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An English Vocabulary Learning App with Self-regulated Learning Mechanism to Improve Learning Performance and Motivation

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Abstract

In recent years, the popularity of smart handheld devices and mobile networks has influenced the way people learn English. Accordingly, numerous English vocabulary learning-assisted apps have been developed to enlarge learners’ English vocabulary through mobile learning. These apps not only make the learning of English vocabulary at any time easier, but also help learners to learn English vocabulary anywhere without requiring a dedicated learning space. However, the ability of learners to engage in self-regulated learning (SRL) importantly affects performance in autonomously learning English vocabulary using mobile apps. Therefore, this study developed an English vocabulary learning app with a self-regulated learning mechanism (EVLAPP-SRLM) to help learners improve their SRL abilities, with a view to improving their learning performance and motivation in a mobile learning context. To evaluate the performance of the proposed EVLAPP-SRLM, a total of 46 Grade 5 students who used English as a foreign language (EFL) were recruited from two classes in an elementary school of Taoyuan City, Taiwan, to participate in the experiment. The two classes were randomly assigned to the experimental or control groups, which used respectively the EVLAPP-SRLM and the English vocabulary learning app without a self-regulated learning mechanism (EVLAPP-NSRLM) to support their English vocabulary learning during a period of two weeks. Experimental results indicate that learners in the experimental group exhibited significantly better learning performance and motivation than those in the control group. Moreover, learners who used EVLAPP-SRLM exhibited significantly greater learning performance and motivation than those who used EVLAPP-NSRLM, regardless of gender. Analytical results also verify that the EVLAPP-SRLM provides more benefits to field-dependent learners than to field-independent learners with respect to learning performance and motivation.

Keywords: Self-regulated learning, English vocabulary learning app, Learning performance, Learning motivation, Cognitive style

1. Introduction

English is probably the most widely spoken international language as a result of globalization.

Therefore, having good English skills is very important to many people. In recent years, the rapid growth of wireless networks and mobile devices has caused the learning of English in a mobile learning context to become increasingly popular. Many studies have developed mobile English learning systems to support the learning of English vocabulary anytime and anywhere (Chen & Chung, 2008; Chen & Hsu, 2008; Chen & Li, 2010; Chen & Tsai, 2010; Chang & Hsu, 2011; Cheng, Hwang, Wu, Shadiev, & Xie, 2010; Oberg & Daniels, 2013). However, when learners use an English vocabulary learning app to learn English autonomously, their SRL abilities critically affect their learning performance because most mobile learners use spare time to engage in learning. Zimmerman, Bonner and Kovach (1996) developed an SRL model that involves the four interrelated learning processes, including self-evaluation and monitoring, goal setting and strategic planning, strategy implementation and monitoring, and strategy outcome monitoring. This model can efficiently help learners examine and evaluate their own learning performance. SRL involves self-awareness, self-motivation, and behavioral skill (Zimmerman, 2002). SRL has received attention from the field of education and other learning-related fields. Pintrich and De Groot (1990) showed that learners with high learning performance were more effective in scheduling time for learning, setting definite learning goals, and using various learning strategies than those with low learning performance. They also verified that learners with high learning performance exhibit better self-efficacy and self-monitoring abilities while they are learning. In contrast, learners with low learning performance do not know how to learn effectively, thus having lower learning achievement.

Learners' cognitive styles affect their learning performance in technology-supported learning environments. Witkin, Moore, Goodenough and Cox (1977) considered cognitive style as a personal style with which people typically perceive, think, solve problems and memorize. Biggs (1978) believed that cognitive style reflects an individual's unique personality in cognitive activity, and it may not be related to the individual's intelligence. Most individuals consistently use a special method when solving problems or receiving external information. Chen, Tan and Lo (2016) pointed out that when learners with different cognitive styles use technology-supported learning tools to assist learning, they exhibit varying learning performance. Chen and Huang (2014) indicated that when differently gendered learners use technology-supported learning tools to assist learning, they also have different learning performances. Therefore, whether the EVLAPP-SRLM that is developed in this study provides different benefits in terms of learning performance and motivation to learners with different cognitive styles or different genders warrants study.

To the best of our knowledge, few studies of English vocabulary learning that are assisted by the SRL mechanism have been published. Hence, the EVLAPP-SRLM that is developed by this study aims to help learners set and monitor their SRL goals as well as remind them to achieve these goals, thus improving their English vocabulary learning performance. This study also examines the effects of EVLAPP-SRLM on the success of learners of different genders and with different cognitive

styles. Consequently, the main research questions in this study are as follows. (1) Does the developed EVLAPP-SRLM significantly improve the English vocabulary learning performance and motivation of learners? (2) Does the developed EVLAPP-SRLM provide significantly different benefits to learners of different genders with respect to their English vocabulary performance and motivation? (3) Does the developed EVLAPP-SRLM provide significantly different benefits to learners with different cognitive styles with respect to their English vocabulary learning performance and motivation?

2. Literature Review

2.1 The methods of English vocabulary acquisition

Undoubtedly, English vocabulary acquisition is the primary basis for the learning of English as a foreign language (Min, 2008). However, English vocabulary acquisition is a long and frequently boring process; if learners do not have a strong motivation to learn or they do use effective learning strategies or methods, then they often give up learning English vocabulary (Dörnyei & Csizér, 2002; Noels, Clement, & Pelletier, 1999). Generally, learners learn English vocabulary more efficiently when teachers guide them in how to do so, such as by reading articles and through writing training (Lee & Muncie, 2006). The use of word cards is the most common and simplest way to acquire English vocabulary. Many studies have indicated that the use of word cards to learn English vocabulary helps learners significantly (Komachali & Khodareza, 2012; Kuo & Ho, 2012; Kornell, 2009). Brown (1994) indicated that communicative language teaching can improve learning performance with respect to English vocabulary acquisition, and confirmed that when an article or a conversation is engaged in a meaningful learning situation, learners acquire, internalize and use vocabulary much more easily and effectively. Ruso (2007) pointed out that the Task Based Learning (TBL) method helps learners acquire English vocabulary. This method gives students a learning task, whose completion improves the English vocabulary acquisition. Gomez and King (2014) noted that mind mapping helps students mentally connect images to acquire English vocabulary, improving memorization.

Generally, the learning of English vocabulary through traditional pedagogical methods is markedly influenced by the teacher's teaching skills and the interactions between teachers and students. Teaching learners English vocabulary using information technology can reduce the effect of the teacher's skills and improve learners' motivation to learn English vocabulary (Wang & Young, 2014). Chen and Tsai (2010) developed a game-style English learning system that involves wireless network positioning technology. The system provides English vocabulary based on an individual learner's location to be learned through a PDA. The results indicate that the system effectively improves learners' interest in learning English vocabulary and their performance. Chen, Kao and Sheu (2003) identified six critical features of mobile learning, which are the urgency of the need to learn, the taking of initiative in acquiring knowledge, mobility of the learning setting, interactivity

of the learning process, the situating of instructional activity, and the integration of instructional content. Chen and Chung (2008) developed a personalized mobile English vocabulary learning system that was based on Item Response Theory and the learning memory cycle that was identified by vocabulary testing. This system automatically generates new English vocabulary for learners that suits their current English vocabulary ability, and helps them to review forgettable English words in a manner consistent with the learning memory cycle. The results obtained by using this system demonstrate that the English vocabulary learning system significantly improves learners' ability to learn English vocabulary and their interest in vocabulary learning. Chen and Li (2010) established a personalized context-aware ubiquitous learning system (PCULS) that was based on wireless network positioning technology. PCULS provides learners with English vocabulary that is suitable for their location. The results indicate that PCULS effectively improves English vocabulary learning.

The trend toward mobile learning arises from the development of wireless network technologies and the popularity of mobile devices, and learning is no longer limited to a specific location. Moreover, mobile learning can help learners learn English vocabulary without any limitation of time. The mobile learning model operates outside the learning circumstances of a classroom and helps learners learn in their spare time. This work thus develops EVLAPP-SRLM to assist learners in acquiring English vocabulary.

2.2 Self-Regulated Learning (SRL) ability on learning performance

To let students know how to plan and learn by themselves, cultivating their SRL ability is critical. SRL encourages students to be actively responsible for their learning; it involves goal setting, the implementation of a strategy, self-monitoring, and self-adjustment (Zimmerman, 1990; Boekaerts, 1997; Pintrich, 2000; Zimmerman & Schunk, 2001). Zimmerman, Bonner and Kovach (1996) indicated that the cycle model of SRL has four interrelated learning stages, which are self-evaluation and monitoring, goal setting and strategic planning, strategy implementation and monitoring, and outcome monitoring. In the self-evaluation and monitoring stage, learners assess their learning performance with reference to their own observations of their learning achievement. Goal setting and strategic planning involves setting learning goals based on an analysis of the learning mission, and following by the setting of appropriate learning strategies to achieve learning goals. Strategic implementation and monitoring requires learners to execute learning strategies and monitor their effectiveness. Monitoring the outcome of a strategy involves learners' assessment of the learning effects of their learning strategies based on observations of their relationship with learning achievement. The SRL model proposed by Zimmerman et al. (1996) has been confirmed to effectively help learners examine and evaluate their own learning performance by monitoring the learning goals that they set during learning processes.

Many studies have demonstrated that the SRL ability of an individual significantly affects

learning performance (Dabbagh & Kitsantas, 2005; Kumar et al., 2005; Narciss, Proske, & Koerndle, 2007; Schunk & Zimmerman, 1994; Zimmerman & Schunk, 1989). Pintrich and De Groot (1990) showed that learners with high learning performance are better at setting learning goals, scheduling learning time, and applying various learning strategies than those with low learning performance, whereas learners with low learning performance did not understand how to plan and learn effectively, so they gradually lost their motivation to learn and their focus on their goals. Pintrich, Marx and Boyle (1993) indicated that the motivation strategies for learning questionnaire (MSLQ) scale is frequently used to understand learners' SRL statuses. The scale involves value components, expectancy components, and affective components. Using the MSLQ scale, Joo, Bong and Choi (2000) demonstrated that web-based learning is better than traditional teaching in cultivating students' self-learning abilities. An analysis that involved the gender of learners indicated that female learners had a greater self-learning ability than male learners. Chang (2005) noted that the MSLQ scale was useful for investigating learners' motivations in a web-based learning environment, and his results revealed that SRL strategies improve motivation to learn. Shih, Chang, Chen and Wang (2005) developed an SRL system that provides learners with a mobile learning environment in which they can set a learning schedule. Learners can also use mobile devices to learn how to manage their learning time. This system not only provides learners with a mobile learning environment, but also helps them to develop their individual SRL abilities. Chen (2009) developed a personalized E-learning system (PELS) with an SRL mechanism for web-based learning. In addition to estimating the ability of learners, PELS recommends teaching material to learners based on their estimated ability. PELS includes an SRL mechanism to improve learning performance. Their results demonstrated that the developed SRL mechanism helps learners improve their SRL abilities and their learning performance. Chen and Huang (2014) presented a web-based reading annotation system with an attention-based SRL mechanism to improve the attention of learners while they read, and to improve their reading performance. Their results demonstrated that learners with a high SRL ability in their experimental group paid better sustained attention and had greater reading comprehension than those with low SRL ability. Owing to the importance of cultivating SRL ability, this work develops an EVLAPP-SRLM, called VOC 4 FUN, which can effectively help learners set, monitor, and revisit their own SRL goals, with the goal of improving English vocabulary learning performance and motivation.

3. Research Methodology

3.1 Research architecture

This study examines whether groups of learners who use the developed EVLAPP-SRLM or EVLAPP-NSRLM to support their learning of English vocabulary differ significantly in learning performance and motivation. Whether gender or cognitive style affected this difference was also studied. Whether the used English vocabulary learning app had or did not have an SRL mechanism

was the independent variable. The considered dependent variables were learning performance and learning motivation. Joo, Bong and Choi (2000) found that females had better SRL than males. Therefore, gender was regarded as a background variable that probably affects the effects of the developed EVLAPP-SRLM and EVLAPP-NSRLM on learning performance and motivation. Witkin (1977) pointed out differences in learning characteristics between field-dependent style learners and field-independent style learners. Therefore, cognitive style was considered herein to be another background variable that probably influences the effects of the proposed EVLAPP-SRLM and EVLAPP-NSRLM on learning performance and motivation.

3.2 Research participants

A total of 46 EFL students (27 male and 19 female) aged 10–11 years were randomly sampled from two classes of fifth graders at an elementary school in Taoyuan City, Taiwan, to participate in an instructional experiment. One class of 21 students was randomly designated as the experimental group, whose members proposed EVLAPP-SRLM to support their English vocabulary learning; the other class of 25 students was randomly designated as the control group, whose members used EVLAPP-NSRLM to support their English vocabulary learning.

3.3 Research design

A quasi-experimental design method was used to set up an instructional experiment that lasted for two weeks to determine whether EVLAPP-SRLM significantly improves learning performance and motivation better than EVLAPP-NSRLM. Before English vocabulary was learned, a pretest was performed in the first 20 minutes of the experiment to evaluate the initial vocabulary abilities of all participants. In the following 20 minutes, the group embedded figures test (GEFT) was used to identify participants as having a field-dependent or a field-independent cognitive style. Over the following 20 minutes, an English-Learning Motivation Questionnaire was completed by learners in both groups to determine whether the groups differed significantly in their initial English-learning motivation. The following 30 minutes were used to provide learners in both groups with instructions for operating EVLAPP-SRLM and EVLAPP-NSRLM, to eliminate experimental errors that could be caused by the participants' unfamiliarity with the systems. In the formal experiment, learners in both groups can learn vocabulary at any time and from anywhere using the proposed EVLAPP-SRLM and EVLAPP-NSRLM in the mobile context. Learners in both groups used the EVLAPP-SRLM and EVLAPP-NSRLM as portable learning tools in an autonomous learning context during the two-week experimental period. As no strict time restrictions were imposed within the two-week experimental period, learners in both groups could plan their own learning schedules; however, they were expected to use EVLAPP-SRLM or EVLAPP-NSRLM for at least five hours per week. Also, to evaluate learning performance and learning motivation, a vocabulary posttest and an English-Learning Motivation Questionnaire posttest were set immediately after the two-week

experimental period. Both of the apps that were used by the experimental and control groups provided the same 800 English words, published by the Ministry of Education, Taiwan, for the purpose of English vocabulary learning by elementary and junior high school students.

To consider the research ethics of the designed experiment that involves collecting questionnaire data of the research subjects, written informed consent was obtained from the research subjects following full explanation of the experiment. The informed consent letter contained the specific nature of the research and that the data collected was only for research purposes, they were allowed to withdraw from the experiment at any time, their names would never appear on any data collected.

3.4 Research Tool

3.4.1 English vocabulary learning app with SRL mechanism

The Ministry of Education in Taiwan has determined that elementary and junior high school students must learn a total of 2000 English words. Excluding the most basic 1200 words from a total of 2000 English vocabularies, the developed English vocabulary learning app with or without SRL mechanism provided 800 advanced words as the English learning vocabulary. The detailed system architecture, system components, and functions of the developed EVLAPP-SRLM are as follows.

(1) System architecture of the proposed EVLAPP-SRLM

Figure 1 shows the system architecture of the proposed EVLAPP-SRLM, called VOC 4 FUN. VOC 4 FUN contains five main components, which are the SRL setting module, the English vocabulary learning module, the quiz module, the note module, and the goal reminder module. When a learner uses a legal account and password to log in to the VOC 4 FUN app via a smart handheld device, she/he can click on the SRL module to set SRL goals. After the SRL goals have been set, the learner can begin to learn English vocabulary using the English vocabulary learning module and acquire the English vocabulary data and pronunciation files from the English vocabulary database and the pronunciation database, respectively. In English vocabulary learning, the note module is started up at the same time so that the learner can take notes about the acquired English vocabulary. After learning the English vocabulary that is assigned by the system, learners can click on the quiz module to take the posttest. After a learner has logged in to the app, all learning processes are recorded in the learning portfolio database. The goal reminder module provides a friendly user interface to help individual learners achieve their SRL goals, and provides references for the setting of subsequent SRL goals. The control group does not have access to the functions of the SRL setting module or the goal reminder module to which the experimental group has access.

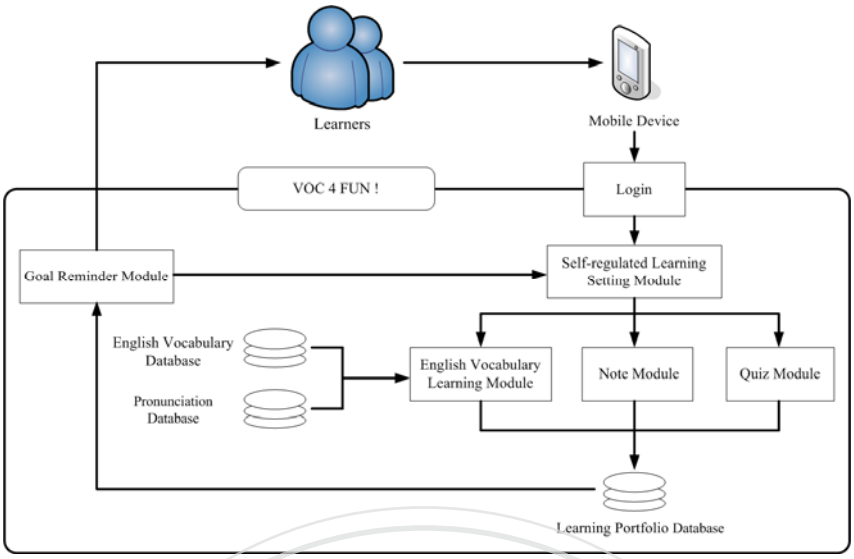

Figure 1. The system architecture of the proposed EVLAPP-SRLM called VOC 4 FUN

(2) Functions of all modules in EVLAPP-SRLM

The app that is developed in this work supports English vocabulary learning and a self-learning management mechanism to help learners of English vocabulary. The functions of the EVLAPP-SRLM are described below.

1. Functions of SRL setting module. The SRL setting module provides a user interface for setting the number of words to be learned daily, the number of notes to be taken daily, and the number of exercises to be done daily. This module also suggests goals according to those previously set by the learner, as shown in Fig. 2.

2. Functions of English vocabulary learning module. If a learner clicks on the English vocabulary learning function, then he/she will receive a new word with its meaning in Chinese from the English vocabulary database and the corresponding pronunciation file from the pronunciation database. Relevant notes, such as example sentences and examples of use that have been written by other learners, will be presented to the user for reference. Figure 3 shows the user interface for learning English vocabulary.

Figure 2. User interface of setting SRL goals

Figure 3. User interface of English vocabulary learning

3. Functions of quiz module. The EVLAPP-SRLM provides multiple choice questions in response to which learners must choose one of three answers based on the English words that the learner has clicked on. This quiz can be taken repeatedly, as shown in Fig. 4. The correct answer to each question is randomly positioned to prevent learners from simply remembering the correct answer. EVLAPP-SRLM repeats questions that the learner has answered wrongly until the correct answer is given, as shown in Fig. 5. The quiz module operated as follows. (1) A learner clicks on the quiz module and the English vocabulary learning module starts up with it. (2) The English vocabulary learning module loads the vocabulary that the learner has learned into the quiz vocabulary list. The quiz is generated according to the quiz vocabulary list. (3) The quiz module generates the test questions from the quiz vocabulary list. (4) If the learner's answer to a question is correct, then the relevant vocabulary is removed from the database. (5) If the learner's answer to the question is incorrect, then the question will appear repeatedly until the learner acquires the relevant vocabulary.

Figure 4. User interface of quiz

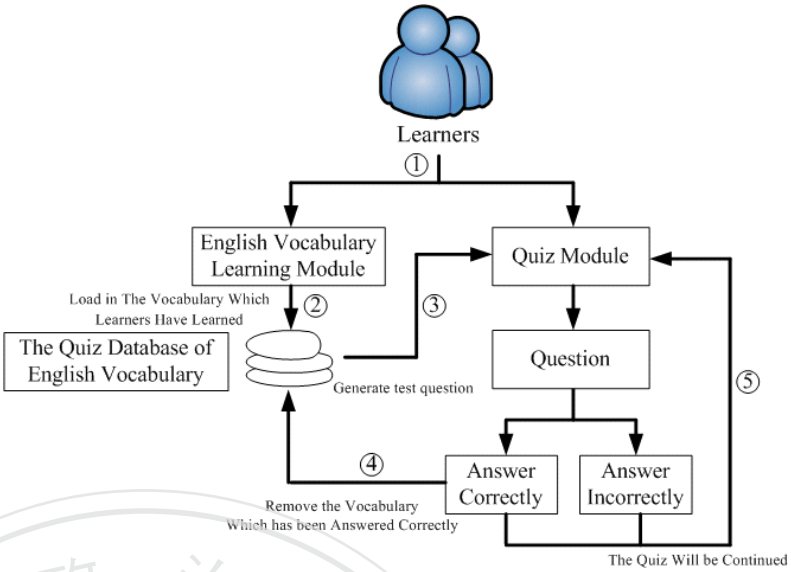

Figure 5. The operating mechanisms of the quiz module

4. Functions of note module. The note module presents not only those notes that are made by the learner but also those that are made by other learners. These notes improve learners' vocabulary learning performance and help learners review their learned content efficiently, as shown in Fig. 6.

5. Functions of goal reminder module. The goal reminder module enables learners to review their SRL goals at any time, as shown in Fig. 7. EVLAPP-SRLM presents the percentage of goals that have been achieved on the right-hand side of the user interface. This function can help learners understand their learning progress and tune their SRL strategies to improve the effectiveness of their learning.

Figure 6. User interface of list of notes

Figure 7. User interface of examining SRL results

3.4.2 Vocabulary ability assessment

Nation (2001) addressed the dimensions on which the vocabulary ability is assessed; they include form, meaning, and use in vocabulary learning theory. The dimension of use, which refers to the ability to use language, is regarded as extremely difficult for elementary school students to master. Therefore, the vocabulary test that was designed for this study consisted of evaluation questions that focus only on form and meaning. Excluding the most basic 1200 words from the list of 2000 words for elementary and junior high school students, published by the Ministry of Education of Taiwan, leaves 800 words, which constituted the English learning vocabulary for learning during this two-week experiment. A total of 25 words were randomly selected from the 800 to assess the learning performance of both groups. The 25 words were provided with various Mandarin words as possible translations, and the participants were asked to read the English word and correctly select the corresponding Mandarin translations.

3.4.3 English-learning motivation questionnaire

A Chinese version of the English-Learning Motivation Questionnaire with 34 items was designed for elementary school students, based on relevant motivational and attitudinal questionnaires (Clément & Kruidenier, 1983; Dörnyei, 1990; Gardner, 1985). The designed questionnaire covers five dimensions, which are learning attitude; learning needs; self-efficacy; self-esteem; and motivation. Responses were given on a five-point Likert-type scale, ranging from 1 for "strongly disagree to 5 for 'strongly agree." Scale reliability was evaluated using 50 students who did not participate in the experiment. The Cronbach's alpha values of the five subscales were .86, .93, .92, .91, and .78, and the Cronbach's alpha of the overall scale was .95, indicating that the scale has high reliability and sensitivity to English-learning motivation.

3.4.4 Group Embedded Figures Test (GEFT) for indentifying field dependent and independent cognitive styles

Witkin (1971) developed the Group Embedded Figures Test (GEFT) as a tool for classifying learners as field-independent or field-dependent learners. The GEFT hides simple geometric figures among more complicated lines, and the examinees must identify the hidden figures. Examinees are classified into field-independent or field-dependent groups by the speed and accuracy with which they identify the simple geometric figures. Based on the literature, cognitive style affects learning performance. The GEFT (Witkin, 1971) is utilized herein to identify students' cognitive styles as field-dependent or field-independent to determine how the cognitive style affects learning performance during the use of the EVLAPP-SRLM or EVLAPP-NSRLM in support of English vocabulary learning. The GEFT was translated into Chinese by Wu (1987) and has been widely used in L2 acquisition research (Hite, 2004; Chen, Tan, & Lo, 2016). Since the length of the GEFT was changed with test procedure, the reliability of the scale has been determined using the Spearman–Brown prophecy formula to be 0.82.

4. Experimental Results

4.1 Difference analysis of initial English abilities of both groups of learners

An experiment was performed using an English vocabulary learning app with and without an SRL mechanism for Grade 6 students in two classes at an elementary school in Taoyuan County, Taiwan. Twenty-one students from one class were randomly assigned to the experimental group, whose members used EVLAPP-SRLM to learn English vocabulary while 25 students from another class were assigned to the control group, whose members used EVLAPP-NSRLM to learn English vocabulary. Each student used one mobile device to learn English vocabulary for two weeks. Before the experiment, a pretest was conducted to determine the initial English abilities of the learners in the experimental and control groups. An independent samples t-test was carried out on the pretest scores to determine differences between the English abilities of the two groups before the experiment. The results showed that the initial English abilities of both groups of learners did not differ significantly ($t = -.689$, $p = .495 > .05$).

4.2 Difference analysis of English vocabulary learning performance of both groups of learners

(1) Covariance analysis of learning performance of both groups of learners. To examine whether a significant difference existed in the learning performance of both groups, analysis of covariance (ANCOVA) was used to analyze the collected pretest and posttest data. The first step is to examine the homogeneity of the regression coefficients. The result ($F=0.392$； $p=.535>.05$) did not reach the level of significance, revealing that the regression slopes of the two groups are equivalent. This result confirms the assumption of homogeneity of regression coefficients, and ANCOVA was performed. Table 1 shows the results, which reach the level of significance ($F=11.074$, $p=.002<.05$) after the dependent effect was adjusted according to the covariance of the pretest, and the posttest score of the experimental group was higher than that of the control group. This result indicates that learners who used the proposed EVLAPP-SRLM exhibited better learning performance than those who used EVLAPP-NSRLM.

Table 1. Covariance analysis of learning performance of both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,43)	Significant
Experimental group	21	40.00	29.065	68.19	22.820	11.074*	.002
Control group	25	46.08	30.444	58.88	27.362		

* indicates $p<.05$

(2) Covariance analysis of learning performance of differently gendered learners in two groups. Gender was considered as one of the background variables. Whether learners with different genders who used EVLAPP-SRLM or EVLAPP-NSRLM differed significantly in learning performance was

examined. The first step was to analyze the homogeneity of regression coefficients. The results (F=1.424, p=.245>0.05; F=.002, p=.969>0.05) determined do not reach the level of significance for either gender, indicating that the regression slopes of the two groups are equivalent. This result confirms the assumption of homogeneity of regression coefficients, so the ANCOVA was performed. Tables 2 and 3 present the ANCOVA results, which reach the level of significance (F=4.540, p =.044<.05; F=7.182, p =.016<.05) after the dependent effect was adjusted according to the covariance of the pretest. This result demonstrates that the posttest scores of the male and female learners in the experimental group are higher than those of the control group. That is, the male and female learners who used the proposed EVLAPP-SRLM exhibited a better learning performance than those who used EVLAPP-NSRLM.

Table 2. Covariance analysis of learning performance of male learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,24)	Significant
Experimental group	12	30.67	28.962	57.67	21.672	4.540*	.044
Control group	15	40.53	32.244	53.60	30.078		

* indicates p<.05

Table 3. Covariance analysis of learning performance of female learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,16)	Significant
Experimental group	9	52.44	25.569	82.22	16.384	7.182*	.016
Control group	10	54.40	26.945	66.80	21.750		

* indicates p<.05

(3) Covariance analysis of learning performance of learners with different cognitive styles in two groups. Cognitive style was considered as the other background variable and whether learners with different cognitive styles who use EVLAPP-SRLM and EVLAPP-NSRLM differed significantly in learning performance was determined. The first step was to analyze the homogeneity of regression coefficients. The results (F=.095, p=.761>0.05; F=.214, p=.649>0.05) do not reach significance for either cognitive style, indicating that the regression slopes of the two groups are equivalent. This result confirms the assumption of homogeneity of the regression coefficients, so the ANCOVA was performed. Tables 4 and 5 show the results of the covariance analysis. Analytical results confirm that the learning performance of field-dependent learners in the experimental group is significantly higher than that of those in the control group (F=9.665, p =.005<.05), but the learning performances of field-independent learners in both groups do not significantly differ (F=.301, p=.590>.05). This result verifies that the proposed EVLAPP-SRLM improved the learning performance of field-dependent learners more than it did that of field-independent learners.

Table 4. Covariance analysis of learning performance of field-dependent learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,21)	Significant
Experimental group	11	46.18	26.555	73.09	21.988	9.665**	.005
Control group	13	28.00	27.227	40.92	24.175		

* *indicates p<.01

Table 5. Covariance analysis of learning performance of field-independent learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,19)	Significant
Experimental group	10	33.20	31.555	62.80	23.630	.301	.590
Control group	12	65.67	20.214	78.33	14.215		

4.3 Difference analysis of motivation to learn English vocabulary in both groups

(1) Covariance analysis of learning motivation of learners in both groups. To examine whether learning motivation differs significantly between both the experimental and control groups, analysis of covariance (ANCOVA) was performed on the collected pretest and posttest data. The first step was to analyze the homogeneity of regression coefficients. The results (F=2.195；p=.146>.05) does not reach significance, so the regression slopes of the two groups were equivalent. This result confirms the assumption of homogeneity of the regression coefficients, and so the ANCOVA was performed. Table 6 shows the results. The ANCOVA result reaches significance (F=9.586；p=.003<.05) after the dependent effect was adjusted according to the covariance of the pretest, indicating that the posttest score of the experimental group is higher than that of the control group. This result reveals that the learners who used the proposed EVLAPP-SRLM had greater learning motivation than those who used EVLAPP-NSRLM.

Table 6. Covariance analysis of learning motivation in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,43)	Significant
Experimental group	21	44.95	8.375	53.24	6.041	9.586**	.003
Control group	25	51.48	7.995	50.52	9.274		

* *indicates p<.01

(2) Covariance analysis of learning motivation of differently gendered learners in both groups. To examine whether a significant difference exists in the learning motivations of differently gendered learners in both the experimental and control groups, an analysis of covariance (ANCOVA) was performed to analyze the collected pretest and posttest data. The first step was to analyze the

homogeneity of regression coefficients. The results (F=.549；p=.466>.05; F=1.957；p=.182>.05) did not reach significance, indicating that the regression slopes of the two groups were equivalent. This result confirms the assumption of homogeneity of the regression coefficients, so the ANCOVA was performed. Tables 7 and 8 show the results, which reach significance (F=4.999；p=.035<.05; F=5.372；p=.034<.05) after the dependent effect was adjusted according to the covariance of the pretest. Analytical results indicate that the posttest scores of the experimental group are higher than those of the control group, revealing that both male and female learners who used the proposed EVLAPP-SRLM had better learning motivation than those who used the EVLAPP-NSRLM.

Table 7. Covariance analysis of learning motivation of male learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,24)	Significant
Experimental group	12	45.75	7.313	52.50	6.303	4.999*	.035
Control group	15	50.40	8.559	48.27	10.089		

* indicates p<.05

Table 8. Covariance analysis of learning motivation of female learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,16)	Significant
Experimental group	9	43.89	9.981	54.22	5.890	5.372*	.034
Control group	10	53.10	7.187	53.90	7.062		

* indicates p<.05

(3) Covariance analysis of learning motivation of learners with different cognitive styles in both groups. To examine whether a significant difference exists between the learning motivations of field-dependent learners in the experimental and control groups, an analysis of covariance (ANCOVA) was performed to analyze the collected pretest and posttest data. The first step was to analyze the homogeneity of regression coefficients. The result (F=1.203；p=.286>.05) does not reach significance, indicating that the regression slopes of the two groups are equivalent. This result confirms the assumption of homogeneity of the regression coefficients, and so the ANCOVA was performed. Table 9 shows the results, which reach significance (F=9.780；p=.005<.05) after the dependent effect was adjusted according to the covariance of the pretest. This result indicates that the posttest score of the field-dependent learners in the experimental group is higher than that of those in the control group. This result demonstrates that the field-dependent learners who used the proposed EVLAPP-SRLM had better learning motivation than the field-dependent learners who used EVLAPP-NSRLM.

Table 9. Covariance analysis of learning motivation of field-dependent learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,21)	Significant
Experimental group	11	46.55	10.202	54.36	7.159	9.780**	.005
Control group	13	48.77	6.139	46.08	9.716		

* *indicates p<.01

To determine whether a significant difference exists in learning motivation between field-independent learners in the experimental and control groups, an analysis of covariance (ANCOVA) was performed to analyze the collected pretest and posttest data. The first step was to analyze the homogeneity of the regression coefficients. The result (F=.972；p=.337>.05) does not reach significance, indicating that the regression slopes of the two groups are equivalent. This result confirms the assumption of homogeneity of the regression coefficients, so the ANCOVA was performed. Table 10 presents the results, which do not reach significance (t=0.145；p=.708>0.05) after the dependent effect was adjusted according to the covariance of the pretest.

Table 10. Covariance analysis of learning motivation of field-independent learners in both groups

Group	Number of learners	Pretest mean	Pretest standard deviation	Posttest mean	Posttest standard deviation	F(1,16)	Significant
Experimental group	10	43.89	9.981	52.00	4.570	.145	.708
Control group	12	53.10	7.187	55.33	6.005		

5. Discussion

SRL ability importantly affects learning performance in an autonomous learning scenario, and particularly the ability to learn English vocabulary in one's spare time with the support of mobile apps. Therefore, this study develops EVLAPP-SRLM to help learners improve their self-regulated learning abilities, with a view to improving their learning performance and motivation while performing English vocabulary learning in a mobile learning context. This study demonstrates that the learners who used the proposed EVLAPP-SRLM had better learning performance and motivation than those who used EVLAPP-NSRLM. This result is consistent with several studies (Chen, 2009; Chen & Huang, 2014; Chen, Wang, & Chen 2014) that have found that technology-supported learning with SRL mechanism support significantly improves learning performance. For example, Chen (2009) presented a personalized e-learning system with an SRL-assisted mechanism that helped learners enhance their mathematical SRL abilities. His analytical results indicated that the proposed personalized e-learning system with an SRL-assisted mechanism helped learners improve their SRL abilities more quickly and improved their mathematical learning performance. Chen and Huang (2014) presented a digital reading annotation

system (DRAS) with an SRL mechanism to help Grade 7 students generate rich and high-quality annotations on reading text online to improve their English-language reading performance. Their results demonstrated that the reading comprehension and reading annotation abilities of the learners who used the DRAS with SRL mechanism support were significantly superior to those of the learners who used the DRAS without SRL mechanism support.

Several studies (Chen & Huang, 2014; Chen, Wang, & Chen 2014; Wolters & Pintrich, 1998; Zimmerman & Martinez-Pons, 1990) have found that technology-supported learning with the support of an SRL mechanism exhibited different effects on learning performance of male and female learners. This study confirms that male and female learners who used the proposed EVLAPP-SRLM to learn English vocabulary had better learning performance and motivation than those who used EVLAPP-NSRLM. This result is inconsistent with previous studies (Chen & Huang, 2014; Chen, Wang, & Chen 2014). For example, Chen and Huang (2014) found that a proposed web-based reading system with an attention-based self-regulated learning mechanism (ASRLM) that was based on brainwave detection promoted sustained attention and improved the reading comprehension of female learners while reading annotated English texts online more than those of male learners. Chen, Wang and Chen (2014) demonstrated that the proposed DRAS with an SRL mechanism improved the reading comprehension of female learners more than that of male learners.

Many field-dependent-independent studies (Kheirzadeh & Kassaian, 2011; Tinajero & Páramo, 1997; Chen, Tan, & Lo, 2016) provide inconsistent results with respect to second language learning performance. The present study confirms that field-dependent learners who used the proposed EVLAPP-SRLM had significantly better learning performance and motivation than those who used EVLAPP-NSRLM, but no significant difference existed for field-independent learners. This study confirms that the proposed EVLAPP-SRLM improves the learning performance and motivation of field-dependent learners more than that of field-independent learners. However, Tinajero and Páramo (1997) found that field-independent students consistently achieve higher academic outcomes than field-dependent students in all of the English learning subjects that they considered. In contrast, Kheirzadeh and Kassaian (2011) found no difference in the performance of field-dependent and field-independent learners in general language listening comprehension. Chen, Tan and Lo (2016) presented a digital pen and paper interaction platform (DPPIP) in which digital pen technologies were integrated with printed textbooks and the Moodle course management system, to support the repeated reading strategy to improve English-language reading fluency. Their results demonstrate that this DPPIP helped learners with field-independent and field-dependent cognitive styles improve their oral reading fluency.

6. Conclusions and Future Works

This study examines the effects of EVLAPP-SRLM on the learning performance and motivation of a total of 46 Grade 5 elementary school students who were recruited from an elementary school

in Taoyuan City, Taiwan. The experimental analyses here support several major findings. First, after two weeks of using the vocabulary learning apps, the learning performance and motivation of learners in the experimental group who used EVLAPP-SRLM significantly exceeded those of the control group who used EVLAPP-NSRLM. Second, the learning performance and motivation of the male and female learners in the experimental group who used the EVLAPP-SRLM were significantly better than those of both male and female learners in the control group who used EVLAPP-NSRLM. Namely, the result confirms that the proposed EVLAPP-SRLM significantly improves the learning performance and motivation of learners of both genders. Third, the learning performance and motivation of field-dependent learners in the experimental group who used EVLAPP-SRLM were significantly better than field-dependent learners in the control group who used EVLAPP-NSRLM, but the learning performance and learning motivation of field-independent learners did not differ significantly between the experimental and control groups. This result suggests that the proposed EVLAPP-SRLM improves the learning performance and motivation of field-dependent learners more than those of field-independent learners.

The SRL mechanism, as promoted with the app, seems to be effective on field-dependent learners, yet not on field-independent learners, and across both genders, on learning motivation (as measured) and on vocabulary improvement (as measured). We suspect that field dependent learners may especially benefit from SRL mechanisms in learning apps, perhaps by supplying them with more learning structure or insight into the critical cognitive processes involved in this kind of learning. Confirmation from other studies is needed to show this and to understand why field dependent learners may be affected differently than field independent learners by the SRL mechanism built into apps like the current one.

The experimental results suggest several directions for future works. First, game functions can be developed for the proposed EVLAPP-SRLM to increase learning motivation. Second, this study found that learners in the experimental group frequently checked the finished percentage of SRL goals that they had reached. Therefore, a mechanism that ranks learners' percentages should be considered for inclusion in the proposed EVLAPP-SRLM, to strengthen their intention to learn and their motivation to enlarge their English vocabulary. Namely, comparing the effects of the proposed EVLAPP-SRLM with and without game functions or with and without ranking learners' percentage of SRL goals on learning performance and motivation can be considered as future works.

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