

An Empirical Study on Improving Chinese College Students' English Vocabulary Use in a Seamless Mobile-Assisted Vocabulary Learning Environment

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Abstract—The purpose of this study is to investigate the effects of the Seamless Mobile Assisted Vocabulary Learning Environment (SMAVLE) on Chinese college students' ability to use English vocabulary. Having reviewed the related literature for the initial step, the researchers then developed SMAVLE based on the literature reviewed. A mixed-method design combined with a quasi-experimental design was utilized in this study. A total of 128 non-English major freshmen participated in the study, with 62 students randomly assigned to the experimental group and 66 to the control group for a 12-week teaching experiment. SMAVLE and the traditional vocabulary learning approach were both used. Vocabulary Knowledge Scale (VKS) tests were administered to students before and after the experiment, and test scores were examined for effects. Additionally, learning logs were used to collect information on students' learning characteristics in SMAVLE. The results revealed: 1) SMAVLE improved students' English vocabulary use compared to traditional learning methods; 2) in SMAVLE, students demonstrated some unique characteristics regarding time allocation, choice of study location, and learning engagement. The study confirms the effectiveness of SMAVLE in vocabulary teaching and provides novel perspectives and practical insights into English vocabulary teaching and learning.

Index Terms—mobile-assist language learning, seamless learning, vocabulary learning

I. INTRODUCTION

As globalization progresses, it is increasingly imperative that Chinese foreign language education system cultivates an English-proficient pool of talent. As the fundamental component of language learning, vocabulary is regarded as a complex and multifaceted process (Nation, 2022). Having a rich and robust vocabulary directly influences learners' language proficiency and expressiveness, which is a crucial determinant of language learning success. Although English curricula at Chinese universities have undergone reforms, students still encounter significant challenges in developing their English proficiency for practical use. Nonetheless, heavy reliance on rote memorization and insufficient contextualization remains prevalent (Schmitt, 2000; Webb, 2008).

In order to address these challenges, it is necessary to gain a comprehensive understanding of vocabulary teaching and learning practices as a basis for more effective instructional interventions. Research suggests that many Chinese EFL learners tend to focus predominantly on the dictionary meanings of words and often neglect their contextual and practical usage (Gu & Johnson, 1996; Zhang & Lu, 2015; Zheng, 2016). Consequently, they may recognize words but have difficulties using them appropriately in real-life situations. There is evidence that learners with rote memorization tend not to understand collocational patterns and pragmatic subtleties, which limits their level of communicative competence when faced with a variety of contexts (Wang & Yang, 2020). Additionally, a recent study conducted by Gong et al. (2020) found that Chinese university students tend to memorize vocabulary forms by rote memorization and acquire them in isolation, which prevents deeper internalization and contextual application of their vocabulary knowledge. The extensive analysis has identified that the main reason is the traditional vocabulary teaching method in China (Zheng & Yu, 2019), one that emphasizes form over semantics, memorization over application, and explicitness over implicitness. As a result, it remains one of the toughest challenges for college English teachers in China to enhance students' flexible vocabulary use in the real world.

Owing to the rapid advancement of information technology, Mobile-Assisted Language Learning (MALL) offers novel concepts and potential solutions to these issues. MALL is undergoing a paradigm shift, as demonstrated by increasingly influential research (Bárcena & Martín-Monje, 2014; KukulskaHulme & Viberg, 2017). Nowadays, rather

than focusing solely on technologies, scholars are increasingly emphasizing learner-centered approaches that consider needs, motivations, attitudes, and authentic interactions (Lin & Lin, 2019; Fu & Hwang, 2018; Zou et al., 2021).

In this regard, seamless learning (SL) offers a valuable framework for enriching vocabulary instruction. Wong and Looi (2011) define SL as a continuum of learning across multiple contexts (formal, informal, personal, social, physical, and digital). As SL eliminates both spatial and temporal constraints, it is able to provide learning experiences that are comprehensive and transferable. As evidenced by an expanding body of empirical research, mobile technology allows learners to experience authentic, personalized, and interactive learning through the realization of seamless learning (Chai et al., 2016; Wong et al., 2017; Hwang et al., 2020; Zou et al., 2021). The lack of research on how diverse design factors impact students' learning processes and outcomes in varying contexts remains a challenge (Lin et al., 2020).

In light of these considerations, the Seamless Mobile Assisted Vocabulary Learning Environment (SMAVLE) was designed and evaluated for its effectiveness in enhancing vocabulary usage among first-year Chinese college students. What's more, it also examined the features of SMAVLE. Its innovative value lies in the integration of several types of learning contexts, formal and informal learning contexts, as well as the adoption of a variety of learning theories. By adopting a mixed-methods approach, the aim of this study is to systematically examine the pedagogical effectiveness of SMAVLE and to identify the key features during the students' word-learning process. Specifically, the study addressed the following two research questions:

- (1) What is the impact of SMAVLE on Chinese college students' English vocabulary usage?
- (2) What are the features of SMAVLE in vocabulary learning of Chinese university EFL learners?

II. LITERATURE REVIEW

To construct SMAVLE for college students, this study conducts a comprehensive review of the relevant theoretical frameworks and prior research, including MALL, the concept of seamless learning, and the design principles of SMAVLE. Through critical examination of these theories and research findings, this study underscores the importance of in-depth understanding of such academic foundations, thereby ensuring both the accuracy of its research direction and the effectiveness of the implementation process.

A. *Mobile-Assisted Language Learning (MALL) and Fragmented Learning*

With the vigorous rise of MALL technology, profound changes have occurred in the way language learning is conducted. Since the advent of mobile technology, language learning has transcended the constraints of time and space and thus offered learners a flexible way to engage in learning anytime, anywhere. Due to the portability and functionality of mobile devices, learners have access to flexible learning opportunities and can take full control of their language learning. One of the core benefits of MALL is also reflected in its unique teaching model. Through the incorporation of multimedia, gamification, and immediate feedback, learners are able to learn vocabulary in daily life when they have fragmented time. Overall, MALL has revolutionized language learning by introducing novel learning models, empowering students to take control of their learning, and enhancing learning efficiency. As a result, MALL has become increasingly recognized as a beneficial instrument in the teaching and learning of modern languages (Li et al., 2023).

However, although MALL has made remarkable progress, it still faces persistent challenges in practical implementation, particularly in achieving seamless integration across learning contexts. This challenge is mainly manifested in the failure of many MALL applications to efficiently integrate formal and informal learning environments, which results in a sense of discontinuity. This weakens the coherence of the learning process and decreases the efficiency of the learning process. Based on the findings of Burston (2015), most MALL tools are only utilized in classroom settings or in specific scenarios outside of the classroom. By using a single application, learners in different environments cannot connect formal classroom learning with self-study afterward, which causes their link and limits deep learning opportunities. As Burston (2015) noted, learners often find it difficult to connect classroom learning with self-study after class when MALL tools are not fully integrated. This fragmented learning experience impairs the learner's ability to absorb and understand knowledge, thereby preventing the maximum benefit from learning. Due to this difficulty, in order to overcome it, the development of more efficient integration strategies has become one of the most pressing issues in MALL.

Among Chinese college students, fragmented time for language learning is becoming more common, especially when they face heavy academic loads and extracurricular responsibilities (Zou et al., 2021; Hwang et al., 2020; Yang et al., 2020). According to Chen et al. (2019), this trend is not only influencing learning behaviors but also reflects students' active adaptations and a focus on time management and self-efficacy (Lin & Lin, 2019; Lai & Zheng, 2017). There are, however, several challenges faced by Chinese students in relation to fragmented MALL, including a lack of motivation, external distractions, and a lack of time management (Kukulka-Hulme & Viberg, 2017). MALL exerts a negative impact on the students' learning, particularly among the factors listed above. Due to the fact that this directly affects MALL's effectiveness, it deserves thorough investigation and discussion.

B. *Seamless Learning Theory and the Design of SMAVLE*

As a core concept, seamless learning involves achieving coherence and fluidity between various learning contexts. It was introduced by Chan et al. (2006) and emphasizes the use of mobile and ubiquitous technologies to enhance coherence and depth in learning experiences. Seamless Learning has its theoretical foundation in Distributed Cognition Theory. According to Hutchins (1995), cognitive processes take place both within individuals and as a result of their environment, their tools, and their social interactions. It is within this framework that External Representations play a crucial role in Seamless Learning. Learning activities, as stated by Chai et al. (2016), allow learners to interact with content, thereby facilitating their understanding and construction of knowledge. It is imperative that educators rethink the design of activities in order to accommodate learners who have transitioned from formal to informal environments (Wong et al., 2020), which includes both physical changes in space and technological changes in tools.

As part of the design principles for seamless learning, coherence between activities in different situations is emphasized, as is flexibility in technical support, and the ability of learners to switch between activities (Wong & Looi, 2011). With the development of big data analytics and learning analytics, seamless learning research focuses on analyzing data generated across various environments to optimize teaching and learning. Learning log systems can be used to capture and repurpose learning activities in order to create seamless learning environments. Ultimately, these studies provide empirical support and new perspectives on educational practice, shifting away from focusing on a single environment toward developing a comprehensive, cross-disciplinary curriculum.

A number of technologies, cultural relevance, and theories are integrated into the design of SMAVLE in order to support seamless learning. The first benefit of SMAVLE is that by relying on mobile devices, it can break down barriers between formal and informal learning, allowing learners to access content from anywhere and at any time. With this support, students are able to study in classes, leisure spaces, or even outdoors, therefore achieving learning anywhere and anytime (Milrad et al., 2013). Further, SMAVLE incorporates multimedia content (audio, video, pictures, interactive exercises), which strengthens interactivity and immersion, thereby improving vocabulary learning (Lin & Lin, 2019; Yang et al., 2020). As part of its design, SMAVLE also considers students' prior knowledge and ensures learning content is as practical as possible. Learning vocabulary becomes more authentic when content is combined with learners' prior knowledge (Wong & Looi, 2019). By contextualizing learning, students enhanced in their ability to master vocabulary and to apply words in real-life situations. By incorporating vocabulary exercises into daily activities, SMAVLE provides learners with a natural opportunity to consolidate and expand their vocabulary use.

Based on seamless learning theory and MALL research, this study proposes SMAVLE as a potentially beneficial learning environment for college students who are learning vocabulary. By employing mobile technology, SMAVLE adheres to the core concept of seamless learning and strives to connect vocabulary content across a variety of contexts. In this design, students are provided with the continuity and flexibility they need to learn vocabulary effectively. With its effective information transmission and smooth transitions between learning stages, this program offers a unique environment for vocabulary study for college students.

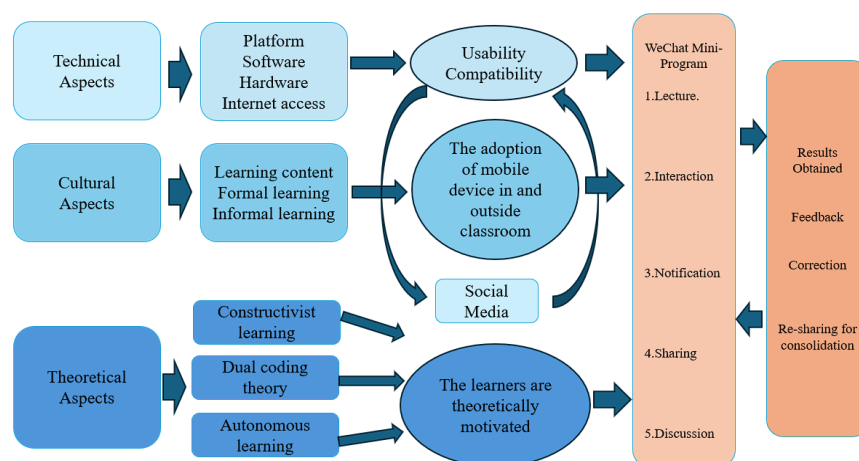


Figure 1. The Conceptual Framework of the SMAVLE

The framework in **Figure 1** comprehensively demonstrates how SMAVLE supports seamless learning through the integration of multi-dimensional modules which cover the design elements and their interrelationships at multiple levels such as technology, culture, and theory, providing a clear perspective to analyze how SMAVLE facilitates seamless learning.

From the technological aspect, SMAVLE relies on core elements like platforms, software, hardware, and Internet access. Hardware performance affects the speed and stability of resource acquisition, while high-quality hardware enables rapid data transmission and stable storage. Good software compatibility ensures smooth operation on various systems, and a simple interface improves usability. Internet stability is key to maintaining learning continuity and allows the learners to smoothly obtain resources and interaction. The design of SMAVLE also incorporates principles of

human-computer interaction (Yang et al., 2020). By leveraging mobile devices, SMAVLE bridges classroom and informal learning, realizing learning anytime and anywhere (Chen et al., 2019).

At the cultural level, SMAVLE integrates formal and informal learning. Formal learning occurs in classrooms with clear objectives and assessments, while informal learning is embedded in daily life with greater autonomy. SMAVLE combines these modes, breaking traditional spatial and temporal limitations. For example, vocabulary acquired in class can be consolidated and expanded in daily life. SMAVLE also incorporates the problem-based learning (PBL) model proposed by Barrows (1996), which emphasizes self-directed inquiry and real-world problem-solving. In this model, learners engage with authentic tasks, allowing vocabulary application across different contexts, thereby bridging learning and daily use.

At the theoretical level, SMAVLE integrates multiple learning theories. Constructivist learning theory (Piaget, 1977) stresses contextualized tasks, and SMAVLE combines real situations to connect semantics, grammar, and context. Dual coding theory (Paivio, 1990) enhances memory by simultaneously presenting text, pronunciation, and images/videos. Self-directed learning theory (Holec, 1981) also plays a vital role, allowing learners to select content and methods based on personal needs, increasing motivation and effectiveness.

Through this literature review, this study establishes a theoretical foundation for designing and implementing SMAVLE and provides a clear direction for subsequent research.

III. METHODOLOGY

A. Research Design

To examine the impact of SMAVLE on English vocabulary use among Chinese freshmen at a university and analyze its features, a mixed research design was employed within a quasi-experimental framework. Specifically, by administering the Vocabulary Knowledge Scale (VKS) test before and after the intervention, quantitative data was obtained to assess the effectiveness of SMAVLE on vocabulary usage. In parallel, qualitative data were collected to explore the features of SMAVLE and its usage patterns in daily learning contexts, and these data were derived from learning logs and interactive performances by students. Aside from assisting in revealing how SMAVLE promotes vocabulary learning, they can support exploring its potential impact on students' learning habits and autonomy. While conducting research, quantitative and qualitative data were collected simultaneously and analyzed independently. As Creswell and Creswell (2018) suggest, integrating different sets of data sources allows for a more comprehensive and detailed interpretation of research findings.

B. Subjects of the Study

In this study, researchers adopted a stratified random sampling method to select research subjects, which are used in educational and psychological research for empirical studies targeting student populations. Students were divided into three levels (high, medium, and low) by the school academic affairs staff based on their English scores on the National College Entrance Examination (NCEE). By doing so, it ensured that the students within each level had a homogeneous level of English proficiency, although there were differences between levels. In this manner, the sample is representative in terms of English proficiency, and the sampling error is reduced. After stratification, students of the same level were randomly assigned to intact classes taught by different teachers. Following this, the researchers randomly selected four intact classes from different disciplines from a total of 128 freshmen who were non-English majors. The experimental group consisted of two classes (N=62), while the control group was composed of two classes (N=66). All participants were native Chinese speakers ranging in age from 18 to 21 years (M=19.2, SD=0.8), and each had 8-10 years of experience in learning English, including English courses at elementary school levels of grades 3-6, junior high school, and high school.

We conducted an independent samples t-test on each group's NCEE scores to ensure comparability before the experimental treatment. It was found that there was no significant difference between the experimental group (M=97.37, SD=7.89) and the control group (M=100.24, SD=8.91; $t=-1.92$, $p>0.05$), which confirms the homogeneity of the groups in terms of English proficiency. According to Creswell and Creswell (2018), stratified random sampling ensures comparability of research subjects under different treatment conditions, which is an advantage of stratified random sampling.

C. Research Instruments

The learning materials were a group of isolated words chosen from the core of College English curricula that belonged to high-frequency words.

As the instrument for assessing students' vocabulary knowledge, the Chinese version of the Vocabulary Knowledge Scale (VKS) developed by Wesche and Paribakht (1996) was adopted in this study. A random selection of fifty vocabulary words was drawn from the core vocabulary list provided in the university English syllabus for both the pre-test and post-test. The scores were attained by items in the VKS test based on five levels (see Figure 2). Accordingly, two foreign language teaching experts independently assessed the performance of the students, strictly adhering to the scoring criteria used by the VKS to ensure objectivity and consistency. The inter-rater reliability coefficient was

calculated at 0.92, which indicates a high level of agreement between the raters. The experts reached a consensus through discussion when discrepancies existed between their scores to ensure reliable data.

1	I don't remember having seen this word before.
2	I have seen this word before, but I don't think I know what it means.
3	I have seen this word before, and I think it means _____ [synonym or translation]
4	I know this word. It means _____ [synonym or translation]
5	I can use this word in a sentence: _____

Figure 2. Vocabulary Knowledge Scale (Wesche & Paribakht, 1996)

In addition, the data regarding SMAVLE features came from the reflective section of the students' learning logs. In the reflection section, students are required to detail the amount of time spent on each learning task, including watching a short video, retrieving target words, writing a learning log, and correcting errors, which provides time-series data for subsequent analysis. Additionally, the students were asked to explicitly list the locations where they performed their learning activities, whether dormitory, library, classroom, or other places, illustrating their spatial preferences for learning. Also, students were asked to record the learning challenges they encountered during the creation of learning materials, such as difficulties with understanding the target vocabulary, confusion in application, and technical difficulties, which provided first-hand information to examine learning challenges in more depth.

D. Experiment Process

Phase 1 (Formal Learning – Physical World). In this phase, the experimental and control groups used the same teaching method. In classroom learning, both groups used the WeChat app “Rain Classroom” for vocabulary teaching, including definitions, examples, and pronunciations of the target words. Using their mobile devices, students took part in live Q&A sessions, group discussions, and vocabulary categorization exercises.

Phase 2 (Informal Personalized Learning – Digital/Physical World). This phase focuses on personalized learning in an informal environment. Based on the SMAVLE design, the experimental group used mobile devices to perform learning tasks flexibly in everyday life situations, such as retrieving information about the target vocabulary, taking pictures of the situation, and writing descriptive sentences, integrating the tasks with real-life contexts. A real-life example of a learning task was combined with the learning task to emphasize flexibility and contextualization. In the control group, students were required to complete vocabulary learning tasks using their mobile devices at a designated study time and location, which included fixed vocabulary exercises (e.g., sentence-building), and these activities were not influenced by classroom or real-life contexts.

Phase 3 (Social and Personalized Learning). In this phase, the experimental and control groups consolidated the comprehension and application of target vocabulary through different tasks. Students in the experimental group selected one target vocabulary word each week and created a short video using a video-editing application to demonstrate real-life use (e.g., narrating a story or role-playing), emphasizing active learning and multiple forms of expression. Students in the control group watched videos prepared in advance by their teacher, covering target vocabulary usage contexts, and recorded the highlights while viewing without performing creative tasks, which were relatively passive.

Phase 4 (Feedback and Consolidation – Digital/Physical World). Students in the experimental group watched the best work selected by the teacher from peer videos and then created a learning log on their mobile devices, which included descriptions of life pictures combined with the target vocabulary, sentence making, and learning reflections, and received instant feedback from the teacher on the mobile platform. In the control group, students recorded examples of sentence construction on paper learning logs, which were corrected by teachers and resubmitted for revision. A digital tool was used by the experimental group to facilitate real-time integration of learning outcomes and feedback, whereas a traditional means of feedback and revision was used by the control group. For this experiment, the learning content, task objectives, and assessment criteria were identical, and the only variable was whether the learning approach was seamless (i.e., integrating formal and informal learning via SMAVLE). This allowed the researcher to assess SMAVLE's specific impact on vocabulary learning.

E. Data Analysis

For the data obtained from the VKS, SPSS 26.0 was utilized to perform measures ANOVA on the pre- and post-test scores to determine whether there were differences in vocabulary learning effectiveness between the two groups.

To analyze data from the students' learning logs, this study applied the content analysis method. As described by Miles and Huberman (1994), the research process was divided into three stages. First, the data was simplified by categorizing and integrating key information extracted from the learning logs with a coding scheme. As an example, temporal data related to various learning tasks was categorized and coded, while similar learning problems were grouped and coded for future processing. Following the data coding stage, a thematic matrix was constructed from the coded data. With learning tasks as rows and time, location, and problem type as columns, this logical layout highlighted features of the SMAVLE application. Lastly, as part of conclusion extraction, the core themes reflecting SMAVLE

features were accurately extracted from the processed data after systematic analysis. These themes provided support for understanding SMAVLE comprehensively.

F. Research Ethics

This study was approved by the Academic Ethics Committee of the university before the research team began the project. Students who participated signed informed consent forms and voluntarily agreed to enroll after being fully informed about the purpose of the study, the mode of participation, and the potential benefits and risks. The data collected was anonymized and kept confidential for research purposes only. To ensure consistency between classes, the researchers standardized the training of classroom teachers, clarifying the teaching process, tasks, assessment, and other operational specifications in advance. There was also a change in the experimental and control groups after the experiment to further ensure that the research did not violate the subjects' interests.

IV. RESULTS

A. Results Regarding Impacts of SMAVLE on Chinese College Students' English Vocabulary Use

Table 1 presents descriptive statistics for the two groups of students who participated in the VKS pre-test and post-test. There was a significant difference in the mean scores of the experimental and control groups, with the experimental group's mean score being 70.95 (SD=7.972, SE=0.981) and the control group being 53.55 (SD=7.010, SE=0.990). This result suggests that SMAVLE appears to be a more effective learning environment to enhance students' ability to use their vocabulary in the real world than the traditional vocabulary learning environment.

TABLE 1
COMPARISON OF VKS POSTTEST RESULTS BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS

VKS	Group Statistics				
	Group	N	Mean	Std. Deviation	Std. Error Mean
	EG-pre	66	44.95	8.626	1.062
	EG-post	66	70.95	7.972	0.981
	CG-pre	62	46.06	7.326	0.930
	CG-post	62	53.55	7.010	0.890

An independent sample t-test was conducted to further analyze the differences between the two groups on the VKS post-test (**Table 2**). Among the experimental and control groups, there was a statistically significant difference in scores, both under chi-square assumptions ($t(126) = 13.09$, $p < 0.001$) and without chi-square assumptions ($t(125.47) = 13.13$, $p < 0.001$). In terms of mean differences between the two groups, the mean difference was 17.41 points (standard error = 1.33), with a 95% confidence interval that ranged from 14.77 to 20.03. Cohen's $d = 2.32$ further supports the significant effect of SMAVLE in enhancing students' vocabulary use.

TABLE 2
INDEPENDENT SAMPLES T-TEST OF VKS POSTTEST RESULTS

		Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
VKS	Equal variances assumed	1.724	.192	13.085	126	.000	17.406	1.330	14.774	20.039
	Equal variances not assumed			13.137	125.464	.000	17.406	1.325	14.784	20.028

Overall, the results of the quantitative data analysis show that when compared with traditional methods of learning English vocabulary, SMAVLE significantly improves students' ability to use English vocabulary effectively and helps them understand vocabulary knowledge more deeply and utilize it more effectively in real-life situations. Not only is this finding a demonstration of the value of SMAVLE in vocabulary teaching, but it also provides empirical support for the theory of seamless learning in language learning contexts.

B. Results Regarding the Features of SMAVLE in Chinese College Students' English Vocabulary Learning Process

For the purpose of collecting data on the features of SMAVLE, the researchers examined the three dimensions of learner participation in reflections posted in the students' learning logs. Among these dimensions were the distribution of learning time, the choice of place for learning, and the engagement of learners in SMAVLE.

(a). Characteristics of Learning Time Distribution

Table 3 summarizes the amount of time students spend on the four main tasks within the SMAVLE per day. As shown in the table, students spent an average of 3.4 minutes, 13.4 minutes, 34.5 minutes, and 10.4 minutes on the four key tasks. The greatest amount of time was spent creating learning logs during vocabulary learning, as it involved taking photographs and editing files.

TABLE 3
TIME SPENT ON FOUR MAIN LEARNING PHASES THROUGHOUT THE DAY
(Figures in parentheses are average times; Proportion is the proportion of learning time in this period to the total daily learning time.)

Time Period	Watching Short Videos	Retrieving Target Words	Creating Personal Learning Logs	Correcting Errors in Artifacts	Total	Proportion
6:00 - 8:20	2.7	3	9.3	7.3	22.3	0.70%
8:20 - 12:00	24.3	61.6	106.6	105.4	297.9	7.80%
12:00 - 14:00	16.8	38.4	82.7	54.6	192.5	5.00%
14:00 - 17:40	69.9	234.7	650.6	75.8	1031	27.00%
17:40 - 19:00	3.9	10.3	82.7	41.1	138	3.60%
19:00 - 21:30	59.5	317.1	776.5	260.4	1413.5	37.00%
21:30 - 6:00	32.9	166.2	439.5	81.4	720	18.80%
All Day	210.1 (3.4)	831.3 (13.4)	2148 (34.5)	626 (10.1)	3815.4 (61.4)	100%

In **Figure 3**, students’ time spent was visualized as it changed throughout the four phases of SMAVLE. It can be clearly seen from the data that students spent considerable time preparing their learning journals after watching video clips and retrieving the information about the target words. Over the course of phase one through phase three, the time invested has increased dramatically. Possibly, this is a result of the fact that in the first stage of learning, students merely viewed the video, which is a passive activity that they routinely engage in in their leisure time. However, as they progressed to the next stage, they gradually realized that they needed to acquire more knowledge of the target vocabulary before creating their learning logs. At the third stage, students were required to incorporate all the relevant information into their creation, which also required a considerable amount of time.

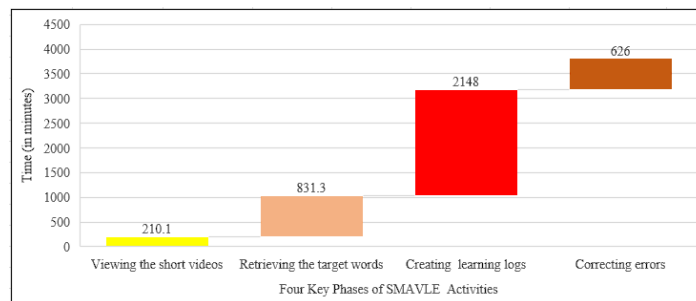


Figure 3. Amount of Time Spent on Four Phases of SMAVLE Activities

To sum up, students spent an average of 3.4, 13.4, 34.5, and 10.4 minutes on four main tasks each day within SMAVLE. It was found that most of the time was spent creating learning logs. Over the course of the learning process, time investment increased significantly from phase one to phase three.

(b). *Characteristics Regarding Learning Locations for SMAVLE Activities*

Figure 4 illustrates the distribution of SMAVLE activities in different locations.

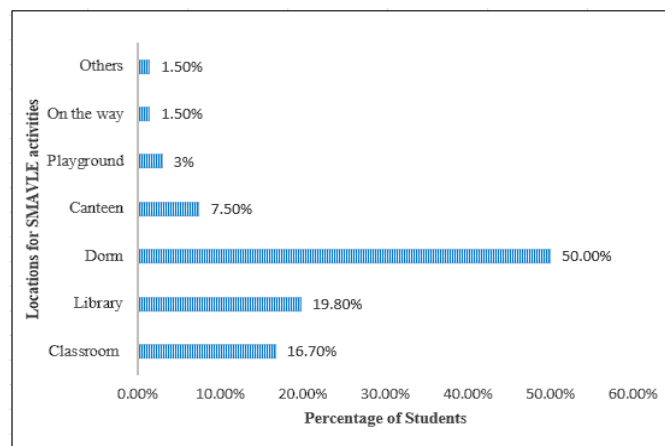


Figure 4. Distribution of Locations for SMAVLE Activities

With a percentage of 50.00%, dormitories were the most prominent location for SMAVLE activities. It is likely that since dormitories offer privacy and relaxation, which promote undisturbed learning, students can engage in SMAVLE learning activities comfortably and conveniently. As the second most popular location, the library received 19.80% of

the votes. Additionally, 16.70% of students choose to study in a classroom. The choice of cafeterias, playgrounds, en-route, and other locations was relatively low, but not negligible. In the cafeteria, 7.5% of students chose to conduct the activities during meal breaks. As an indication of the versatility of the SMAVLE, 3% of students chose the playground, and 1.50% chose on-the-way, which indicated that some students preferred to study in a transitional or recreational environment. The “Other” category, at 1.50%, encompasses a wide range of unspecified locations, demonstrating the adaptability of students’ choice of location for SMAVLE activities.

(c). Characteristics Regarding Learners’ Engagement

Several key themes regarding learner engagement were revealed by a qualitative analysis of student learning logs.

In the first place, students demonstrated a high level of motivation and enthusiasm for participating in SMAVLE activities. The majority of students expressed that they enjoyed creating learning outcomes such as videos and learning journals in their reflections. As one student commented, “*Making videos was fun. It felt more like a creative project than a vocabulary lesson. It makes me look forward to practicing the words.*” This suggests that the multimedia components in SMAVLE increased students’ intrinsic motivation for learning.

In addition, students appreciated the flexibility and autonomy that SMAVLE offered. The data indicated that students engaged in learning activities at varying times and locations, suggesting that they incorporated vocabulary practice into their daily lives through mobile devices. As one learner noted, “*I like the freedom of studying anywhere with just my phone.*” “*I can review vocabulary between classes or at bedtime.*” With this flexibility, students were given the opportunity to take control of the learning process.

A final point to note is that students are attracted to SMAVLE’s social features. A significant portion of the feedback focused on the motivating effects of peer interaction and teacher feedback. “*Watching my classmates’ videos gave me new ideas and motivated me to do better work,*” commented one participant. Many participants described the instructors’ “*instant feedback*” as “*keeping them learning and encouraging them to keep going.*” Social elements such as these appear to reduce isolation during mobile learning. Learning engagement, however, was also challenged. Several students reported experiencing “*technical difficulties*” when using certain application features, which temporarily prevented them from participating in the program. Several other participants reported that they were occasionally “*distracted by notifications*” while learning on their mobile devices. These barriers, although minor, are of concern.

V. DISCUSSION

Regarding research question one, whether SMAVLE impacts Chinese college students’ English vocabulary use or not, the findings indicate that students in the experimental group significantly outperformed the control group regarding the VKS scores. There are several possible explanations for this result.

To begin with, the design of SMAVLE emphasizes the enhancement of vocabulary knowledge by frequently exposing students to real-life vocabulary use in a variety of settings. This is in line with Nation’s (2022) assertion that diverse meetings and varied vocabulary use play an important role in first and second language vocabulary acquisition. “*At its most striking, the new meeting with the word forces learners to reconceptualize their knowledge of that word.*” (Nation, 2022, p. 113). For the experimental group in SMAVLE, students needed to view the videos created by their peers, retrieve the words by themselves, create the learning logs with daily pictures, and correct the errors in their work. As a result of repeated encounters and reconceptualization of the word, they become more familiar with the semantic, grammatical, and pragmatic features of vocabulary, leading to more comprehensive and in-depth knowledge. For instance, students may gain a better understanding of vocabulary usage when they watch videos related to daily life. This makes them more comfortable with vocabulary in real-life situations.

Second, SMAVLE promotes independent learning and interactive participation among students. This increases their motivation and enhances their autonomy as learners, thus promoting vocabulary acquisition. Holec (1981) argues that a self-directed learning environment allows learners to be more in control of their learning process, thus improving learning outcomes. The validity of this concept has been further validated by studies in digital learning environments (Lai & Gu, 2011; Reinders & White, 2016). The adoption of SMAVLE allows students to select their own learning pace and methods based on their needs. This autonomy stimulates students’ interest and motivation in learning. This finding is consistent with Zimmerman’s (2013) study on self-regulated learning in technology-enhanced environments.

Third, SMAVLE has the potential to bridge the gap between formal and informal learning environments. It breaks down the time and space boundaries of traditional learning and offers students a richer, more flexible, and efficient vocabulary learning experience. This is in line with Kukulska-Hulme and Viberg’s (2017) findings that mobile technology facilitates the continuum between formal and informal learning and empowers learners to learn in various settings. By utilizing mobile technology, SMAVLE offers a seamless vocabulary learning experience both inside and outside the classroom in a systematic manner. After class, students are also free to study and review at any time and from any location. SMAVLE is a comprehensive learning environment that integrates vocabulary learning with learners’ real-life situations, in which students consolidate and expand their vocabulary knowledge by studying, searching for information, and recreating real-life scenarios relevant to the vocabulary they have acquired. This is consistent with Gorjian et al.’s (2012) findings that learners can improve their language skills by integrating language

learning into daily life. In addition, by utilizing the convenience and functionality of mobile devices, SMAVLE may provide students with a wider range of opportunities to access and use vocabulary. Students may become more motivated and interested in learning vocabulary and be more likely to retain the information. Similar to Lai and Zheng (2018), their findings suggest that the use of mobile devices can enhance students' engagement in the learning process as well as contribute to improving their performance.

Last but not least, SMAVLE is designed based on several well-established learning theories to maximize students' vocabulary acquisition and application. Specifically, Piaget's constructivist learning theory and Paivio's dual coding theory provide the basis for the system's approach to facilitate active knowledge construction and enhance memorization. Piaget (1977) emphasized that the learner plays a central role in building understanding and knowledge. SMAVLE conforms to this principle by involving students in context-based learning activities that require them to apply vocabulary to real-life situations. According to research (Piaget, 1977), authentic, situated learning experiences enhance deeper understanding and retention of language skills. It was proposed by Paivio (1990) that the combination of verbal and non-verbal mental representations enhances the ability to remember and learn information. SMAVLE capitalizes on this insight by presenting vocabulary through multiple modalities, such as text, speech, images, and videos. There has been a substantial body of research confirming the effectiveness of multi-modal learning materials for enhancing vocabulary acquisition (Khoshnevisan & Le, 2018). By stimulating different sensory channels, SMAVLE aims to facilitate the recall and application of learned vocabulary, creating richer mental representations and associations. While these learning theories provide a solid foundation for SMAVLE, it is important to note that the system's effectiveness likely stems from a complex interplay of factors. Further research is required to determine the relative importance and potential synergistic effects of each factor. Nonetheless, by grounding its approach in established theories and empirical evidence, SMAVLE may offer a promising means of improving students' skills for using vocabulary.

In regard to the second research question, which is concerned with the characteristics of SMAVLE in the process of learning English vocabulary among Chinese college students, several significant findings were found across three dimensions of the study: the distribution of learning time, the choice of learning location, and the involvement of learners.

As far as the distribution of learning time is concerned, SMAVLE has four main tasks in which students allocate different amounts of time, with the majority of time spent on creating a learning log. As the learning process progressed from Phase I to Phase III, there was a considerable increase in the amount of time students committed to the process. The students recognized that vocabulary knowledge was crucial to the completion of the task and, therefore, invested more time and effort as it progressed. This is also in line with Li's (2022) claim that learning vocabulary is influenced by learners' attention and effort.

Second, students' choice of learning locations varied, which is in line with Kukulska-Hulme and Viberg (2017) argument that mobile learning breaks the constraints of time and space and allows learners to experience a broader range of learning opportunities. This study, however, found a surprising finding: Chinese college students are most likely to engage in SMAVLE activities in their dormitory, followed by libraries and classrooms. Several non-traditional learning spaces, such as the cafeteria and playground, also demonstrated the flexibility and convenience of SMAVLE. These results confirm Lai's (2017) conclusion that diverse learning environments enhance learning experiences and improve learning outcomes.

Finally, regarding student engagement, SMAVLE was favored by students due to its high level of motivation and enthusiasm, its flexibility and autonomy, and its social learning features. These findings are consistent with previous studies showing that mobile learning environments can boost learner autonomy and generate intrinsic motivation to learn (Reinders & White, 2016). Furthermore, the study indicated that technical difficulties and distractions have some negative effects on learning engagement, similar to the challenges facing mobile learning outlined by Stockwell and Hubbard (2013) and should be considered.

VI. CONCLUSIONS AND IMPLICATIONS

In this study, we investigated the impact of a seamless mobile-assisted vocabulary learning environment (SMAVLE) on the ability of Chinese college students to use English vocabulary effectively. Results of the study indicated that SMAVLE significantly improved students' vocabulary use abilities as compared to traditional vocabulary learning methods. This result can be attributed to the following design features of the SMAVLE: it emphasizes frequent exposure to and use of vocabulary in authentic contexts; it encourages self-directed learning and interactive participation; it breaks down the boundaries between formal and informal learning; and it is based on well-established learning theories that facilitate learning. Additionally, the study found that students displayed unique characteristics in terms of how much time they allocated for learning, the location in which they learned, and their engagement in learning.

This study has important implications for the teaching of English vocabulary. To facilitate vocabulary learning, teachers should consider creating authentic contexts, utilizing mobile technology to provide flexible, autonomous, and efficient vocabulary experiences, and designing teaching activities that are grounded in scientific learning theories. It is also important that teachers design learning tasks in a manner that makes the most use of students' time, balance their

cognitive input with their time, and improve their participation in learning. In order to provide students with positive learning experience and technical support, schools should develop a better mobile learning infrastructure.

As a final note, there are a few limitations, including a relatively small sample size and short experimental duration. In future studies, the sample size and period of the experiment can be expanded to further investigate the long-term effects of SMAVLE, as well as examine the role that different individual characteristics play in SMAVLE as a basis for developing personalized vocabulary teaching. In terms of generalization, it is likely that it is not possible to do so due to the focus on a single university.

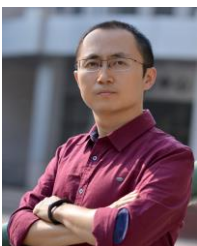
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