

The Effects of Using a Self-developed Mobile App on Vocabulary Learning and Retention among EFL Learners

Xingxing Ma*

Butsakorn Yodkamlue

School of Foreign Languages, Suranaree University of Technology

111 University Avenue, Nakhon Ratchasima 30000, Thailand

Email: maxxjxnu@163.com

Abstract

This study investigated the effects of a self-developed mobile app on Chinese university EFL learners' vocabulary learning and retention. Their perceptions of the mobile app were also explored. Data were collected using mixed methods. The results can be summarized as follow: firstly, the students using the mobile app could learn more words than those using the paper-based word list; secondly, the students in the experimental group could retain more words than those in the control group; thirdly, based on students' responses on both the questionnaire and the interview, most of them perceived the mobile app to be convenient and easy to use for vocabulary learning. Additionally, most of them believed that the mobile app was very useful and effective for their vocabulary learning and retention. Finally, all of them enjoyed using the mobile app to learn and remember EFL vocabulary.

Keywords: mobile app; English vocabulary learning; vocabulary retention; Chinese university EFL learners

Introduction

Vocabulary is important for language learning because language learners cannot understand others or express their ideas without vocabulary. Wilkins (1972) pointed out that “[w]hile without grammar very little can be conveyed, without vocabulary nothing can be conveyed” (pp.111-112). This viewpoint reflects the importance of vocabulary in language communication. Gass (1999) maintained that to learn a foreign language is to learn its vocabulary.

However, the fact that the English vocabulary level of Chinese university students is low can be found in many studies (e.g., Jiang, 2016; Luo, 2009; Wang, 2014; Wu, 2011). English as a foreign language (EFL) learners’ vocabulary learning through via a mobile system, i.e. Mobile-assisted Language Learning (MALL) has been investigated in many studies (e.g., Basoglu & Akdemir, 2010; Burston, 2015; Bensalem, 2018; Duman et al., 2015; Wu et al., 2012). A number of these studies seem to indicate that MALL has positive effects on facilitating vocabulary learning. Nevertheless, less encouraging and even negative results have been reported by several researchers (e.g., Okunbor & Retta, 2008; Stockwell, 2007, 2010). Stockwell (2007) found that vocabulary learning through mobile phones was not better than through desktop computers. In learning vocabulary using two techniques, no significant differences were identified with respect to learners’ performance. In addition, Stockwell (2010) found that learners were reluctant to use mobile phones for vocabulary learning. Similarly, Okunbor and Retta (2008) found that most of the students using mobile phones perceived the devices to be insignificant. To sum up, the findings on the effectiveness of mobile devices for vocabulary learning are inconsistent.

One of the most popular mobile devices in mobile-assisted vocabulary learning is mobile phones or smartphones with unique advantages such as “accessibility, personalizability, and portability” (Saran & Seferoglu, 2010, p.253). However, little research has been done on EFL vocabulary learning through mobile apps on smartphones (Afzali et al., 2017; Burston, 2013). In order to fill this gap, the development of a mobile app for EFL vocabulary

learning among EFL students and a test of its effectiveness are urgently needed.

Literature Review

Theoretical Framework

The design of the mobile app is based on four theories, which are the ten design principles for MALL (Stockwell & Hubbard, 2013), dual coding theory (Paivio, 2007, 1986, 1971), the cognitive theory of multimedia learning (Mayer, 2014, 2005, 1997), and the memory-based strategic framework for vocabulary learning (Ma, 2014a). These theories are introduced and their implications for the present study are presented.

Stockwell and Hubbard (2013) proposed ten design principles for mobile language learning. Table 1 illustrates the ten design principles and their adaptations in the present study.

Table 1: Ten design principles and their adaptations in the present study

| Principles | The adaptations in the present study |
|---|---|
| 1. Mobile activities, tasks, and apps should distinguish both 1) the affordances and limitations of the mobile device and 2) the affordances and limitations of the environment in which the device will be used in light of the learning target. | Students would make use of their smartphones to access the internet to download the mobile app in order to learn or review vocabulary. |
| 2. Limit multi-tasking and environmental distractions | The task in the mobile app is divided into two sections: Learning and Retrieval, in order to decrease distractions. |
| 3. Push, but respect boundaries. | Two hours prior to the deadline (23:00 P.M.) on the day of English class, students would receive a textual reminder on their phones through QQ or WECHAT (two popular chat apps in China) that the report of vocabulary learning via the app would be due. This helps them commit to vocabulary learning via the app. |

| Principles | The adaptations in the present study |
|--|---|
| 4. Strive to maintain equity. | Every student in the experimental group owns a smartphone and can get access to the app. |
| 5. Acknowledge and plan for accommodating language learner differences. | Students have very similar learning and living environments as they all study at and live around the same university. |
| 6. Be aware of language learners' existing uses and cultures of use for their devices. | A study (Wang, 2015) confirmed a high percentage (98%) of smartphone ownership among Chinese university students. Secondly, the subjects are from the same country, so the cultures surrounding smartphone use are similar. |
| 7. Keep mobile language learning activities and tasks short and succinct when possible. | Students are required to learn 9 words via the app at a time which would not surpass the working memory capacity (Miller, 1956). Besides, the vocabulary in the app is presented in multimedia ways and simple to follow. |
| 8. Let the language learning task fit the technology and environment, and let the technology and environment fit the task. | The tasks are designed in such a way that students do not need to read substantial text on the screen and they can watch the video clips or listen to the pronunciation of the new word with earphones or speakers. |
| 9. Some, possibly most, learners will need guidance and training to effectively use mobile devices for language learning. | Instructions or orientations on how to use the app to learn vocabulary would be offered in detail to the students the first time they use the app. |
| 10. Recognize and accommodate multiple stakeholders. | The students with the mobile app are required to learn or review words on their own, so their use of mobile apps will not impact classmates, teachers or other people. |

The second theory is the dual coding theory (DCT) (Paivio, 2007, 1986, 1971) which is a cognitive theory explaining the powerful effects of mental imagery on memory. The DCT postulates the existence of two separate, but interrelated, coding systems, which process and store information in the memory: a verbal system and a nonverbal/visual system. The verbal system stores and processes linguistic information/units (such as text or sound) and the non-verbal/visual system visual deals with information/units such as pictures, animations, or videos. In addition, these verbal and non-verbal/visual systems interact, and the activation of both systems results in better recall (Paivio, 2007).

Thirdly, the cognitive theory of multimedia learning (CTML) is about how people learn from multimedia presentations (Mayer, 2014, 2005, 1997) and gives the learner the role of “knowledge constructor who actively selects and connects pieces of visual and verbal knowledge” (Mayer, 1997, p.4). This theory is based on three assumptions, which are dual channels, limited capacity and active processing.

The fourth theory is a specific memory-based strategic framework for vocabulary learning proposed by Ma (2014a). As shown in Figure 1 below, the framework includes two four-stage parallel vocabulary learning processes. Firstly, the word form in visual or auditory form needs to be noticed. Secondly, its meaning needs to be accessed from the mental lexicon, which could be made possible by looking up the word in a dictionary or guessing. Thirdly, the word needs to be established as a new L2 lexical entry in the mental lexicon by connecting the existing meaning (L1 definition) with the form via repetition, imagery and so on. In the end, each time the learned word is retrieved from the mental lexicon for receptive or productive use, the memory trace for the word will be strengthened.

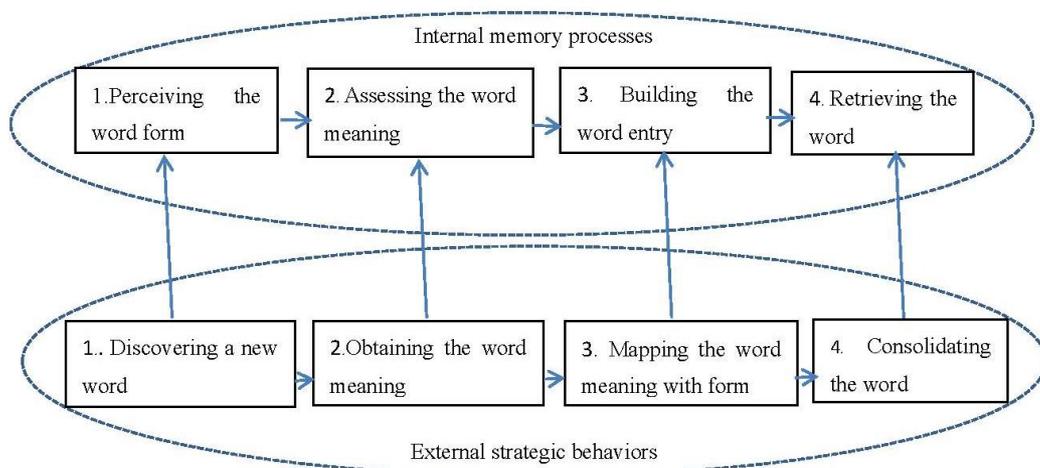


Figure 1: A memory-based strategic framework for vocabulary learning (Ma, 2014a, p.43)

As for the implications from the theories above for the mobile app in the present study, they are summarized in the following sections. First of all, the target words are presented in both visual and audio form simultaneously to get learners to notice as well as arouse their attention. Then, example sentences containing the target word would be provided to help the students obtain the word meaning more easily in context. Thirdly, in order to help students map the meaning of the new learned word with form, the vocabulary exercises are provided for students to complete. One such exercise puts forth an English word for which the student must choose the Chinese meaning from four choices. Alternatively, a Chinese meaning would require the corresponding English word to be selected from four choices. Finally, spelling exercises like offering Chinese meanings for students to spell corresponding English words would be presented to help learners retrieve the new learned word from memory so as to consolidate it in the mind.

EFL Vocabulary Teaching and Learning in Chinese University Setting

The following phenomena about vocabulary teaching and learning are found in Chinese universities by researchers (e.g., He

et al., 2017; Liu, 2018; Li, 2006; Liu, 2015; Yang, 2013; Yang, 2018). First of all, many English teachers do not pay attention to vocabulary and believe that vocabulary learning should be done independently by students outside classroom (He et al., 2017; Liu, 2018;). Secondly, wordlist-based teaching is the most typical EFL vocabulary teaching method from grade three of elementary school to university (Wang, 2014).

Thirdly, low vocabulary size among Chinese university students was found in several studies (e.g., Cai, 2012; Dai, 2013; Wang, 2010; Wu, 2011; Tang & Yin, 2015). The result of a large-scale survey showed that the average vocabulary size among Chinese college students was 2,899 words (Cai, 2012). Wang (2010) found that the average size of receptive and productive vocabulary was 3,174 words and 1,142 words respectively among Chinese non-English majors. Wu (2011) found that about 68% of non-English majors' vocabulary size was less than 3,000 words. Dai (2013) determined that the vocabulary size of non-English major sophomores was 3,934 words. Tang and Yin (2015) showed that the average size of receptive and productive words of non-English majors was 3,945 and 3,045 respectively. To sum up, the average English vocabulary size of Chinese university students is no more than 4,000 words which does not meet the general requirement (4,500-word level) of the College English Curriculum Requirements of 2007. In order to find a solution, a mobile app was proposed in the present study to offer help in regards to vocabulary learning.

Research on EFL Vocabulary Learning and Retention through Mobile Apps

In the following sections, research regarding the effects of different mobile apps on EFL vocabulary learning or retention is reviewed.

Basal et al. (2016) found that a group using WhatsApp achieved significantly better results than the control group did, suggesting that WhatsApp was helpful for EFL students' learning vocabulary. Jafari and Chalak (2016) revealed that the group

using WhatsApp performed better in vocabulary achievement than the control group did. Dehghan et al. (2017) found that there was no significant difference on vocabulary achievements between two groups with or without WhatsApp. Bensalem (2018) showed that the experimental group using WhatsApp significantly outperformed the control group on a vocabulary post-test. The results of the questionnaire showed that the students held positive attitudes towards WhatsApp. To sum up, using WhatsApp has positive effects on EFL vocabulary learning in several studies (e.g., Basal et al., 2016; Bensalem, 2018; Jafari & Chalak, 2016). The reasons why the WhatsApp group were able to achieve more vocabulary learning were summarized by Ahn (2018). Based on Ahn's (2018) study, the students in the WhatsApp group showed very specific preferences for content, functions and presentation methods of the app, which improved their interest and motivation to use the app often to learn vocabulary. As a result, they achieved more vocabulary learning and retention tests. Nevertheless, Dehghan et al.'s (2017) findings are contrary to the results from the studies above. Lastly, only in one study (Bensalem, 2018) students' attitudes towards WhatsApp were explored.

Agca and Özdemir (2013) found that a mobile learning environment could increase EFL students' vocabulary knowledge. In addition, in students' opinions, a 2-dimensional barcode was an innovative and fun application, and a mobile-assisted vocabulary learning environment created curiosity and made vocabulary learning more attractive. Wu (2015) showed that the group with her designed mobile app got higher scores in EFL vocabulary achievement than the control group did. Ou-Yang and Wu (2017) found their designed app significantly enhanced both non-English majors' and English majors' vocabulary achievements. As seen from the above three studies, all self-developed mobile apps could facilitate EFL vocabulary learning (Agca & Özdemir, 2013; Ou-Yang & Wu, 2017; Wu, 2015). However, only in one study (Agca & Özdemir, 2013) were students' opinions of the mobile app explored. Furthermore, all studies

focused only on the effects of the apps on vocabulary learning, not on retention.

To summarize, WhatsApp is a social communication app. Language learners will often choose not to use or are very reluctant to use the target language via social communication apps for fear of not being understood by others (Alm, 2013; Chen, 2013). Furthermore, in the reviewed literature, though there are few studies (e.g., Agca & Özdemir, 2013; Ou-Yang & Wu, 2017; Wu, 2015) developing mobile apps for vocabulary learning, all show benefits in facilitating EFL learners' vocabulary learning. Based on Afzali et al. (2017) and Burston (2013), the studies concerning the effects of self-developed mobile apps on EFL vocabulary learning are still rare and their attitudes towards them need to be explored. Although there may be mobile apps for vocabulary learning in other countries, it is almost impossible for Chinese learners to connect to Google and get access to the apps due to the policy of the government concerning access to applications in overseas app stores. Therefore, in order to fill these gaps, a mobile app for vocabulary learning and retention was developed and its effects were tested among Chinese EFL learners.

Methodology

Research Design

The present study followed a quasi-experimental design that aimed to explore the effects of using a mobile app on vocabulary learning and retention over a 12-week period.

Research Questions

The present study was driven by three research questions:

- 1) What are the effects of using the mobile app on EFL students' vocabulary learning achievement?
- 2) What are the effects of employing the mobile app on EFL students' vocabulary retention in their long-term memory?
- 3) What are the EFL learners' perceptions of vocabulary learning via the mobile app?

Participants

Two intact classes with 139 first-year non-English major students were selected from Anshun university of China based on convenience and availability to participate in the study during the first semester of the 2018 academic year. One class with 56 students was the experimental group and the other with 83 students was the control group. In the present study, the experimental group means the group in which the students used the mobile app to learn target words, while the control group means the group in which the students used a paper-based wordlist (Appendix D) to learn the same target words. The demographic information of the two groups was gathered from the first part of the questionnaire and is shown in Table 2 below.

Table 2: The demographic information of the two groups in the present study

| | Number | Average Age | Gender | Length of Learning English | English Proficiency | Sig. |
|------------------|--------|-------------|----------------------|----------------------------|---------------------|------|
| Experiment Group | 56 | 19 | Male=26 Female=30 | 7-9 years | Mean=88.68 | .351 |
| Control Group | 83 | 18 | Male=40 Female=43 | 8-9 years | Mean=91.82 | |

Significant level $p < .05$

As seen in Table 2 above, the two groups had similar features in terms of number, age, the proportion of male/female and length of English learning. Their English proficiency was based on the English scores from the National College Entrance Exam (NCEE). The NCEE is held yearly to screen students for universities all over China. It is well known as having high reliability and validity. From an independent-samples t-test, no significant difference in English proficiency was found between the two groups at $p = 0.351 > 0.05$.

Furthermore, during the first week, the Vocabulary Size Test (Nation & Beglar, 2007) (Appendix A) and Knowledge Scale of 72 target words (Appendix B) selected randomly from the vocabulary list of CET4 (College English Test) were used as a

pretest for both groups in an English class with teacher supervision in order to examine whether there were significant differences in vocabulary level and in knowledge of the target words between the groups.

As seen in Table 3 below, based on an independent-samples t-test, no significant difference was found ($P=0.788>0.05$) regarding in vocabulary sizes of the two groups even though 8 students in the control group did not attend the pretest. Moreover, the 8 students of the control group absent from the pretest were not allowed to attend the post-test or the delayed-post-test in order to keep data consistent. Therefore, a total of 75 students in the control group participated in the whole experiment. Additionally, as seen in Table 3, the students' mean vocabulary size was about 2,300 words, which considerably lower than the requirement of 4,500 words for CET4. Thus, they were very suitable for the experiment. Furthermore, there was no significant difference ($P=0.119>0.05$) in knowledge of the target words between the two groups in the pretest, as analyzed with an independent-samples t-test, which can be seen in Table 4. In addition, as evidenced by the means of the 72 target words for the two groups in the pretest (M of *EG =153.11, M of *CG =160.20), these words were worth learning for the students because they were almost unfamiliar or unknown to all of them.

Table 3: Comparison of the Vocabulary Size Test between two groups

| | Group | N | Mean | S.D. | Sig. |
|----------------------|-------|----|---------|---------|------|
| Vocabulary size test | * EG | 56 | 2335.00 | 454.539 | .788 |
| | *CG | 75 | 2375.00 | 477.96 | |

Note: * EG: Experimental Group; *CG: Control Group

Table 4: Comparison on the means of target words between two groups

| | Group | N | Mean | S.D. | Sig. |
|---------|-------|----|--------|--------|------|
| Pretest | * EG | 56 | 153.11 | 26.700 | .119 |
| | *CG | 75 | 160.20 | 24.057 | |

Note: * EG: Experimental Group; *CG: Control Group

Instruments

The Target Words

Seventy-two target words (Appendix B) were selected from CET4 vocabulary based on frequency. Each of the target words was presented with phonetic symbols, part of speech, Chinese definitions, example sentences, pictures, audio files and exercises. The Chinese definitions, part of speech and phonetic symbols were extracted from the Oxford Advanced Learners' English-Chinese Dictionary (2014), and the example sentences and exercises were from CET4 vocabulary books. Finally, the pictures and audio files were extracted from a Chinese search engine, Baidu.

The Mobile App

The mobile app was designed together by an associate professor in computer science and by the researcher. Firstly, the target words, followed by phonetic symbol, word class, as well as a simple Chinese definition, were presented with pictures and audio files at the same time. The reason why a simple Chinese definition was provided is that simple definitions are the most effective for vocabulary learning (Ellis, 1995), and many learners' learning is faster if the meaning of the word is conveyed via a first language translation (Nation, 1982). Later, an example sentence with a Chinese translation was provided to help the students obtain the target word meaning more easily in context (Groot, 2000). Next, when the students finished learning nine target words in one Learning Section, they could choose the corresponding Retrieval Section. Retrieval sections were made up of two kinds of exercises: a multiple choice exercise and a spelling exercise. In the multiple choice exercises, students needed to choose the correct Chinese meaning from four choices as well as select the correct English word from four choices. In the spelling exercises, students were asked to spell the corresponding English word when shown a Chinese meaning, in order to help them retrieve the new learned word from memory so as to consolidate it in their mind. After students finished every type of exercise, the feedback would pop up for them. Based on the findings from several researchers (e.g.,

Butler et al., 2008; Pashler et al., 2005; Roediger & Butler, 2011), feedback, including the correct answer, will increase learning for it enables students to correct errors and to maintain correct responses. Sample screenshots of one target word in the mobile app are shown in Appendix F.

Vocabulary Size Test

The Vocabulary Size Test (Appendix A) that was used in the present study was developed by Nation and Beglar (2007) in order to test EFL/ESL learners' vocabulary size. In order to validate the Vocabulary Size Test, Beglar (2010) conducted a Rasch-based validation of the monolingual test finding that it has these features: 1. it can be used with learners with a very wide range of proficiency levels; 2. it clearly measures a single factor (presumably written receptive vocabulary knowledge) and other factors play a minor role in performance on the test; and 3. it performs consistently and reliably, even though circumstances change. In Beglar's trial of the test, the Rasch reliability measurement was about 0.96.

Vocabulary Knowledge Scale

In order to measure to what extent the participants knew the target words, to determine if the participants of the two groups had differences in their knowledge of the target words before the treatment, and to gauge the achievement as well as retention of target words after the treatment, Paribakht and Wesche's (1993, 1997) Vocabulary Knowledge Scale (VKS) was adapted and then applied in the pretest, post-test and delayed post-test. Paribakht and Wesche's (1993, 1997) VKS uses a five-point elicitation scale that comprises the following items:

- I. I don't remember having seen the word before.
- II. I have seen this word before, but I don't know what it means.
- III. I have seen this word before, and I think it means _____ (synonym or translation)

- IV. I know this word. It means _____. (synonym or translation)
- V. I can use this word in a sentence: _____. (Write a sentence.) (If you do this section, please also do Section IV.)

These categories are coded in accordance with the VKS Scoring Scale, in which possible points range from 1 to 5. As illustrated in Figure 2, the arrows mean that the selection of category I will result in 1 point and the selection of category II, 2 points. For categories III-V, various points can be awarded based on the quality of the answers provided

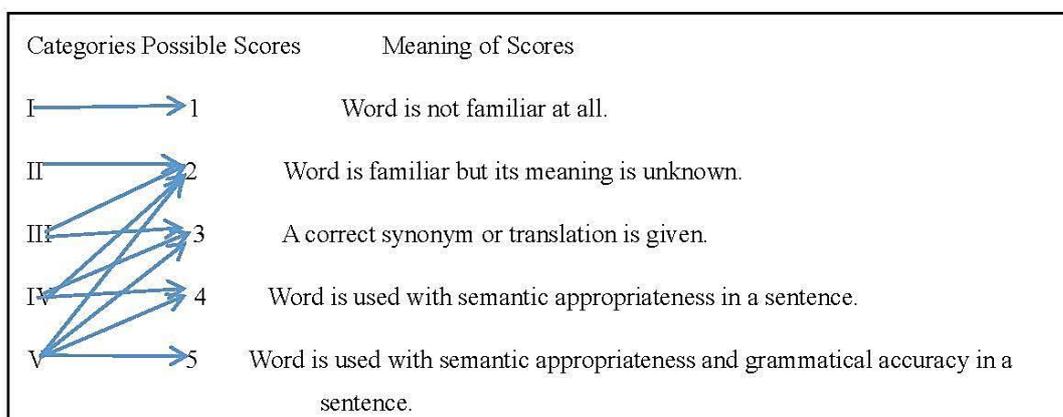


Figure 2: VKS Scoring Scale (Paribakht & Wesche, 1997, p.181).

The reliability of the VKS was found to be high (0.89) (Wesche & Paribakht, 1996), and the test has been proven to be useful in gauging vocabulary learning and retention in studies (e.g., Paribakht, 2005; Wesche & Paribakht, 2009).

The Questionnaire of Students' Perceptions

The current questionnaire was developed based on several studies (Chang et al., 2012; Davis, 1989; Wang, 2015), and on additional guidance from Dörnyei's (2003) and Presser et al.'s (2004) publications about the nature, merits and shortcomings of questionnaires. The questionnaire consisted of two parts. The first

part was about background information. The second part aimed at eliciting students' perceptions of vocabulary learning via the app; it contained 16 items and used a 5-point Likert scale (1= strongly disagree, 2= disagree, 3= not sure, 4= agree, and 5= strongly agree). In order to examine the validity of the questionnaire, the index of item-objective congruence (IOC) developed by Rovinelli and Hambleton (1977) was applied. Later, two experienced Chinese teachers were invited to rate each item together with the researcher to see whether they were congruent with the objectives (congruent=1, uncertain=0, incongruent=-1).

The IOC index of all the items in the questionnaire was 0.875 (Appendix C). In terms of Rovinelli and Hambleton (1977), the IOC index being 0.875 means that most of the items in the questionnaire were acceptable for the present study. To test its reliability, the questionnaire was trialed with 42 undergraduate students who were not the target group. Reliability was calculated by using Cronbach's Alpha. The reliability check from the trial of the questionnaire was 0.91 ($\alpha=0.91$). Therefore, the questionnaire in the current study could be considered reliable based on Deniz and Alsaffar (2013), who claimed that the reliability of a questionnaire is good if the alpha value is higher than or equal to 0.7.

Interview

To collect in-depth data about students' perceptions of the mobile app, a semi-structured interview was selected for the interviewees. The semi-structured interview consisted of eleven questions (Appendix E). Since it was a semi-structured interview, some questions could be asked based on the interviewees' responses. In addition, based on Wang (2015), as seen in Appendix G, 19 students were selected as a representative sample to attend the interview. During the interview, the questions were not asked in the same sequence or with the exact same words as in the guided questions for the 19 interviewees. In addition, in order to make students understand the questions clearly and answer freely, the first language of Chinese was used in the process.

Results

To answer research question 1, a paired-samples t-test and an independent-samples t-test were used to analyze the data. As shown in Table 5, looking at the experimental group, there was a statistically significant difference between the pretest and post-test ($P=0.000$). Also, in the control group, there was a significant difference between two tests. Additionally, it was determined that the means of the post-tests (M of the experimental group=289.09; M of the control group=248.44) were higher than those of the pretests (M of the experimental group=153.11; M of the control group=160.20). This signified that students in the two groups noticeably improved in regards to the words' learning achievements.

Table 5: Comparison on the two tests scores between the two groups

| Group | Tests | Mean | S.D. | N | Sig. |
|-------|-----------|--------|--------|----|------|
| * EG | Pretest | 153.11 | 24.057 | 56 | .000 |
| | Post-test | 289.09 | 45.893 | 56 | |
| *CG | Pretest | 160.20 | 26.700 | 75 | .000 |
| | Post-test | 248.44 | 50.939 | 75 | |

Note: * EG: Experimental Group; *CG: Control Group

Furthermore, after running an independent-samples t-test of the post-test between the two groups, as shown in Table 6 below, a statistically significant difference ($p=0.000<0.05$) was found. In addition, the post-test mean of the experimental group (M=289.09) was much higher than that of the control group (M=248.44). This showed that students achieved many more words by using the mobile app compared with the control group, which answered the first research question.

Table 6: Comparison on the post-test scores between the two groups

| | Group | N | Mean | S.D. | Sig. |
|-----------|-------|----|--------|--------|------|
| Post-test | * EG | 56 | 289.09 | 45.893 | .000 |
| Post-test | *CG | 75 | 248.44 | 50.939 | |

Note: * EG: Experimental Group; *CG: Control Group

To answer research question 2, a paired-samples t-test and an independent-samples t-test were used. In Table 7 below, the means of the delayed-post-tests from two groups were 274.59 and 202.73 respectively, which both decreased compared with those of the post-tests (M of the experimental group=289.09; M of the control group=248.44). However, the control group students' retention of the words decreased greatly while the experimental group students' retention of the words decreased only slightly. Furthermore, according to a paired-samples t-test of the experimental group's scores, no significant difference was found between the delayed-post-test and post-test ($p=0.104>0.05$). Nevertheless, a significant difference was found between the delayed-post-test and post-test of the control group ($p=0.000<0.05$). Furthermore, after conducting an independent-samples t-test on the delayed-post-test scores between the two groups, seen in Table 8 below, it was found that there was a statistically significant difference between the two groups ($p=0.000<0.05$), and the delayed-post-test mean of the experimental group (M=274.59) was much higher than that of the control group (M=202.73). To sum up, the students' retention of the vocabulary would decline with time but the students employing the mobile app could retain more words than those from the control group, which answered the second research question.

Table 7: Comparison between the delayed-post-tests and post-tests from the two groups

| Group | Tests | Mean | S.D. | N | Sig. |
|-------|-------------------|--------|--------|----|------|
| * EG | Delayed-Post-test | 274.59 | 47.708 | 56 | .104 |
| | Post-test | 289.09 | 45.893 | 56 | |
| *CG | Delayed-Post-test | 202.73 | 36.926 | 75 | .000 |
| | Post-test | 248.44 | 50.939 | 75 | |

Note: * EG: Experimental Group; *CG: Control Group

Table 8: Comparison on the delayed-post-test scores between the two groups

| | Group | N | Mean | S.D. | Sig. |
|-------------------|-------|----|--------|--------|------|
| Delayed-Post-test | * EG | 56 | 274.59 | 47.708 | .000 |
| Delayed-Post-test | *CG | 75 | 202.73 | 36.926 | |

Note: * EG: Experimental Group; *CG: Control Group

In order to answer research question 3, the responses from the questionnaire and the interview were examined. Generally speaking, based on their responses of items 4 and 5 in the questionnaire, 90.1% of the students held positive attitudes towards the mobile app for vocabulary learning. In the interview, 18 out of 19 interviewees expressed their liking for the mobile app. In addition, 89.3% of the students agreed that the mobile app was convenient to use for vocabulary learning, as in the responses to items 2 and 11, and 82.7% of them reported that the mobile app made their vocabulary learning easier, as seen in the responses to items 1, 3 as well as 12. In the interview, all 19 interviewees thought that it was more convenient and easier to carry a mobile phone than an English textbook for vocabulary learning and retention. Moreover, 65.4% of the students agreed that it was very useful to learn and retain the vocabulary by using the mobile app, as seen in their responses on items 6, 7, 8, 9, 10, 13, 14 and 15. In the interview, 17 interviewees thought that the pictures of the words in the mobile app were very vivid, which was very helpful for their vocabulary learning and retention, and one interviewee St.14 (St.14 stands for the fourteenth student to be interviewed) believed that the example sentences in the mobile app would facilitate his improvement of vocabulary, sentences making, as well as grammar. Last but not least, 82.2% of the students expressed their willingness to continue to use the mobile app for learning vocabulary in the future, as shown in the responses to item 16.

In addition, based on Dörnyei (2007), a thematic analysis was used to analyze the data from the interviews in the study. In order to form the themes from data in the present study, the responses of the interviewees were used as data evidence. Each interviewee was

numbered according to their order of being interviewed. For instance, St.1 stands for the first student to be interviewed. Through data analysis, four categories were found and these formed one theme. The theme, categories and evidence are shown in Table 9 below.

Table 9: Theme and categories found from the interviews

| Theme: perception | Evidence (quotes from interviewees) |
|------------------------------|---|
| Category 1: feel helpful | <p>St.19, ...the three kinds of exercises help me remember the learned words.</p> <p>St.11,...it only focuses on CET4 words, so it helps me a lot for preparation of CET4.</p> <p>St.14,...the pictures are very vivid which could help remember words better.</p> <p>St.3,...the example sentences could facilitate me to make sentences and improve grammar.</p> <p>St.8,...the immediate feedback makes me realize shortcoming and pay more attention to the words.</p> |
| Category 2: feel interesting | <p>St.1,...the pictures and example sentences are very interesting to arouse my interest in learning words.</p> <p>St.6,...it is interesting to learn and review vocabulary by the app with flexibility.</p> |
| Category3: feel convenient | <p>St.5,...there is no limitation of time and space for learning words via the app, so it is convenient.</p> <p>St.9,...as long as the mobile phone is on me, I can use the app to learn vocabulary, so convenient.</p> <p>St.18,...it is much more convenient to carry a mobile phone than a textbook to learn vocabulary</p> <p>St.7,...as long as I want to learn vocabulary, I can use the app at my disposal.</p> |
| Category 4: feel no pressure | <p>St.13,...when I take the textbook and look at the word list, I feel so stressful for there are lots of words to learn and recite. The app makes me no pressure and happy to learn words.</p> |

| Theme: perception | Evidence (quotes from interviewees) |
|-------------------|---|
| | <p>St.16,...learning 10 words one time via the app brings me fun just like to complete a mission. And the contents are diversified that I cannot feel depressed.</p> |

According to the interviewees' responses, four categories were formed and a theme could be refined from them. Firstly, as seen in Table 9, students considered the app to be helpful mainly for the contents' design and the target words. Next, the app was perceived as being interesting because of the presentation of the words and the app itself. Thirdly, most of the students thought of the app as being convenient, because it was much more convenient to carry a mobile phone than to carry a textbook, and they could use it anytime, anywhere to learn words through the app. Fourthly, the students referred to the app as a method to learn vocabulary without pressure, because the diversified contents and the number of words to be learned made them feel like they were having fun, especially compared with the traditional long word list for them to learn. Finally, based on the four categories above, one theme, perception of the app, was refined. To conclude, students had good perceptions of vocabulary learning via the mobile app.

Discussions

Discussion of students' vocabulary achievement

As mentioned in the previous section, the results show that the students with the mobile app showed a statistically significant achievement of words. Two main reasons may account for the experimental students' greater achievement in vocabulary learning. First of all, the mobile app provides a multimedia learning environment for learners to learn the target words. In the learning section, learners can learn the target words through related pictures, comprehensible example sentences, word pronunciation, and Chinese meanings. The multimedia

presentations help learners understand words easily and stimulate their motivation, which gives the learners the role of “knowledge constructor who actively selects and connects pieces of visual and verbal knowledge” (Mayer, 1997, p.4). Moreover, the use of pictures and audio files are superior to words alone in improving memory, and can help L2 learners remember the words faster, which is in line with the findings of the study conducted by Ramezanali (2017).

The second reason concerns the portability and convenience of the mobile app. The responses from the questionnaire and the interview consistently indicate that learners could learn and review the target words with the mobile app both inside and outside the classroom wherever they wanted. These findings corroborate Steel’s (2012) study. Steel (2012) found that a mobile app for language learning was a more practical aid because it extended language learning outside the classroom, especially when the in-class language practice time was limited; a large amount of time is essential to language acquisition. Therefore, the mobile app can meet students’ needs provided that they have enough time to learn and review the target words as many times as they want without time or space limits. In addition, the mobile app offers individualized and private learning, so that students can learn vocabulary at their own pace according to their individual language competence, or the speed at which they can memorize words.

Discussion of Students’ Vocabulary Retention

The results in the prior section show that the participants with the mobile app were able to retain more words in their long-term memory. The enhancement of the vocabulary retention may be attributed to the following two reasons. The first reason concerns the spaced review. In this study, the students are exposed to the target words at least twice in different kinds of exercises. Based on Ma (2014a), each time the newly learned word is retrieved from the mental lexicon for receptive or productive use, the memory trace for the word would be strengthened. Thus,

there is reason to believe that the subsequent exercises are helpful for them to retrieve and then consolidate the target words in their minds for a longer time. In addition, the more the students review and use the words in various exercises, the longer the words stay in their memories. These findings confirm the previous study of Daloğlu et al. (2009) which showed that intervals of repetition of vocabulary learning had a positive effect on transferring vocabulary knowledge from the short-term memory to the long-term memory. Spaced review and multiple encounters with words could stimulate their learning and retention, concepts which have been verified by many researchers (e.g., Daloğlu et al., 2009; Russo & Mammarella, 2002; Schuetze & Weimer-Stuckmann, 2011).

The second reason may be that the mobile app is installed on their smartphones directly, so the smartphones can be used by students to learn as well as review the words anywhere, thereby taking advantage of their extra time to relearn vocabulary since the amount of class time is limited. Effective vocabulary learning needs frequent reviews and mobile phones provide sufficient opportunities for learners to have a continuous connection to the target words (Kukulska-Hulme, 2012). It was found from the responses of the interview in this study that learners enjoyed using the mobile app to review words and they still could remember the target words after several weeks. Compared to the traditional wordlist learning, the learners preferred to retain the target words through the subsequent exercises with multiple contexts in the mobile app rather than memorizing words in isolation without contexts. The wordlist learning method is boring and now has few advocates, because students soon forget the words they have learned and fail to store the new words in their long-term memory (Boonkongsaen, 2013). Therefore, the portability and immediacy of the mobile app enables learners to improve their vocabulary retention in a relatively interesting and effective way.

Discussion of Students' Perceptions of the Mobile App

Based on responses from the questionnaire and the interview, the majority of students were fond of using the mobile app and expressed their positive opinions towards it because they could learn the target words and retain them in their long-term memory due to the availability, accessibility, portability, and flexibility of the mobile app. In addition, most of the participants acknowledged that the mobile app eliminates time and space limits in vocabulary learning as well as allows one to review inside or outside the classroom. These findings can find a large amount of support from other studies (e.g., Agca & Özdemir, 2013; Bensalem, 2018; Kim, 2011; Motallebzadeh et al., 2011; Ornprapat & Wiwat, 2015; Tabatabaei & Goojani, 2012). Furthermore, using technology could promote language learners' motivation, create positive attitudes toward learning a foreign language (Yu, 2019), and lower learners' anxieties in language classes (Rahimi & Yadollahi, 2011). Last but not least, some participants consider the traditional wordlist learning method as boring because they have to learn a large number of vocabulary items in a short time in isolation. According to Lin (2015), only when learners assimilate new words into their own schemata can they store them for a long time and use them freely as well as productively.

Conclusion

This study adds to existing research on mobile app-assisted vocabulary learning in EFL settings. First of all, based on four theories which yield the 10 design principles for MALL (Stockwell & Hubbard, 2013), dual coding theory (Paivio, 2007, 1986, 1971), the cognitive theory of multimedia learning (Mayer, 2014, 2005, 1997), and the memory-based strategic framework for vocabulary learning (Ma, 2014a), a mobile app was designed especially for vocabulary learning and retention in the Chinese EFL setting.

Then, the mobile app was verified as feasible and effective in helping EFL learners learn more words and retain them in their long-term memory. In the learning section of the mobile app, the

target words are presented with pictures and audio which can help learners learn words more effectively and retain them longer in their memory compared to the words presented alone on a wordlist (e.g., Clark & Paivio, 1991; Mayer, 2014; Ramezanali, 2017). Also, in the review section of the mobile app, when the students do or redo the word exercise for receptive use or productive use, the memory trace for the word or the link between form and meaning of the word would be strengthened in the mind (Ma, 2014a), which can increase learners' retention of the words in long term memory.

Finally, according to the responses from the questionnaire and the interview, most of the students had positive attitudes towards the mobile app. Based on Zou and Li (2015), the availability, accessibility and flexibility of a mobile app contributes greatly to students' motivation for learning and enables ubiquitous learning. Moreover, a mobile app can extend the learning environment outside classrooms. As for language learning, the app with the features above is very practical for students, as they often do not have sufficient time to practice language in classrooms (Kennedy & Levy, 2008).

The authors

Xingxing Ma, the corresponding author, is a Ph.D candidate at School of Foreign Languages, Suranaree University of Technology, Thailand. He earned a MA degree in Foreign Linguistics and Applied Linguistics from Jiangxi Normal University of China in 2012. His areas of interest include EFL teaching, second language acquisition and technology-assisted vocabulary learning.

Butsakorn Yodkamlue works at School of Foreign Languages, Suranaree University of Technology. She earned her Ph.D degree in linguistics, University of South Carolina, USA in 2008. Her areas of interest include linguistics, foreign language teaching and learning. She can be reached at butsakorn@sut.ac.th

References

- Afzali, P., Shabani, S., Basir, Z., & Ramazani, M. (2017). Mobile-Assisted Vocabulary Learning: A Review Study. *Advances in Language and Literary Studies*, 8(2), 190-195.
- Agca, R. K., & Özdemir, S. (2013). Foreign language vocabulary learning with mobile technologies. *Procedia-Social and Behavioral Sciences*, 83, 781-785.
- Ahn, S. K. (2018). *Korean EFL College Students' Acceptance and Use of Smartphone Applications for English Language Learning* (Doctoral dissertation, Alliant International University, San Diego, USA).
- Alemi, M., Sarab, M. R., & Lari, Z. (2012). Successful Learning of Academic Word List via MALL: Mobile Assisted Language Learning. *International Education Studies*, 5(6), 99-109.
- Basal, A., Yilmaz, S., Tanriverdi, A., & Sari, L. (2016). Effectiveness of mobile applications in vocabulary teaching. *Contemporary Educational Technology*, 7(1), 47-59.
- Basoglu, E. B., & Akdemir, O. (2010). A comparison of undergraduate students' English vocabulary learning: Using mobile phones and flash cards. *Turkish Online Journal of Educational Technology-TOJET*, 9(3), 1-7.
- Beglar, D. (2010). A Rasch-based validation of the Vocabulary Size Test. *Language Testing*, 27(1), 101-118.
- Bensalem, E. (2018). The Impact of WhatsApp on EFL students' Vocabulary Learning. *Arab World English Journal (AWEJ)*, 9(1), 23- 38.
- Brown, B., McGregor, M., & Laurier, E. (2014). iPhone in vivo: Video analysis of mobile device use. In *Proceedings of CHI* (Vol.13, pp.1031-1040). Paris, France: ACM Press.
- Burston, J. (2013). Language learning technology MALL: future directions for BYOD applications. *The IALLT Journal for Language Learning Technologies*, 43(2), 89-96.
- Burston, J. (2015). Twenty years of MALL project implementation: A meta-analysis of learning outcomes. *ReCALL*, 27(1), 4-20.

- Butler, A. C., & Roediger, H. L. (2008). Feedback enhances the positive effects and reduces the negative effects of multiple-choice testing. *Memory & Cognition*, 36(3), 604-616.
- Cai, J. G. (2012). The evidence of China college English diminishes and its trends. *Foreign Language Research*, 3, 46-52.
- Cavus, N., & Ibrahim, D. (2009). m-Learning: an experiment in using SMS to support learning new English language words. *British Journal of Educational Technology*, 40 (1), 78-91.
- Chang, C. C., Yan, C. F., & Tseng, J. S. (2012). Perceived convenience in an extended technology acceptance model: Mobile technology and English learning for college students. *Australasian Journal of Educational Technology*, 28(5).
- Chen, X.-B., (2013). Tablets for informal language learning: Student usage and attitudes. *Language Learning & Technology*, 17(1), 20-36.
- Dai, J.H. (2013). A Study on the Vocabulary Size of Non-English Majors at CET-4 Level. *Journal of Chongqing University of Technology (Social Science)*, 27(1), 118-123.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quart.* 13(3) 319-339
- Dehghan, F, Rezvani, R, & Fazeli, S. (2017). Social networks and their effectiveness in learning foreign language vocabulary: A comparative study using WhatsApp. *CALL-EJ*, 18(2), 1-13.
- Deniz, M. S., & Alsaffar, A. A. (2013). Assessing the validity and reliability of a questionnaire on dietary fiber-related knowledge in a Turkish student population. *Journal of health, population, and nutrition*, 31(4), 497.
- Dörnyei, Z. (2003). *Questionnaires in Second Language Research: Construction, Administration, and Processing*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

- Dörnyei, Z. (2007). Creating a motivating classroom environment. In *International Handbook of English Language Teaching* (719-731). Springer, Boston, MA.
- Duman, G., Orhon, G., & Gedik, N. (2015). Research trends in mobile assisted language learning from 2000 to 2012. *ReCALL*, 27(2), 197-216.
- Ellis, N. (1995). Vocabulary Acquisition Research Group Virtual Library. *The Language Teacher*, 19(2), 12-16
- Gass, S. (1999). Discussion: Incidental vocabulary learning. *Studies in second language acquisition*, 21(2), 319-333.
- Groot, P. J. (2000). Computer Assisted Second Language Vocabulary Acquisition. *Language Learning & Technology*, 4(1), 60-81.
- He, S.R, Chen,T.T & Zhang, L.F. (2017). On the thinking of vocabulary teaching of college English. *Home Drama*, (1) 196-198.
- Hockly, N. (2013). Interactive whiteboards. *ELT journal*, 67(3), 354-358.
- Hwang, G. J., & Tsai, C. C. (2011). Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology*, 42(4), E65-E70.
- Jafari, S., & Chalak, A. (2016). The Role of WhatsApp in Teaching Vocabulary to Iranian EFL Learners at Junior High School. *English Language Teaching*, 9(8), 85-92.
- Jiang, L.R. (2016). The analysis on how to improve the passing rate of CET4 among Chinese universities. *Rural Economy and Technology*, 27(10), 239-240.
- Kennedy, C., & Levy, M. (2008). L'italiano al telefonino: Using SMS to support beginners' language learning. *ReCALL*, 20(3), 315-330.
- Kim, H. S. (2013). Emerging mobile apps to improve English listening skills. *Multimedia-Assisted Language Learning*, 16(2), 11-30.

- Kukulska-Hulme, A. (2013). Re-skilling Language Learners for a Mobile World. *The International Research Foundation for English Language Education (TIRF)*, Monterey, USA.
- Li, F.I. (2006). The survey and analysis of non-English majors' vocabulary learning. *Journal of Huanggang Normal University*, 26, 204-206.
- Liu, X. (2015). *Application of mobile learning based on smartphone in the vocabulary learning of senior high school students* (Master's thesis, Central China Normal university, Wuhan, China).
- Liu, Y.L. (2018). A study on the vocabulary teaching of college English in China. *Journal of Shan Xi Institute of Energy*, 31(4), 95-97.
- Ma, Q. (2014a). A contextualized study of EFL learners' vocabulary learning approaches: Framework, learner approach and degree of success. *Asia TEFL*, 11(3), 33-71.
- Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational psychologist*, 32(1), 1-19.
- Mayer, R. E. (Ed.). (2005). *The Cambridge Handbook of Multimedia Learning*. Cambridge university press, New York.
- Mayer, R.E., & Fiorella, L. (2014). Principle for reducing extraneous processing in multimedia learning: Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), *The Cambridge handbook of Multimedia learning* (2nd ed, pp. 279–315). New York, N.Y.: Cambridge University Press.
- McCarthy, M. (1990). *Vocabulary*. Oxford University Press. Oxford, New York.
- Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81–97.
- Motallebzadeh, K., Beh-Afarin, R., & Daliry Rad, S. (2011). The Effect of Short Message Service on the Retention of Collocations among Iranian Lower Intermediate EFL Learners. *Theory & Practice in Language Studies*, 1(11).

- Nation, I.S.P. & Beglar, D. (2007). A vocabulary size test. *The Language Teacher*, 31(7), 9-13.
- Okunbor, D., & Retta, G. (2008). Analysis of a mobile learning pilot study. *Math and Computer Science*, [Online]. Retrieved March, 04, 2018. Available: <http://digitalcommons.uncfsu.edu/macsc/wp/2>.
- Ornprapat, S. & Wiwat, W. (2015). Using Mobile-Assisted Exercises to Support Students' Vocabulary Skill Development. *TOJET: The Turkish Online Journal of Educational Technology*, 14(1), 163-171.
- Ou-Yang, F. C., & Wu, W. C. V. (2017). Using Mixed-Modality vocabulary learning on Mobile Devices Design and Evaluation. *Journal of Educational Computing Research*, 54(8), 1043-1069.
- Paivio, A. (1971). *Imagery and Verbal Processes*, Holt, Rinehart, and Winston, New York (Reprinted 1979, Erlbaum, Hillsdale, New Jersey).
- Paivio, A. (1986). *Mental Representations: A Dual-Coding Approach*. Oxford University Press, New York.
- Paivio, A. (2007). *Mind and Its Evolution: A Dual Coding Theoretical Approach*. New York: Psychology Press. Previously published by Lawrence Erlbaum Associates.
- Paribakht, T. S. (2005). The influence of first language lexicalization on second language lexical inferencing: A study of Farsi speaking learners of English as a foreign language. *Language Learning*, 55(4), 701-748.
- Paribakht, T. S. & Wesche, M. (1993). Reading comprehension and second language development in a comprehension-based ESL program. *TESL Canada Journal*, 2(1), 9-29.
- Paribakht, T. S. & Wesche, M. (1997). Vocabulary enhancement activities and reading for meaning in second language vocabulary acquisition. *Second language vocabulary acquisition: A rationale for pedagogy*, 174-200.
- Rajan, M. K., & Kumar, S. P. (2014). Approach and Analysis of M-Learning in Higher Education. *International Journal of Advanced Research in Computer Science*, 5(1).

- Ramezanali, N. (2017). *Short and long-term vocabulary learning and retention through multimedia glossing: A mixed methods research* (Doctoral dissertation, University of Western Ontario, Ontario, Canada).
- Rovinelli, R. J., & Hambleton, R. K. (1977). On the use of content specialists in the assessment of criterion-referenced test item validity. *Dutch Journal for Educational Research*, 2, 49-60.
- Sandberg, J., Maris, M. & Geus, K., (2011). Mobile English learning: An evidence-based study with fifth graders. *Computers & Education*, 57,1334-1347.
- Soleimani, E., Ismail, K., & Mustafa, R. (2014). The acceptance of mobile assisted language learning (MALL) among post graduate ESL students in UKM. *Procedia-Social and Behavioral Sciences*, (118), 457-462.
- Stockwell, G. (2007). Vocabulary on the move: Investigating an intelligent mobile phone-based vocabulary tutor. *Computer Assisted Language Learning*, 20(4), 365-383.
- Stockwell, G. (2010). Using mobile phones for vocabulary activities: Examining the effect of the platform. *Language Learning & Technology*, 14(2), 95-110.
- Stockwell, G., & Hubbard, P. (2013). *Some emerging principles for mobile-assisted language learning*. Monterey, CA: The International Research Foundation for English Language Education.
- Tabatabaei, O., & Goojani, A. H. (2012). The impact of text-messaging on vocabulary learning of Iranian EFL learners. *Cross-Cultural Communication*, 8(2), 47-55.
- Tang, H.J. & Yin, B.L. (2015). The study of non- English majors' vocabulary size. *Journal of Shangdong University of Technology* (Social sciences), 31(3),76-80.
- Valarmathi, K. E. (2011). Mobile assisted language learning. *Journal of Technology for ELT*, 2(2), 1-8.
- Wang, F.F. (2015). *Constructivism-based mobile application for EFL vocabulary learning* (Master's thesis, Suranaree University of Technology, Nakhon Ratchasima,Thailand).

- Wang, H. (2010). *A study of college students' vocabulary proficiency and vocabulary strategic learning* (Master's thesis, Shanxi Normal University, Linfen, China).
- Wang, Y. (2015). *Study on EFL students' mobile assisted English learning in Guizhou university*. (Master's thesis, Guizhou University, Guiyang, China).
- Wang, Z.Y. (2014). An empirical study of the predictability of the vocabulary size test on language proficiency. *FLLTP*, (2), 71-75.
- Wesche, M., & Paribakht, T. S. (1996). Assessing second language vocabulary knowledge: Depth versus breadth. *Canadian Modern Language Review*, 53(1), 13-40.
- Wesche, M. & Paribakht, T. (2009). *Lexical inferencing in a first and second language: cross-linguistic dimensions*. Clevedon: Multilingual Matters.
- Wilkins, D. (1972). *Linguistics in Language Teaching*. London: Arnold.
- Wu, H.M. (2011). An English Vocabulary Test Survey among Non-English Majors. *Higher Education Forum*, (9), 102-104.
- Wu, Q. (2015). Designing a smartphone app to teach English (L2) vocabulary. *Computers & Education*, (85), 170-179.
- Wu, W., Wu, Y. J., Chen, C., Kao, H., Lin, C., & Huang, S. (2012). Review of trends from mobile learning studies: A meta-analysis. *Computers & Education*, (59), 817-827.
- Yang, J. (2013). Mobile assisted language learning: Review of the recent applications of emerging mobile technologies. *English Language Teaching*, 6(7), 19-25.
- Yang, Y.F. (2018). Main problems existing in college English vocabulary teaching and solutions. *Education Teaching Forum*, (42), 187-188.
- Yu, A.Q. (2019). *Understanding Information Technology Acceptance and Effectiveness in College Students' English Learning in China*. (Doctoral dissertation, University of Nebraska, Nebraska, America).

- Zhang, H., Song, W., & Burston, J. (2011). Reexamining the effectiveness of vocabulary learning via mobile phones. *TOJET*, 10(3), 203-214.
- Zhang, X.C. (2008). *A study of non-English majors' vocabulary level and vocabulary learning strategies* (Master's thesis, Shanghai International Studies University, Shanghai, China).
- Zou, B., & Li, J. (2015). *Exploring mobile apps for English language teaching and learning*. In F. Helm, L. Bradley, M. Guarda, & S. Thouésny (Eds), *Critical CALL—Proceedings of the 2015 EUROCALL Conference*, Padova, Italy (pp.564-568).

Appendix A

An excerpt of 10 words in Vocabulary Size Test (Nation & Beglar, 2007)

<http://www.lex tutor.ca/>.

Choose the letter a-d with the closest meaning to bold word to fill in the bracket.

1. SEE: They **saw** it. ()
a. cut b. waited for c. looked at d. started
2. TIME: They have a lot of **time**. ()
a. money b. food c. hours d. friends
3. PERIOD: It was a difficult **period**. ()
a. question b. time c. thing to do d. book
4. FIGURE: Is this the right **figure**? ()
a. answer b. place c. time d. number
5. POOR: We are **poor**. ()
a. have no money b. feel happy
c. are very interested d. do not like work hard
6. DRIVE: He **drives** fast. ()
a. swims b. learns c. throws balls d. uses a car
7. JUMP: She tried to **jump**. ()
a. lie on top of the water b. get off the ground suddenly
c. stop the car at the edge of the road d. move very fast
8. SHOE: Where is your **shoe**? ()
a. the person who looks after you
b. the thing you keep your money in
c. the thing you use for writing d. the thing you wear on your foot
9. STANDARD: Her **standards** are very high. ()
a. the bits at the back under her shoes
b. the marks she gets in school
c. the money she asks for d. the levels she reaches in everything
10. BASIS: This was used as the **basis**. ()
a. answer b. place to take a rest c. next step d. main part

Appendix B

Knowledge Scale of 72 Target Words

Please choose the most suitable one (I-V) to fill in the bracket, and do as told in the bracket if you choose one from III to V. One example is taken below to illustrate how to do it.

- I. I don't remember having seen the word before.
 II. I have seen this word before, but I don't know what it means.
 III. I have seen this word before, and I think it means _____. (synonym or translation)
 IV. I know this word. It means _____. (synonym or translation)
 V. I can use this word in a sentence: _____. (Write a sentence.)
 (If you do this section, please also do Section IV.)

For example, drive (V) I can drive the car. 驾驶

treat () local () apart () acknowledge () transfer () behalf ()
 chew () generous () objective () resolve () intend () automatic ()
 optional () species () despite () involve () intense () estate () liar
 () conduct () illegal () individual () economical () award () alter
 () ending () register () hint () ensure () remark () emit ()
 efficient () distribute () adequate () strategy () appropriate ()
 influence () brand () dim () overall () casual () illustrate ()
 staff () discipline () link () characteristic () appeal () criticize ()
 tackle () exhaust () reputation () assist () slip () deceive ()
 contact () overtake () assignment () consume () entitle () legal ()
 kit () launch () drain () reluctant () squeeze () chill () collect
 () boast () install () chase () response () switch ()

Appendix C

Checking Item-Objective Congruence (IOC) of Questionnaire

| Items | The researcher | Expert Ms.Hu | Expert Mr.Cai | Agreement |
|---|----------------|--------------|---------------|-----------|
| 1. The vocabulary learning app is easy to use. | 1 | 1 | 1 | √ |
| 2. Learning vocabulary via the app is convenient since I can choose the materials | 1 | 0 | 1 | × |
| 3. The app makes vocabulary learning easier for me compared with wordlist. | 1 | 1 | 1 | √ |
| 4. It is a good method to learn vocabulary via the app. | 1 | 1 | 1 | √ |
| 5. I like the app more than the method I used. | 1 | 1 | 0 | × |
| 6. The vocabulary learning app motivates me to learn new words. | 1 | 1 | 1 | √ |
| 7. The app is useful for me to learn vocabulary. | 1 | 1 | 1 | √ |
| 8. The vocabulary learning can help me learn more. | 1 | 0 | 0 | × |
| 9. The immediate feedback in the app can push me to monitor and adjust my vocabulary learning. | 1 | 1 | 1 | √ |
| 10. The Retrieval Session in the app enables me to review and remember the vocabulary very well. | 1 | 1 | 1 | √ |
| 11. The app makes learn vocabulary more convenient outside classroom. | 1 | 1 | 1 | √ |
| 12. I can learn the words easier based on the clues of the images and example sentences in the app. | 1 | 1 | 1 | √ |
| 13. The contexts of the example facilitate words' knowledge in my mind. | 0 | 0 | 1 | × |
| 14. The vocabulary learned via the app is not easily forgotten. | 1 | 1 | 1 | √ |
| 15. The contexts of the example sentences helps me learn how to use the words appropriately. | 1 | 1 | 1 | √ |
| 16. In the future I will continue to use the app to learn vocabulary. | 1 | 1 | 1 | √ |
| Total score | 15 | 13 | 14 | |

Notes: 1. “1” for the item is congruent with objective; 2. “0” for the uncertainty of the item;

3. “-1” for the item is not congruent with objective;

2. Result of IOC:

$$\text{IOC} = \hat{O}R / N$$

$$\hat{O}R = 15 + 14 + 13 = 42 \text{ (Scores from experts)}$$

$$N = 2 \text{ (Number of experts)} \quad \text{IOC} = 42/3 = 14$$

Number of Items: 16

$$\text{IOC index: } 14/16 = 0.875 > 0.5 = \text{valid}$$

Appendix D

A Sample of Wordlist with 20 Words for the Control Group

| | |
|---|--|
| illegal /ɪ'li:gl/ adj. 不合法的, 违法的; n. 非法移民, 非法劳工; 间谍 | ending /'endɪŋ/ n. 结束; 结局; 末尾 |
| individual /,ɪndɪ'vɪdʒuəl/ adj. 个别的; 独特的; 单独的 n. 独立的个体 | register /'redʒɪstə(r)/ v. 登记, 注册; (仪表等) 显示; 留意 n. 登记, 注册; 现金收纳机 |
| economical /,i:kə'nɒmɪkl/ adj. 节约的; 经济学的; | hint /hɪnt/ n. 暗示, 示意; 建议 v. 作暗示; 透露 |
| award /ə'wɔ:d/ n. 奖品; 奖学金; 判决 vt. 授予; 给予 | ensure /m'ʃʊə(r)/ v. 确保, 保证 |
| alter /'ɔ:lteɪ(r)/ vi. 改变 vt. 改动, 使变样; 改做 | remark /rɪ'mɑ:k/ n. 评论; 谈论; 话语, 话; 备注 vi. 议论 vt. 评论 |
| overall /,əʊvər'ɔ:l/ adj. 全部的, 全面的 n. 工装裤; 罩衫 adv. 总的来说; 总共 | dim /dɪm/ adj. 暗淡的, 弱的 v. 变暗淡 n. 笨蛋, 傻子; |
| brand /brænd/ n. 商标, 品牌; 烙印 v. 给.....打上烙印; 归为 (不好 的事物) | Influence /'ɪnfluəns/ n. 影响; 势力; 有影响的人 (或事物 v. 影响 |
| appropriate /ə'prəʊpriət/ adj. 合适的; 适当的 v. 挪用; 拨款; 私占 | strategy /'strætədʒi/ n. 谋略, 策略 |
| adequate /'ædɪkwət/ adj. 充足的; 尚可的, 过得去的 | distribute /dɪ'strɪbjʊ:t/ v. 分配, 分发, 配送; 散布 |
| efficient /ɪ'fɪʃnt/ adj. 效率高的; 有能力的; 能胜任的 | emit /i'mɪt/ v. 散发; 发射; 发表 |

Appendix E

A Semi-structured Interview on Students' Perceptions of the App

1. Do you enjoy learning vocabulary via the app? Yes or no?
And why?
2. Is the app helpful for your vocabulary learning? Yes or no?
And why?
3. Is the app interesting to you? Yes or no? and why?
4. Comparing the traditional word list-based learning approach with the app-assisted vocabulary learning, which one do you prefer? And why?
5. Is it convenient for you to learn vocabulary via the app? Yes or no? and why?
6. Do you think that the pictures or example sentences are helpful for you to learn vocabulary? Yes or no? And Why?
7. Do you believe that the vocabulary exercises can facilitate your retention of vocabulary? And why?
8. Is the feedback provided by the app useful for you to adjust your vocabulary learning? Yes or no? and why?
9. What else would you like to say about the app-assisted vocabulary learning in the present study?
10. What do you think of the mobile app in general?
11. What don't you like about the mobile app?

Appendix F

Sample screenshots of one word from the mobile app

Sample screenshots of one word and the like for the left 71 words to save space



the word 'involve' in learning section multiple choice one for the word 'involve'



multiple choice two for the word 'involve' spelling exercise for the word 'involve'

Appendix G
Criterion for Determining a Representative Interview Sample
(Wang, 2015)

| Participants | Minimum Interviews | Participants | Minimum Interviews | Participants | Minimum Interviews |
|--------------|--------------------|--------------|--------------------|--------------|--------------------|
| 0-9 | ALL | 86-99 | 22 | 339-369 | 53 |
| 10-12 | 9 | 100-149 | 24 | 370-475 | 58 |
| 13-17 | 11 | 150-199 | 26 | 476-550 | 65 |
| 18-24 | 13 | 200-220 | 30 | 551-600 | 70 |
| 25-30 | 15 | 221-240 | 35 | 601-700 | 80 |
| 31-44 | 17 | 241-299 | 37 | 701-800 | 86 |
| 45-64 | 19 | 300-320 | 42 | 801-900 | 90 |
| 65-85 | 21 | 321-338 | 47 | 901-1000 | 100 |