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Exploring Deep Learning of English Vocabulary Acquisition from Mobile Learning Environment

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ABSTRACT

With the advent of the 5G era, the rapid development of communication networks has provided comparatively favorable conditions for the popularity of mobile learning. Mobile learning devices, mainly smartphones and tablets, have gradually replaced traditional computer-assisted devices as one of the important forms of learning for learners in the new era. This study summarizes the characteristics of mobile learning as: Ubiquitous; Portable; Personalized; Interactive; Updated; and Seamless. Based on the above characteristics, mobile vocabulary learning has its advantages such as convenience and efficiency, but due to its fragmented learning characteristics. However, the fragmented nature of learning makes it difficult for learners to achieve deep learning. In the content of vocabulary acquisition, deep learning refers to after a word has been learnt, it may trigger associations, images or stories on the basis of the learner's past experiences. In the field of education, deep learning provides an effective solution to the problem of fragmentation in mobile learning and provides a new path and idea for effective vocabulary acquisition. This study uses a combination of questionnaires and empirical research to ask the following research questions: Question 1: To what extent do learners have an understanding of mobile learning of English vocabulary? Question 2: To what extent can deep learning-based mobile learning of English vocabulary improve students' English vocabulary? From the questionnaire survey and the empirical study, we can see that Learners have a degree of understanding of deep learning-based mobile vocabulary learning and that deep learning-based mobile learning of English vocabulary can contribute positively to the acquisition of English vocabulary.

Keywords: Deep Learning; Mobile Learning; L2 Vocabulary Acquisition; CALL; Distance Education

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1. Introduction

With the rapid development of society and the popularity of smart devices and 5G networks, English learning has begun to break through the traditional limitations of paper textbooks and books and move to mobile. English vocabulary, as the foundation of English learning, has always had a pivotal role in English teaching. However, vocabulary teaching, which is the foundation of second language acquisition, is often neglected in the teaching process, and students' acquisition of vocabulary often remains in its fragmented and superficial meaning, while ignoring its internal nature and deeper acquisition of its deeper meaning and use. Therefore, in English vocabulary teaching, deep learning strategies based on cognitive semantics should be introduced to transform students' passive and superficial learning into deep learning that is more in line with the rules of language acquisition.

Mobile learning which was defined by John Taxler (2005) as any educational provision where the sole or dominant technologies are handheld or palmtop devices, the definition empathized the technology aspect of mobile learning as well as pointing out that the devices can be handheld such as smartphone or tablet computer. The traditional e-learning or CALL (Computer Assisted Language Learning) devices like computer or laptop has the feature of media-rich and massive, but the mobile learning surpassed it with the merits of spontaneous, portable and personalized. It is because of these features of mobile learning that many mobile learning vocabulary applications are popping up in the smartphone application market and are downloaded in high numbers, especially the education applications, which are widely popular. However, mobile learning, due to its fragmented learning characteristics, the problem of how to obtain permanent deep learning is always in need of a solution. One of the most fundamental questions both teachers and learners face when teaching or learning a second language is how to efficiently increase long-term retention of vocabulary (Hirschel & Fritz, 2013). At the same time, in order to achieve permanent and deep memory of vocabulary, it is necessary to introduce the concept of deep learning into the mobile learning of English vocabulary.

The concept of deep learning in education was first introduced by the Swedish educational psychologist Ference Marton in his series of papers ON QUALITATIVE DIFFERENCES IN LEARNING with Roger_Säljö (1976). In an empirical investigation of Swedish university students' reading ability, the authors found that the subjects used two distinct information processing processes, one focusing only on the meaning of the text itself, called "surface-level processing," and the other one, which focuses on the intention of the text and the author's directionality, is called "deep-level processing". In Matron's view (Marton & Säljö, 1976), surface learning involves the use of minimal involvement in task completion, and the learner usually focuses on acquisition at the memorization and application levels, but this process does not include reflection on knowledge, and the purpose of learning is usually to achieve a grade on a test. Deep learning, however, involves a willingness to understand and deeply interpret intentions. In deep learning, students focus more on understanding the relationships between the many dimensions of the text, developing hypotheses and their own understanding of the concepts and issues within the text. More attention is given to gaining an intrinsic interest in learning and understanding. Therefore, in English vocabulary learning, we have to apply the principles of deep learning to make mobile learning of English vocabulary more productive.

2. Literature Review

2.1. Features of Mobile Learning

The unique nature of mobile learning makes it different from traditional learning and has a number of features that make it unique. Kearney et al (2012) described three distinctive features of mobile learning in a rationale as "personalization, authenticity and collaboration". Among those three, personalization was regarded as the most important one. Personalization features are also included in mobile learning. These include the ability to customize the experience of learning and the agency of the program (McLoughlin & Lee, 2008). By authenticity, it refers to the tasks in mobile learning that are authentic and provide real-world relevance to the learner (Radinsky, Bouillion, Lento, & Gomez, 2001). By collaboration, it refers to mobile learners using mobile devices that may connect to a wide variety of resources online and also get connected with other learners.

Tarxler (2005) distinguished the unique features and characteristics of mobile learning (m-learning) by making a comparison between m-learning and e-learning. He concluded the core features of mobile learning are as followed: spontaneous; private; portable; situated; informal; bite-sized; light-weight; context aware; connected; personalized; interactive. Ozdamli and Cavus (2011) summarized the 7 characteristics as follows: (i) Ubiquitous/Spontaneous: learners will able to learn at anytime and anyplace. (ii) Portable size of mobile tools: the size of the mobile devices is easy to carry. (iii) Private: usually one user at a time has access to the mobile devices. (v) Interactive: Due to the availability of technology, students are able to engage actively in the learning process. (vi) Collaborative: for collaborative learning activities among students and teachers. (vii) Instant information: the feedback from mobile device is quick and immediate.

Taking the above findings into consideration, this study concludes that mobile learning has the following 5 features.

Ubiquitous: This feature is the most distinctive characteristic that distinguishes mobile learning from other learning methods. ubiquitous can be understood as mobile learning being less constrained by time and place than traditional learning, and mobile learning does not have to be conducted exclusively in the classroom or directed by a dedicated teacher. Learners can take advantage of any available fragmented time to learn. Learning can be informal, with flashcards, visual prompts and tabs in mobile software allowing learners to access information even if they pick up their phone and glance at it. At the same time, learning can take place in a just-in-time manner, so that if you come across any word and want to learn its meaning, you can use mobile learning to look it up immediately. Because mobile learning is linked to a web-based database, the feedback given to the learner is also timely and synchronized.

Portable: The major mobile devices that are currently used for mobile learning are smartphones, smart tablets and electronic dictionaries. This study focuses on mobile learning on smartphones. Smartphones and other mobile devices are portable, light and flexible. Due to their portable characteristics, smartphones or tablets can be used as a supplement to traditional learning. In today's classrooms, especially in second language education, it is common to see students who are being taught in a non-native language bringing their mobile phones or tablets into the classroom. When they are unable to understand the content of the teacher's lecture due to their language proficiency, they can turn on their mobile devices and use the app Otter to get real-time transcription of class note or meeting notes, and they can also use Google translate for simultaneous translation of class content. This timely and portable way of learning makes great use of the wealth of smartphone apps available to complement traditional learning and achieve better results.

Personalized: This feature refers to the fact that in mobile learning, the goal setting, process management and time scheduling of mobile learning can be arranged and carried out exactly according to the learner's own needs. For example, learners can choose materials to suit their own learning objectives, and learners in high school, junior high school and primary school can improve their performance by choosing content that matches their textbooks. For learners seeking to study or work abroad, they can choose materials related to the IELTS or TOEFL exams to improve their language skills, or choose speaking materials to practice their everyday conversations. Learners have a high degree of autonomy over their own learning process, and the content can be customized and personalized. Learners can set the time and frequency of their learning according to their own study habits. Learning is no longer passive, but a highly

personalized learning process in which the learner is involved in the whole process of tailoring the learning program.

Interactive: This feature refers to the active use of the interactive nature of the application by the learner in the mobile learning process. Mobile application enabling human-mobile interaction and communication by the user and the learner at the same time. During the mobile learning process, learners actively participate by providing inputs in the software, which are analyzed as a whole by the application, and the learning plan is tailored to the learner's situation and adjusted to the learner's learning at any time. Tailor-made revision and testing plans are available for learners. At the same time, many of today's applications include learning communities, which are similar to online learning groups or forums, where learners can communicate with other learners and have fun through various types of games, and promote each other through interaction.

Updated: By updated it means all m-learning information is up-to-date and contemporary m-learning applications can be easily linked to the internet with 5g technology and the internet environment and provide access to the latest and fastest information in a timely manner. Outdated information is replaced in a timely manner and learners are exposed to the most up-to-date materials and resources.

Seamless: As more people and children use mobile devices, the scope of networked learning extends beyond the traditional boundaries of homes and classrooms. It can also be used to become part of their daily lives (Sharples, 2000). School classroom can only provide the learners with limited resources and learning materials. Scholars (Chan et al., 2006) who suggest seamless learning propose that learning (in-class and out-of-class; academic and non-academic; curricular and co-curricular) should be a continuous whole. Learners may pick up a piece of interesting information at any time and place accidentally.

2.2. Mobile Learning of Vocabulary

English vocabulary learning within the field of mobile learning has attracted the attention of many scholars. Vocabulary learning with mobile devices allows learners to be exposed to spaced repetition of vocabulary items, which is believed to be more effective than massed repetition (Mahdi, 2018). Mobile devices are used for language learning in a variety of ways. Mobile devices are used for language learning in multiple ways. Researchers have demonstrated that mobile-assisted language learning provides rich, real-time, convenient, and contextualized learning experiences for students, whether they are inside or outside of the classroom(Kukulska-Hulme & Shield, 2008). In examining the pedagogical use of mobile learning in vocabulary acquisition, relevant empirical studies have demonstrated the effectiveness of mobile learning in teaching and acquisition of vocabulary (Wang & Shih, 2015). For instance, Mahdi (2018) conducted a meta-analysis research that compared the outcomes of students learning vocabulary using the traditional way with using the mobile devices, and conclude that mobile devices have moderate effect sizes on both productive and receptive aspect of vocabulary learning. Zeng (2021) reviewed the empirical studies of the effectiveness of mobile apps on EFL vocabulary learning and identified 8 categories of impacts, ranging from retention of the vocabulary to feedback and learning environment. A 5-step(FSVL) strategy was developed and an empirical study was conducted. The results showed that the learning motivation and performance of the FSVL taught students was superior to that of the traditional ones (Huang, Yang, Chiang, & Su, 2016). In general, mobile vocabulary

learning has received more and more attention in recent years, and most of the researchers based on this study have adopted an empirical research approach. Researchers are keen to use empirical research methods to demonstrate that mobile acquisition of English vocabulary is more positive, effective, interactive, ubiquitous, and easier for deep vocabulary acquisition than traditional vocabulary acquisition methods.

2.3. Deep Learning

The concept of deep learning was introduced and discussed in the content of education. Craik and Lockhart (1972) mentioned that a series of hierarchical processing stages is referred to as "depth of processing"; "depth" implies a greater degree of semantic or cognitive analysis. In the content of vocabulary acquisition, for example, after a word is learnt, it may trigger associations, images or stories based on the learner's past experiences of the world. Deep learning in education is a learning approach that aims at constructing meaningful learning, understanding based on memory, generalizing, comprehending, applying, combining original cognitive structures, critically accepting and learning new knowledge, establishing interconnections between knowledge, making judgements and solving problems through analysis. Deep learning focuses more on the understanding and long-term retention of concepts. The main features of deep learning compared with surface learning are shown in the table below.

Table 1.
Deep Learning versus Surface Learning (Zhang, 2012)

	Deep Learning	**Surface Learning**
Routes of Vocabulary Acquisition	Comprehension Memory	learn by rote
System of Knowledge	Make connections between new knowledge and prior to master complex concepts, deep knowledge and other un-structured knowledge	knowledge that is fragmented, isolated, learned in the moment, shallow
Focus	Focus on the core arguments and concepts learned in problem solving	Focus on consensus and extrinsic clues learned from problem solving
Willingness	Active Learning	Passive Learning
Reflections	Progressive deepening of understanding, critical thinking, self- reflection	Lack of reflection in the learning process
Knowledge transfer capability	Be able to transfer and apply what you have learned to practice	Inability to apply what you have learned flexibly
Level of thinking	High-Level Thinking	Low-level thinking
Motivations	Learning because of your own needs	Study because of external pressure

2.4. Construction of Intelligent Mobile Vocabulary Learning System

The 46th "China Statistical Report on Internet Development Status" released by China Internet Network Information Centre (2020) on September 29, 2020 showed that, as of June 2020, the scale of mobile phone Internet users reached 932 million, and the proportion of Internet users using mobile phones to access the Internet reached 99.2%. The number of online education users reached 381 million, accounting for 40.5% of all Internet users; the number of mobile phone online education users reached 377 million, accounting for 40.5% of mobile phone Internet users. In the first half of 2020, under the guidance and impetus of the “classes suspended but learning continues” policy during the COVID-19 epidemic, 282 million school

students across China generally switched to online education, further increasing the level of information technology in education. The level of information technology in education has further improved.

With the popularity of mobile learning and the rapid development of smartphone-based mobile education, learners tend to use fragmented time to learn at anytime and anyplace. A wide variety of English vocabulary learning software has emerged in China and abroad. In the Chinese smartphone application market, the most downloaded English vocabulary acquisition software is Buzzword, which has reached 870,000 downloads in Apple's Chinese application market, and behind its popularity, we can see its Intelligent Mobile Vocabulary Learning System, as shown in Figure 1.

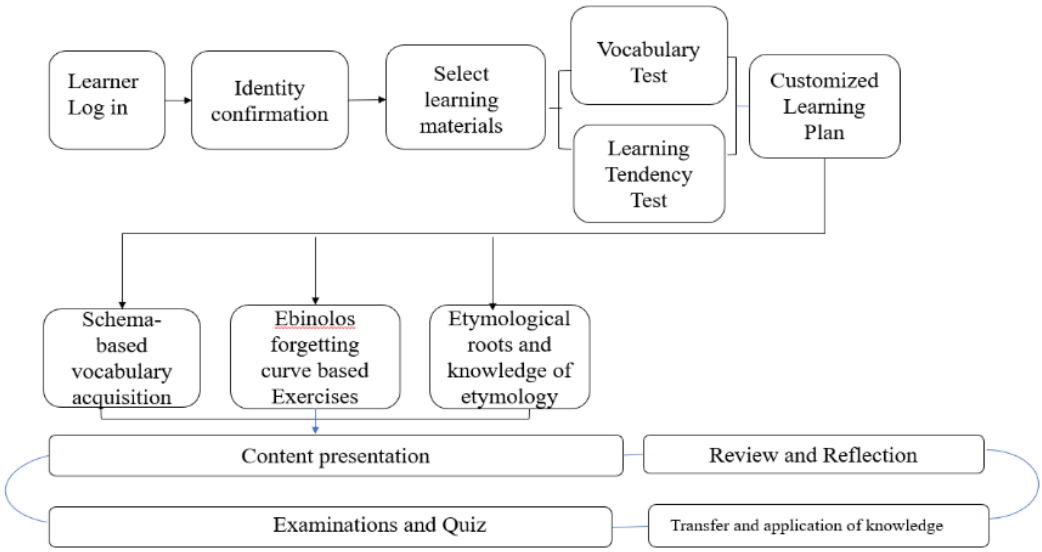


Figure 1. Intelligent Mobile Vocabulary Learning System

From Figure 1, we can see that after the user logs in, the application will set the purpose of the user's learning, and then test the user's English vocabulary to find the appropriate learning method and make a personalized learning plan for the user. The learning plan includes a learning content and a review content. The learning content is based on the schema theory, which selects the appropriate cognitive schema to explain the target vocabulary, while the daily learning plan and review plan are based on the Ebinolos forgetting curve. At the same time, exams and tests are given after a period of time to review what has been learned. Finally, the vocabulary acquisition is consolidated by arranging targeted connections for vocabulary use in the higher-level thinking stage.

2.5. Description of the Mobile Vocabulary Learning Application

With the emergence of the mobile era, vocabulary learning applications have a relatively higher number of downloads in various application markets. This research selects several English vocabulary learning applications with the highest number of downloads in the worldwide and domestic Chinese application markets, and conducts a comparative study of their login interface, user setting interface, learning interface, review interface, and test interface. The study selected Vocabulary-Learn words daily, an English vocabulary learning application developed by Monkey Taps with 44,000 downloads in the app market, and Words Booster, an application developed by SleepSci, with 59,000 downloads worldwide. In the Chinese app

market, the application Baicizhan, developed by Chaoyoucai Tech. was selected for this study, which has 870,000 downloads in the Chinese application market alone.

2.5.1. User identity Setting System

User information setting system is a very important part of mobile vocabulary learning application. In this section, application users can input their identity, learning goals, learning plan tendency, and choose the courses they want to learn. By collecting and analyzing this information, the application can create a personalized learning program for the user. As seen in Figure 2, in the User identity setting system, the application focuses on the learner's learning objectives based on different priorities, e.g. Vocabulary asks learners to choose whether they want to learn English for business or for travel; Words Booster asks learners to choose their own daily word study plan: for example, the number of words and the starting and ending times. Baicizhan, however, allows the user to choose your status as a learner for the next few months, whether you are in elementary school, middle school, high school or as an adult, etc.

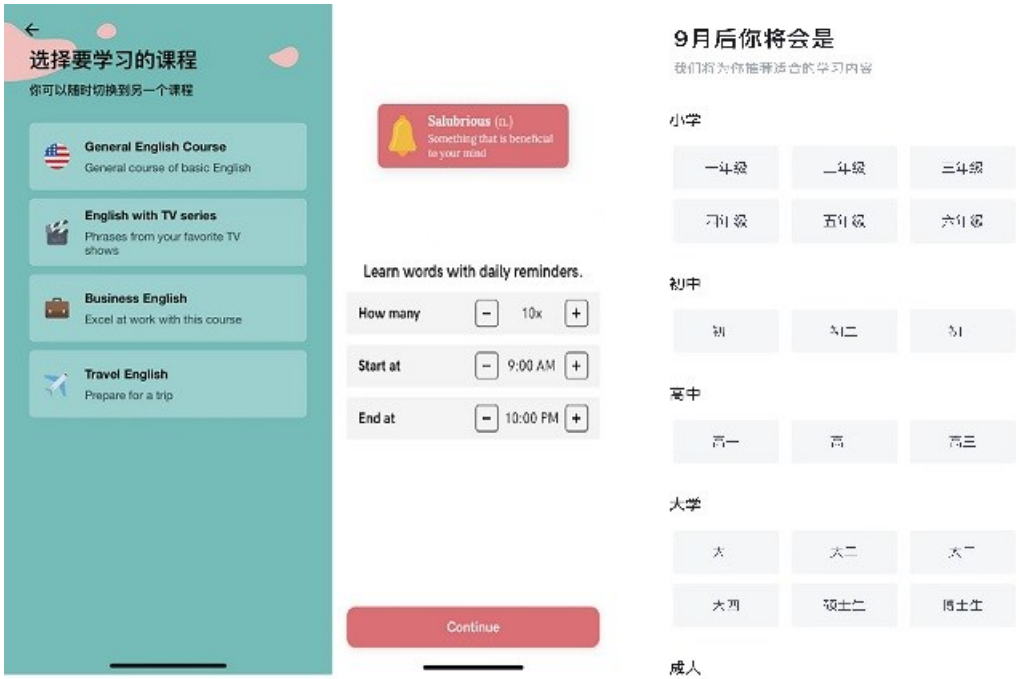


Figure 2. Screenshot for User identity setting system

2.5.2. Selection of Learning Material

Almost all of the applications provide a range of learning materials for learners to choose from, as seen in Figure 3, Vocabulary and Words Booster provide learning materials that focus on different categories of vocabulary in life, such as "Describing People" or "Tech&science". They are based on the practical types of language courses. The Chinese application Bacizhan, on the other hand, is based on different types of vocabulary that learners at different stages of education need to master for certain sorts of English exams. For example, "Vocabulary for college entrance exams", "Vocabulary for TOEFL", etc. This difference also shows that learners in different regions do not have the same focus on learning English, ranging from those who focus on practical usage in daily life to those who focus on passing various types of English exams.

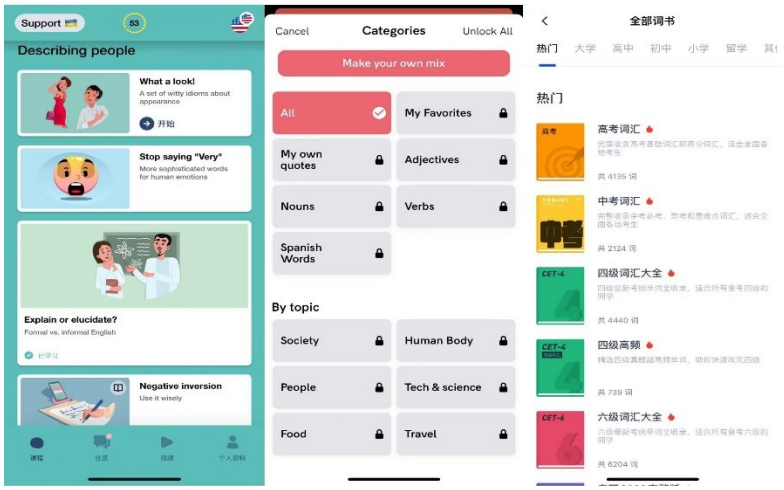


Figure 3. Screenshot for Selection of Learning Material

2.5.3. Presentation of Learning Content

The presentation of the learning content is the core part of the entire vocabulary learning process, and the selection and arrangement of the content is crucial to the extent of vocabulary deep learning. In Figure 4, we can see that the content presentation of Vocabulary is relatively simple, focusing on the explanation of the basic meaning of words and the presentation of example sentences. Words Booster and Baicizhan, on the other hand, take a relatively interesting approach to the presentation of content, with Words Booster using cartoon images that represent the meanings of words, and Baicizhan presenting the content in two parts. At the same time, morphological knowledge of word roots and affixes is provided, and word shapes are designed to be easily remembered.

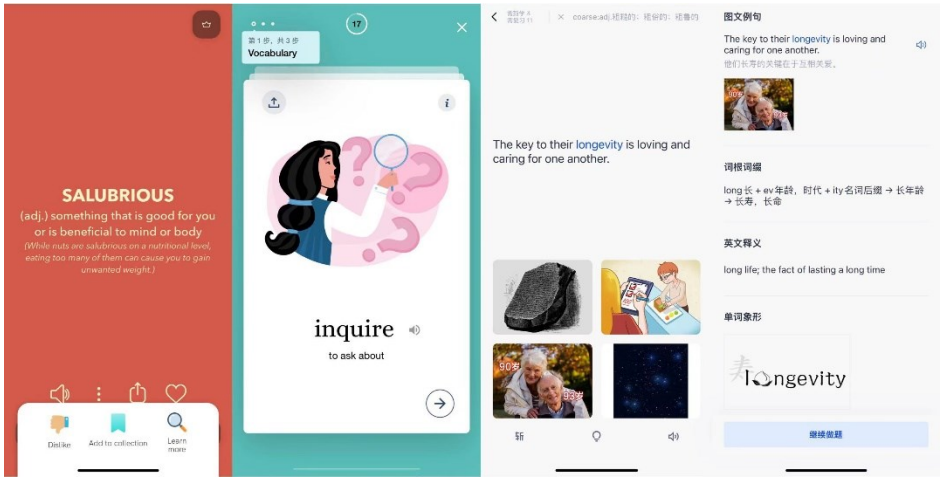


Figure 4. Screenshot for Learning Content

2.5.4. Presentation of Revision and Examination

Review and examinations are effective means of testing and consolidating word acquisition. All three applications have some form of review and examination, as Figure 5 shows. Vocabulary has a relatively simple review format, listing a list of words already learned for the learner to view. Word Booster takes two different approaches to revision. The first is to select the corresponding word based on the picture and the second is to select the corresponding word or phrase based on the English explanation. Bacizhan, on the other hand, offers seven forms of special training, including English-English Meaning Matching, English-Chinese Meaning

Matching, Combined Spelling, Pronunciation Meaning Match, Spelling, Fill-in-the-blank, Read-in the-blank. Users can choose the appropriate revision method according to their needs.

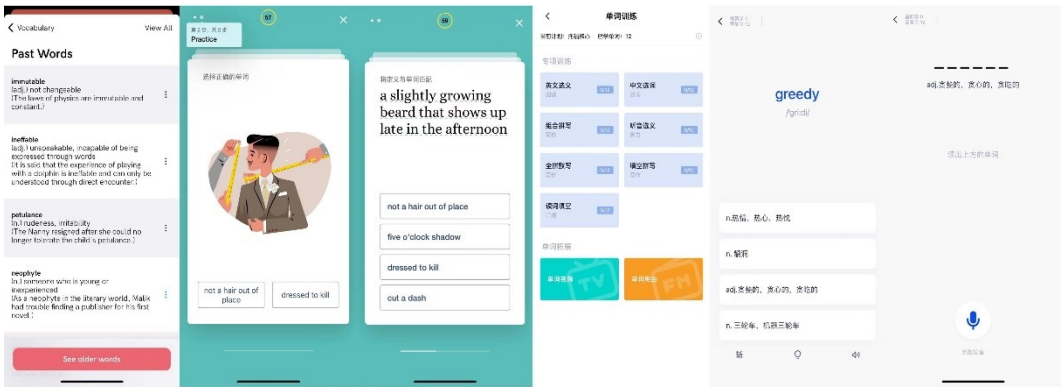


Figure 5. Screenshot for Revision and Examination

3. Methodology

3.1. Participants

In this study, 120 students from a 211 Project key university in China were selected as observation subjects. These subjects were between 17 and 21 years old and were freshmen. The main subjects of this study are freshmen, who not only have the task of passing the CET4(College English Test Band 4) exam in the second semester of their second year of college, but also face the demand for English for job hunting, apply graduate school and study abroad. Therefore, students in this group are more enthusiastic about learning English vocabulary, and we can basically obtain the data we hope to learn from this group. The reason for not including the group in the middle school or high school is that this group of students tends to study English for the purpose of passing the senior high school entrance examination and college entrance exams, and has relatively low requirements for in-depth English vocabulary learning.

These subjects were for preparatory students whose majors had not yet been determined, and they were expected to take four weekly, 45-minute intensive reading courses of college English and two weekly, 45-minute listening courses of college English during their first college years. The experiment was conducted mainly with the intensive reading course. The 120 students came from two classes at the identical pace, and their English teachers were the authors themselves. In this study, one of the classes was set up as the experimental group (N=60), and the vocabulary teaching in the experimental class was based on the deep vocabulary teaching method of mobile learning, while the other class was set up as the control group (N=60), and this group would adopt the traditional teaching method, i. e., reading the words, explaining the meaning, and explaining the words with the content of the text, but no mobile teaching content was arranged, and no mobile teaching aids were used to carry out the experiment.

3.2. Instruments

This research adopts a mixed research approach, in which the researcher uses both qualitative and quantitative research methods in a study or survey project to conduct student interviews, collect perspectives, form research questions, and use questionnaires to quantify the research stages and finally draw conclusions and uncover answers to the research questions. This

method allows us to summarize and organize students' views, as well as to understand their acceptance and recognition of mobile vocabulary learning, so that we can discover students' most authentic views on mobile learning.

The empirical study will also be conducted after the questionnaire survey. A semester-long English vocabulary tutorial based on deep learning of English vocabulary on mobile device will be conducted. The vocabulary instruction for the experimental group is designed to help develop deep vocabulary learning methods. During the vocabulary instruction, word-specific vocabulary instruction is taught using a targeted instructional program. Pre-test, post-test data were recorded, compared, analyzed and conclusions were drawn.

3.2.1. Questionnaire Survey

In order to understand the role of English vocabulary mobile applications in facilitating students' English vocabulary acquisition, we should first conduct a questionnaire survey on respondents' basic information, their demands for English learning, and their preferences for the choices of English vocabulary applications. The questionnaire should also focus on the views and attitudes of whether and to what extent English vocabulary acquisition software can enhance students' deep English vocabulary learning. In the first chapter of this paper, we explored the concept and connotation of deep learning of English vocabulary. We can see from the definition of deep learning that it is a higher level of learning that requires a higher level of willingness, initiative, motivation, and knowledge transfer from learners. However, it is not clear whether and to what extent existing vocabulary learning applications can facilitate learners' deep English vocabulary acquisition; nor do we understand learners' real experiences in using these applications and how they facilitate various aspects of English listening, reading, and writing; so we ask the following questions:

Question 1: To what extent do learners have an understanding of mobile learning of English vocabulary?

Question 2: To what extent can deep learning-based mobile learning of English vocabulary improve students' English vocabulary?

Based on the above research question, a questionnaire was formed to further elaborate on the detailed analysis of the students' perceptions of mobile vocabulary learning behaviors.

3.2.2. Empirical Research

The empirical methodology will be used to compare the test scores of the experimental group and the control group. As shown in Chapter 3.1, two groups of students: the Experimental Group (EG) and the Control Group (CG) were randomly divided into 60 students each, and 20 words of TOEFL core vocabulary were selected for testing as the pretest. Both groups of students were asked to translate the Chinese meanings of the 20 words given to them. As can be seen from Table 2, there is no significant difference in the English vocabulary proficiency of the two groups. The difference between the mean scores of the two groups of students was not significant.

Table 2.
Pretest score of the EG and CG by the one-sample t-test

Items	n	Min	Max	Mean	Std. Deviation	t	p
Pre test CG	60	42.000	70.000	55.600	7.466	88.814	0.000**
Pre test EG	60	32.000	68.000	54.867	7.749	84.832	0.000**

* p<0.05 ** p<0.01

4. Result and Discussion

4.1. The Discussion of Questionnaire Survey

A questionnaire survey on a 5-point Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree') with 7 retrospective questions (14 items) was constructed. As shown in Table 4, questionnaire was measured using Cronbach's alpha, achieving a satisfactory value of 0.767. Questions 1 to 4 of the questionnaire were used to answer the first research questions: To what extent do learners have an understanding of mobile learning of English vocabulary, and what deep learning entails? The research used this questionnaire to examine four aspects of learners' tendency to value English vocabulary mobile learning; learners' mobile learning habits; the amount of time learners spend on mobile learning; and their motivation for adopting mobile learning. Table 2 summarizes the results of the questionnaire (N=52) and several notable findings are addressed below:

- After examining the means of all 7 questions, there were 5 questions whose means were higher than 3.00 and approaching 4.00, which suggested that the participants had a relatively positive attitude towards applying mobile devices to the acquisition of L2 words. See Table 2.
- Question 3.1 to 3.5 indicated the amount of time the participants spend daily on using the mobile device for pedagogical purposes. The responses to the options in this question show that the amount of time the participants spend daily on using the mobile device for the greatest number (69.23%) of participants spent 5-20 minutes daily on their mobile devices to learn vocabulary, followed by 55.77% in the 20-30 minutes group, and a significant number (38.46%) also spent as much as 30-60 minutes daily. The above data indicates that most learners do not spend significant amounts of time on mobile learning, which is related to the fragmented nature of mobile learning. Mobile learning is usually an active rather than a passive learning behavior, so learners often take advantage of every bit of time to acquire vocabulary. See Table 3

Table 3.
The amount of time participants spend daily on mobile device for vocabulary acquisition

Items	N	Proportion
3.1 Less than 5 minutes.	12	23.08%
3.2 5 to 20 minutes	36	69.23%
3.3 20 to 30 minutes	29	55.77%
3.4 30 to 60 minutes	20	38.46%
3.5 More than 60 minutes	11	21.15%
Number of valid samples	52	

- Q1 and Q2 were designed to answer research question 1, These questions were used to reflect users' basic perceptions of mobile vocabulary learning. From Q1's Mean=3.808 we can see that the majority of learners agree that vocabulary is fundamental to English learning and from Q2's Mean=3.712 we can see that more than half of the learners have the habit of using their mobile phones regularly for vocabulary learning.
- Q4 was used to examine the motivations of users for using English mobile learning applications. From the participants' responses, it is clear that the majority of users are more interested in the convenience of the application; the possibility of using fragmented time; and the fact that it is resourceful and interesting. However, they were less concerned with the ability of the application to give them timely feedback, reflecting the fact that learners value the content of the application more than the format.
- Q5, Q6 and Q7 were designed to answer research question 2: To what extent can deep learning-based mobile learning of English vocabulary improve students' English vocabulary? Q6 has the highest Mean=3.864, indicating that mobile devices are more effective in facilitating learners' understanding of vocabulary composition, which is an attribute of deep learning. This demonstrates that among the attributes of deep learning, mobile devices are more helpful in helping learners understand the composition and etymology of words which learners lack in traditional word learning.

Table 4.
Questionnaire on Student's Attitude towards Mobile Learning

Questions	**Mean (SD)**
Q1 I think vocabulary learning is a very important aspect of English learning.	3.808 (0.930)
Q2 I regularly use my mobile device to learn English words.	3.712 (0.957)
Q3 The amount of time I spend each day using my mobile device for English vocabulary study is	
3.1 Less than 5 minutes.	0.231 (0.425)
3.2 5 to 20 minutes	0.692 (0.466)
3.3 20 to 30 minutes	0.558 (0.502)
3.4 30 to 60 minutes	0.358 (0.491)
3.5 More than 60 minutes	0.212 (0.412)
Q4 The main reasons I choose mobile device to learn English includes	
4.1 Easy and convenient to use	0.404 (0.495)
4.2 Richer access to various materials and resources	0.481 (0.505)
4.3 Fragments of time can be used	0.481 (0.505)
4.4 Access to timely feedback	0.192 (0.398)
4.5 Vocabulary recitation in a more active and interesting	0.365 (0.486)
Q5 Mobile vocabulary learning can improve my vocabulary application and association skills	3.692 (0.919)
Q6 Mobile vocabulary learning enables me to understand more about the composition and etymology of words	3.864 (0.937)
Q7 Mobile vocabulary learning has a beneficial effect on my interest in learning English	3.731 (0.992)

4.2. Discussion of the Empirical Study

4.2.1. Result of the Experimental Group (GE) in the pre- and post- Group

The tables below (Table 5 and Table 6) show that the paired t-test was used to investigate the differences in the experimental data, and it can be seen from the table below that a total of 1 set of paired data showed a difference ($p<0.05$). The specific analysis shows that the Pre test EG and Post test EG are significant at the 0.01 level ($t=-25.962$, $p=0.000$) and the specific comparison shows that the mean of the Pre test EG (54.87) is significantly lower than the mean of the Post test EG (85.22). A total of 1 set of paired data would all show variability. This result illustrates that after a semester of training in mobile-based deep learning of English vocabulary, the experimental group's post-test scores improved significantly. It proves that the mobile vocabulary teaching method based on deep learning of English vocabulary contributed positively to the improvement of students' English vocabulary skills.

Table 5.
Paired Samples Statistics of pre- and post- test EG

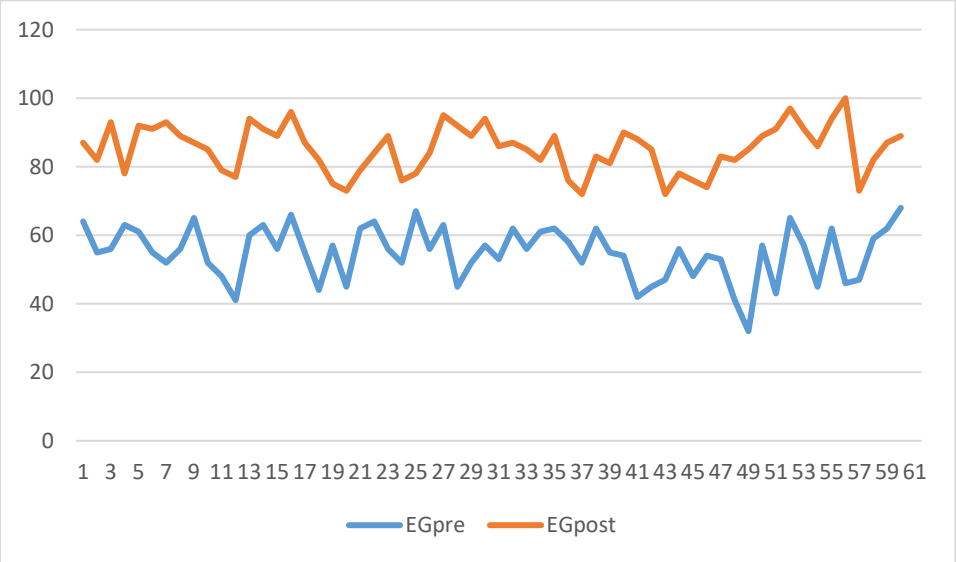
Paired Samples Statistics of pre- and post- test EG

	N	Mean	Std. Deviation	Std. Error Mean
Post test EG	60	85.2167	6.90392	.89129
Pre test EG	60	54.8667	7.74918	1.00041

Table 6.
Paired Sample t-test of EG

Paired Sample t-test of EG

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Post test EG	95.610	59	<.001	85.21667	83.4332	87.0001
Pre test EG	54.844	59	<.001	54.86667	52.8648	56.8685



4.2.2. Comparison of the EG and CG Result

After comparing the pre-test and post-test scores of the experimental and control groups, it can be seen that after a period of training, both the experimental group and the control group experienced an improvement in their scores. The Mean gains of the experimental group increased by 30.35000, while the Mean gains of the control group increased by 22.2333. (see Table 7) This result shows that the experimental group improved more significantly than the control group. The higher mean scores of the experimental group also suggest that the deep learning-based mobile vocabulary acquisition method is a better way to improve the learners' vocabulary performance than the traditional vocabulary teaching method (see Figure 6).

Table 7.
Comparison for Mean Gains of the EG and CG

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Post test EG - Pre test EG	30.35000	9.05506	1.16900	28.01083	32.68917	25.962	59	<.001
Pair 2	Post test CG - Pre test CG	22.23333	8.53381	1.10171	20.02882	24.43785	20.181	59	<.001

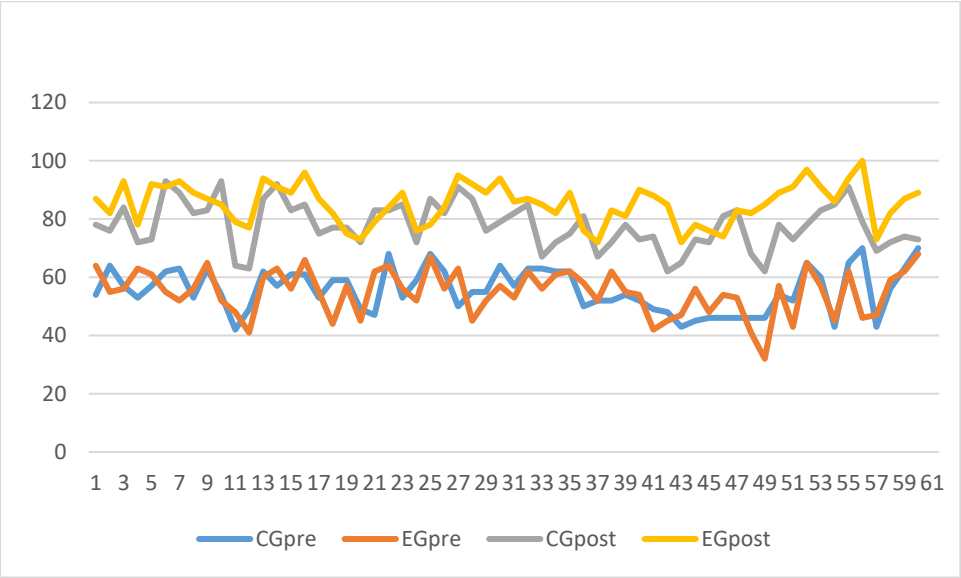


Figure 6. *Comparison of EG Scores and CG Scores*

5. Conclusion

With the advent of the 5G era, communication has become increasingly fast, real-time and time-sensitive, and the way of learning has changed and improved accordingly with the times. On the one hand, mobile learning can facilitate the efficiency and convenience of learning and provide favorable support for learners' independent and fragmented learning. However, on the other hand, mobile learning also suffers from a lack of depth in learning due to the limitations of its nature and methods. Therefore, this study introduces the concept of deep learning from educational theory into mobile learning, hoping to fill the gap of over-fragmentation of mobile learning.

This study summarizes the concepts and connotations of deep learning and reviews the concepts related to mobile learning of English vocabulary. An Intelligent Mobile Vocabulary

Learning System based on deep learning is constructed. By comparing existing English vocabulary mobile learning applications, this study summarizes the features of the applications and their advantageous aspects for English vocabulary learning, and makes recommendations. Using a questionnaire, this study poses research questions and draws conclusions.

The majority of the learners who participated in the survey had some knowledge of English vocabulary mobile learning and were used to using mobile devices for vocabulary learning. The second research question: To what extent can deep learning-based mobile learning of English vocabulary improve students' English vocabulary? After the empirical investigation, it can be concluded that deep learning-based mobile learning of English vocabulary can help learners improve their performance more than traditional vocabulary learning methods.

Disclosure statement

The authors report there are no competing interests to declare.

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