indicate there is no statistical difference in English proficiency in terms of learning outcome. However, the p value $= 0.052$ has reached the brink of significance. In other words, learners' prior English ability still made a difference in the effectiveness of learning when students received the proposed mobile AR instruction.

23.4.4 Research Question 4

To examine whether there is a statistical difference in learning motivation between high and low English proficiency learners, independent samples t-test was

Table 23.4 Descriptive statistics of high and low English proficiency learners' learning outcome

English proficiency	Mean		Std. deviation		N
	Pretest	Posttest	Pretest	Posttest	
High Eng. proficiency	9.36	9.93	1.393	0.267	14
Low Eng. proficiency	4.36	7.86	3.249	1.657	14

Table 23.5 ANCOVA test on high and low English proficiency learners' learning outcome

Source	SS	df	MS	F	p
Eng. Proficiency	5.425	1	5.425	4.179	0.052
Error	32.458	25	1.298		
Total	2281.000	28			

conducted. The mean and SD of High proficiency were 72.07 and 8.18, respectively; the mean and SD of low proficiency were 71.21 and 4.93, respectively. The results of the t-test further inferred that there is no statistical difference, $p = 0.74$, in motivation between learners of two different English proficiency levels. That is, learning motivation of both high and low English proficiency learners is more or less similar after they received the proposed mobile AR English vocabulary instruction.

23.4.5   Findings from the Interviews

The main focus of the qualitative part of the study centered on students' self-perceptions upon their experience in the mobile AR learning activity. The findings are presented in clusters that described the five third-grade students' self-reported perceptions of using mobile technologies in learning English vocabulary. Specifically, four categories emerged according to the elements the interviewees brought out, which are, *fun*, *effectiveness*, *confidence,* and *satisfaction*.

23.4.5.1   Fun

One of the main findings from the interviews was that all five interviewees found the learning method fun, interesting, special, and different from the way they used to acquire English vocabulary.

> I never knew English vocabulary could be learned this way, with tablets and with team-work. It's so different from how our teacher teaches us in the classroom. This activity impressed me a lot. (A1)
> Learning with tablets made everything so fun and exciting! (C4)

The idea of learning with tablets excites most of the third graders, giving them an impression of fun, untraditional, novel learning experience that they are willing to actively take part in.

23.4.5.2   Effectiveness

Effectiveness was what all five interviewees found in the instructional approach. According to the students, the learning activity enabled them to better memorize those vocabulary by actually seeing the object.

> Clearly seeing, touching, and feeling the actual objects enables me to memorize the words. Although there are pictures for the vocabulary in the textbook, you can't see the side or back of that object from a flat image. (C5)
> Seeing the real objects helps memorizing it. Helping teammates to pronounce the word when we check with the instructor to get the next clue also helps with my own learning. (B3)

> I can better memorize these words because they are important, needed, and widely seen in my daily life. (A2)
>
> Hearing the pronunciation of that word from the tablet helps me pronounce and memorize the word. (C4)

From interviewees' viewpoint, it can be concluded that seeing the authentic object in front of them, finding relevance in the vocabulary, helping teamwork by teaching them, and hearing the pronunciation enabled them to fully understand and retain the word.

23.4.5.3   Satisfaction

Interviews expressed the fun and effectiveness of such learning method satisfied them, because they find it interesting and useful. However, there were some technical problems that unsatisfied one of the interviewees:

> I encountered problem like failing to detect the object, problems with saving the screenshot and having the camera to focus. These made me upset because I really wanted to find all of the assigned items. (C5)

The technical problems need to be solved in order to provide learners with a more pleasant, effective learning experience.

23.4.5.4   Confidence

Interviewees gained confidence from knowing they could fully memorize the words:

> I felt confident when I knew I would not forget these words for a while. (A2)

Confidence may be derived from the abovementioned effectiveness and satisfaction of the learning activity. In other words, all four factors, *fun, effectiveness, satisfaction,* and *confidence* are all correlated. For example, *fun* of the activity motivated learners to give it a try; while trying, they found it to be an effective way of acquiring vocabulary. Satisfaction and confidence were then subsequently enhanced.

23.5   Conclusion

23.5.1   *Summary and Discussion of Major Findings*

The researcher first investigates the first independent variable, learning styles, examining whether there is a significant difference between FI and FD learners in learning outcome and learning motivation while the proposed mobile AR English

vocabulary instruction was applied. The second part of the results probes into the other independent variable, English proficiency, divided into two groups, high/low English proficiency levels, and examines whether learners' initial English proficiency has an impact on their learning outcome and learning motivation while the proposed mobile AR English vocabulary instruction was applied.

There was a significant difference in FI and FD's learning outcome. Both FI and FD learners improved greatly after the instruction. However, FD learners appear to benefit a lot more than FI learners when this mobile AR instruction was applied. The result showing FD learners benefitting more from the mobile AR instruction which allowed learners to learn in an authentic context is consistent with what Chapelle and Roberts (1986), Brown (1987) and Wyss (2002) suggested that FD learners tend to learn language through contextualized practice and achieve greater success beyond the constraints of traditional teaching method in the classroom. The results also debunked the claims that the significant positive correlations are always in favor of FI learners (Dörnyei and Skehan 2003). Instead, FD learners can be the significant positive correlations given an instructional approach that relates to their learning style.

The results showed that there was no significant difference between FI and FD learners in learning motivation after the learning activity. That is, it can be concluded that both FI and FD learners found this mobile AR learning activity to be motivating at a similar level, which proves the findings of Ogata and Yano (2004) that when vocabulary learning is associated with authentic objects and context, learning interest, and engagement are then increased.

There was a borderline significant difference in high and low English proficiency learners' learning outcome, showing high English proficiency benefits slightly more than low English proficiency learners while the mobile AR instruction was applied. In other words, students of high English proficiency did statistically outperform those who have lower initial English proficiency after removing the effect of covariance. However, low English proficiency learners showed significant improvement in scores after the proposed mobile AR instruction. It can be inferred that a learning method that incorporates context-awareness into daily life with the help of augmented reality and mobile devices may be an effective way for lower English proficiency learners to acquire L2 vocabulary, as it is more related to the learner, enabling learners to find relevance in learning and at the same time providing them with hands-on understanding of the vocabulary by actually seeing and feeling it. Aside from the possibility of high relevance and hands-on learning experience offered by the proposed learning method, learning motivation may be another critical key that leads to ideal learning performance, especially for those lower English proficiency learners, who have more difficulties finding motivation in a subject which they are already poor at. As one interviewee who has lower English proficiency learner suggested, being able to use tablets in learning enhanced his motivation in English learning, which he used to have no interest and confidence in, and in turn showing an improved learning result.

The results further showed that there was no significant difference between high and low English proficiency learners in learning motivation after the learning

activity. In other words, both high and low English proficiency learners share more or less the same perception concerning learning motivation, which echoes with the findings of August et al. (2005) that the use of technology in vocabulary learning can generally provide learners with incentives, and thus be motivated regardless of learners' individual differences.

23.5.2   Pedagogical Implications

This study aims to investigate whether individual differences, learning styles, and English proficiency make a difference when receiving the proposed mobile-facilitated augmented reality instruction for English vocabulary learning. The present study would like to shed light on the relations between individual difference and the mobile AR instruction. So the two main pedagogical implications of this study are as follow.

To begin with, teacher should fully recognize students' individual differences, such as their learning styles and prior knowledge. Learning styles can be easily revealed, in the present study, by taking a Group Embedded Figures Test that takes no longer than 20 minutes. After getting the information of students' learning styles, it is important to learn the difference of each learning style and come up with appropriate instructional methods. Students' prior knowledge should also be paid careful attention to, since students at different level may benefit from different instruction. From the results of the present study, students of lower achievement are more likely to benefit from an instructional approach that learners find related to and one that enhances motivation and confidence in learning; while FD learners on the other hand, may also perform outstandingly in a contextualized learning environment like this, rather than in the traditional classroom learning which involved more analysis, attention to details and mastering in exercises such as tracking grammatical correctness, acquiring linguistic rules, and taking classroom-oriented language tests like cloze tests.

Second, the idea of using mobile devices as a learning tool is fully appreciated by elementary school students, where they find enormous learning interest and motivation. As mobile devices usage and ownership have reached a new peak among students, there is great potential in mobile learning. With the help of technology such as augmented reality, learning can then take place everywhere, at any time, beyond the constraints of traditional classrooms. If mobile devices are well used in educational context, students' common belief that mobile devices are only for recreational purposes can be reversed. Instructors should also ponder how mobile learning can be taken advantages of inside the classroom and outside of the classroom, balancing formal and informal learning to the upmost.

In general, instructors should be aware of individual difference, come up with appropriate instruction that benefits students of different characters, and always welcome the idea of incorporating new concepts and technology into instruction.

23.5.3   Limitations of the Study and Suggestions for Future Research

Several limitations have been found in the process of the research, including small sample size, time constraint, limited teaching material, and constrained learning environment. Some suggestions for future studies are also brought out within the limitations.

First, limitations from this study mainly stem from its scope, which is the size and composition of the sample population, and lack of a control group, in particular. The present study involved only 52 third-grade students in elementary school. It would be inappropriate to generalize the results of the study and jump to a conclusion that the effectiveness of a mobile AR instruction applies to every student and that it successfully leads to students' improvement. There is a need for future empirical studies with a larger and more varied sample to clarify the present findings and investigate the relationship between individual differences and such learning approach. What is more, as this study applied random grouping arrangements, it is recommended that future studies look into the effects of different grouping methods, for example, heterogeneous or homogeneous, on the effectiveness of learning among different students.

Second, the time which the mobile AR instruction was carried out was not enough to ensure there is a steady improvement in English vocabulary acquisition. And when any technology is introduced in an educational context, there is always a problem with a novelty effect; implying students tend to get more motivated in the beginning as it is something new to them. However, as students get used to such innovative instruction, the novelty might wear off. Thus, it is recommended that future studies on education incorporated with new technology should include more longitudinal research to examine the effectiveness of learning and its relationship with individual differences.

Third, the target words in the present study consist of only ten vocabularies, which is about the amount students learn from one unit in their formal English classes. It would be more desirable if the number of target words increase. If so, the time for test and burden of the students should also be considered.

Fourth, learning was still constrained in a classroom setting due to practical matters and safety issues. Although the classroom setting counts as an authentic context, the effectiveness of learning English vocabulary outside of the classroom setting should also be investigated in future studies. As there is great potential in the present instructional approach to be utilized in self and informal learning, which learning mostly occurs outside of the classroom setting.

Appendix A: Motivation Questionnaire

學習動機的問卷

班級：＿＿＿＿＿＿　　座號：＿＿＿＿＿＿　　組別：＿＿＿＿＿＿

題號	注意力	非常同意	同意	普通	不同意	非常不同意
1	這個學習單字的方式能吸引我的注意力。					
2	螢幕上面並沒有出現太多東西，我可以抓住重點。					
3	這個學習活動很有趣。					
4	這個學習活動能引起我的好奇心。					
題號	關連	非常同意	同意	普通	不同意	非常不同意
5	這個活動中的內容值得學習。					
6	這個活動的學習內容跟我的日常生活有關。					
7	這個學習活動對我的英文學習有幫助。					
8	我可以將這次所學到的內容與我以前學到的東西做出連結。					
題號	信心	非常同意	同意	普通	不同意	非常不同意
9	活動進行的時候，我有信心可以學好這些內容。					
10	活動進行的時候，我可以自己控制學習的步調。					
11	活動進行的時候，我有把握自己可以通過等一下的測驗。					
12	這個學習單字的方式能夠增加我的學習自信。					
題號	滿足	非常同意	同意	普通	不同意	非常不同意
13	我很喜歡這種學英語單字的方式。					
14	這個活動結束後，我很有成就感。					
15	我很滿意我在這個活動中所學到的東西。					
16	這個活動結束後，我感到滿足。					

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