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Study on computer-based systematic foreign language vocabulary teaching

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Since ineffective foreign language (FL) vocabulary teaching has been shown in the higher education of mainland China, this study aims to achieve a satisfactory vocabulary teaching outcome through the construction of a computer-based systematic vocabulary teaching mode. Based on constructivism, the mode was established with three essential teaching phases, which were incorporated with systematic cognitive processes of vocabulary learning, supported by appropriate vocabulary teaching strategies, and also facilitated by computer technologies. To illustrate its efficacy, two classes, altogether 58 non-English major undergraduate students, were selected randomly from a university in mainland China. The participants were divided into two groups by class, which were taught target words under the computer-based systematic vocabulary teaching mode and the traditional paper-based one, respectively. Under the traditional mode, the same teacher adopted the teaching methods as they had normally done in the past, such as rote memorization and mechanical practice with paper-based materials. Through the comparisons of vocabulary achievement in word form, meaning and usage, it was revealed that the computer-based systematic vocabulary teaching mode was superior to the traditional, with a detectable difference either immediately after or one month after the treatment. The significance was further reinforced by the results from a questionnaire survey conducted among the group taught under the computer-based systematic vocabulary teaching mode.

Keywords: cognitive processes, computer technology, FL vocabulary teaching, learning strategies, vocabulary acquisition

1. Introduction

As a basic unit of one sentence, vocabulary is one of the most important targets in language teaching. Vocabulary teaching plays a crucial role in the success of FL teaching. Numerous studies have revealed that the degree to which

vocabulary has been grasped is highly related to the development of various language skills. For instance, vocabulary knowledge is strongly correlated with quality listening (Mehrpour & Rahimi, 2010; Zeeland, 2013), speaking (Akbarian, 2018; Koizumi, 2013), reading (Grabe & Stoller, 2018; Li & Kirby, 2015), and writing (Johnson et al., 2016; Laufer, 2013). However, FL vocabulary learners are often confronted with setbacks when learning vocabulary in terms of both breadth and depth (Vu & Peters, 2021). In mainland China, on one hand, college students lack autonomy. They memorize a large number of words by rote or decontextualized mechanical drills, devoid of using effective vocabulary learning strategies (Wu, 2011). On the other hand, FL teachers usually spend their limited class time on reading comprehension at the expense of vocabulary explanation. They seldom introduce vocabulary learning strategies to their students, which are supposed to prove a strong impetus to vocabulary learning (Li, 2023; Wang & Li, 2018). Nowadays, with the rapid development of computer technology, research (Wu, 2015, 2017; Şahin Kızıl & Savran, 2018) reveals that it has positive effects on learner autonomy or self-directed vocabulary learning from an overall perspective. Then, regarding the significance of vocabulary teaching in FL teaching, as well as the attendant problems arising in it, an integrated vocabulary teaching mode is attempted based on constructivism. Constructivism emphasizes that knowledge is not received via transmission through teachers, while effective learning should start from learners' active participation in the process of learning. This integrated mode is constructed with the involvement of systematic vocabulary learning processes in three essential teaching phases, as well as students' engagement in different vocabulary learning strategies, which computer technologies are applied to initiate. In this interdisciplinary study, covering disciplines such as cognitive psychology, course design, human-computer interaction, and second language acquisition (SLA), teachers are expected to be accountable for the appropriate arrangement of vocabulary teaching contents in systematic vocabulary learning processes and the composition of meaningful strategy-induced computer-based tasks so that both teaching quality and learning motivation could be enhanced.

2. Literature review

2.1 Constructivism and computer technology

In recent decades, FL language teaching has been actively advocating for constructivism, which is derived from the development perspective of Piaget (1936), the cognitive psychology of Bruner (1966), and the social development theory of Vygotsky (1978). Constructivism provides strong support for the argument that knowledge is not received via transmission through teachers while effective learning should start from learners' active participation in the process of learning. During this process, learners are active processors of information and constructors of new knowledge. They try to make sense out of the materials presented to them and build meaningful cognitive representations actively. Social constructivism further underscores that meaning is constructed

by learners themselves from the socio-cultural context with the help of teachers, peers and learning resources. In light of social constructivism, Williams and Burden (2001) identify four key factors that influence the learning process: teacher, learner, task, and context. They interact as a part of a dynamic, ongoing process. Mayer (2003) summarized, "Cognitive constructivism rests on the premise that knowledge construction occurs within the minds of individual learners, so learning is essentially a psychological event" (p. 144) while social constructivism "is based on the premise that constructed knowledge is stored within social/cultural groups so learning is essentially a sociocultural event" (p. 145). For FL vocabulary teaching, constructivism is also thought to be applicable. In other words, the success of vocabulary acquisition is both a process of discovering and constructing word knowledge by students themselves and an outcome of their interactions with others. During the teaching process, teachers compose meaningful tasks, through which students are motivated to acquire word knowledge by themselves.

The concept of constructivism has an important implication for instructional technology (Hof, 2021). Constructivism is aimed at fostering and guiding independent learning and activating appropriate cognitive processes that lead to learners' understanding. Under this approach, instructional technology may serve as a cognitive guide to help learners promote their efforts on making sense out of the materials presented during various teaching or learning tasks by activating their prior knowledge or modeling the steps of problem-solving. Instead of just offering access to advanced technology, the focus should be on promoting learners' cognitive processing through the assistance of technology. Schneiderman (1993) states that constructivist notions of learning as activity, exploration, and creation are well suited to the computer environment.

2.2 Vocabulary learning processes

Learning processes are defined as the psycholinguistic and cognitive processes within an integrated learning model that can facilitate learning in a certain field. They have a direct effect on both learning efficiency and outcome. A small number of reflections on the processes of vocabulary acquisition (Hatch & Brown, 1995; Nation, 2001; Webb & Nation, 2017) have come forth in recent decades. In light of previous research, a new framework of systematic vocabulary learning processes was designed and justified, including word concentration, construction, confirmation, connection, consolidation, and composition (Wu, 2012). Word concentration determines what is important in the sensory input and it is a prerequisite for subsequent processing. Next, students construct new word knowledge from phonological, morphological, syntactic, semantic, and pragmatic aspects, and the interrelations among the knowledge. In the following, students need to confirm all the knowledge of the new word that they have constructed in the preceding process. In the process of word connection, students associate the new word with its related words. Word consolidation is an important reinforcing process, providing more varied exposures and elaboration of the new word in a variety of contexts. What is more, word

composition refers to the generation of the new word for production, which involves retrieving the word and generating it in either spoken or written form, in different grammatical forms, with different meanings, or within different contexts.

2.3 Effects of computer technology on vocabulary teaching

Nowadays, computer technology has become increasingly indispensable in a variety of fields, such as economy, education, and culture. Regarding tertiary education, computer technology can provide favorable conditions for the FL teaching reform so as to enhance teaching quality as well as learning efficiency. Its unique features entail texts, images, audios, videos, hands-on tools (e.g. electronic dictionaries and corpora), and opportunities for authentic online communication (Chang, 2021; Cheng & Chen, 2022; Dziemianko, 2022; Liu, 2022; Mueller & Jacobsen, 2016; Thomas et al., 2012; Zeng, 2017; Zhang, 2021). Those features can help students achieve a good understanding of language knowledge and use different learning strategies effectively. Based on Kern's (2006) distinction, there are three essential roles of technology in language learning, i.e. tutor, tool, and medium. The distinction is also applicable to vocabulary teaching. Some research has a particular focus on the effects of computer technology in FL vocabulary teaching. Regarding the tutor role of technology in vocabulary teaching, various research (e.g. Dizon, 2016; Manik & Christiani, 2016; Mirzaei et al., 2015; Wang et al., 2015) has shown that language teachers can instruct students to gain more vocabulary knowledge in its breadth or depth by using computer-based drill and practice programs. Meanwhile, the computer-based instruction is proven to be valid by the preference from students and their enhanced motivation. Then, the tool role of technology also has an immense potential in vocabulary teaching, including the employment of audios, videos, online dictionaries, and corpora. For instance, language teachers can make use of audiovisual materials to help students achieve a better performance in either receptive or productive vocabulary learning (Hsu, 2017; Montero Perez et al., 2018). In classroom teaching, corpora can provide information which may not be accessible in other sources. Mizumoto and Chujo (2015) reinforce the use of data driven learning (DDL) approach with corpora in the classroom. Thus, it is apparent that corpus-based language teaching has become a new trend in language teaching. As for the medium role of technology in vocabulary teaching, computer-mediated communication (CMC) allows new forms of interaction among students, teachers, and peers, which lays more emphasis on the learning process rather than the learning outcome. Learners can collaboratively negotiate meanings and solve problems in word learning with their teachers, peers, and native speakers (Bueno-Alastuey, 2011; Cañado, 2010; Yanguas, 2012; Zeinali Nejad et al., 2021).

Despite the potential applications of computer technology in vocabulary teaching as mentioned above, noticeable problems exist. First, most research touches upon the effects of computer technology on one particular aspect of vocabulary teaching. In other words, there is a lack of comprehensive research

on its overall effects. Some research only gives a brief introduction to the effects of computer technology on vocabulary teaching and few in-depth empirical studies are conducted in it. This problem is especially apparent in the relevant research from mainland China. Finally, some studies are only concerned with drill and practice under teachers' instruction that makes target words being learnt isolated without adequate contexts. As a result, the conditions for long-term word retention and good word transfer are hard to satisfy. Thus, compared with the previous computer-based vocabulary teaching, this research attempts to investigate a more integrated computer-based vocabulary teaching approach.

3. Construction of computer-based systematic vocabulary teaching mode

Based on constructivism, this research constructs a computer-based systematic vocabulary teaching mode, which is demonstrated below in Figure 1.

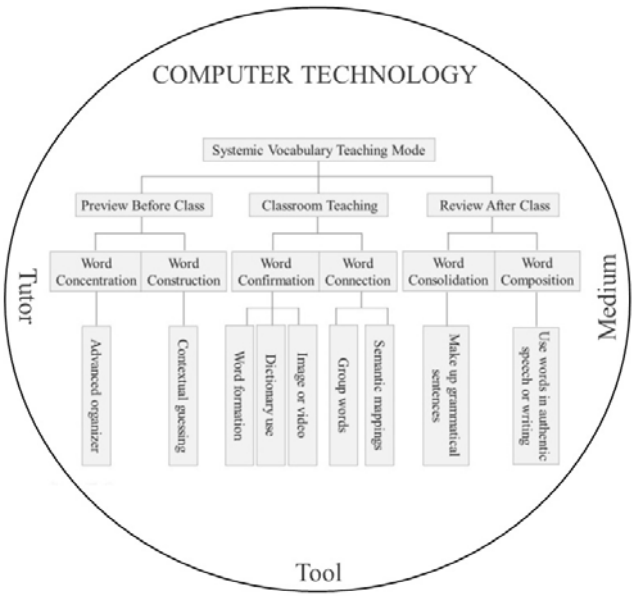


Figure 1. Computer-based systematic vocabulary teaching mode

The mode construction is expected to help promote FL vocabulary teaching as well as learning. First, a systematic FL vocabulary teaching mode is established. It covers three essential teaching phases: preview before class, classroom teaching and review after class. In particular, a series of systematic vocabulary learning processes (Wu, 2012) is incorporated in the procedure for teaching and learning efficiency, including word concentration, construction, confirmation, connection, consolidation, and composition. These cognitive processes are well suited in the three teaching phases respectively, which can not only facilitate students' vocabulary knowledge discovery and construction but also increase their learning interests and motivations. The incorporation aims to encourage the teacher to help students initiate their mental efforts on word

discovery and construction, and their use of various vocabulary learning strategies (e.g. advanced organizer, contextual guessing, image or video, dictionary use, word formation, semantic mappings, group words, make grammatical sentences, and use words in authentic speech or writing) in a systematic way, ultimately achieving long-term word retention and good word transfer.

Moreover, under the constructivist approach, and with the rapid development of computer technologies, computer technology may help achieve a constructive physical environment as a cognitive guide to help students activate their prior knowledge or modeling the steps of solving problems. Kern (2006) puts an emphasis on language learning and explicate the roles of technology in terms of tutor, tool, and medium. In the tutor role, computers provide instruction, feedback, and testing in different dimensions of language learning. In the tool role, computers provide access to verbal and non-verbal stimuli relevant to the language being studied and reference tools, such as online dictionaries and concordances. In the medium role, computers provide platforms for interpersonal communication, distance learning, and identity formation. Likewise, computer technology can be applied in the newly constructed systematic vocabulary teaching mode to further establish the computer-based systematic vocabulary teaching mode, facilitating the strategy-induced task building in each of the systematic vocabulary learning processes for the promotion of both teaching quality and learning efficiency. It wraps the warmth around all the essential teaching phrases.

In order to alter the current worrisome situation of traditional FL vocabulary teaching in mainland China, which mostly relies on rote memorization and mechanical drills, the study on the efficacy of the integrated vocabulary teaching mode above is urgently needed. It is expected to achieve a significantly more satisfactory vocabulary teaching outcome under the computer-based systematic vocabulary teaching mode in comparison with the traditional mode. This study attempts to attain the objective by addressing the two questions below:

RQ1: Does the computer-based systematic vocabulary teaching mode assist the teacher to improve teaching quality and thereby significantly enhance students' learning efficiency compared with the traditional paper-based mode?

RQ2: Are students satisfied with the computer-based systematic vocabulary teaching mode, especially the teaching conditions provided by computer technology?

4. Method

4.1 Participants

Two classes, altogether 58 non-English major undergraduate students, were selected randomly from a key university in mainland China. They were divided into two participating groups by class for the purpose of this study. They came from different schools and studied in different fields, such as sociology, economics, medicine, electronic science, and technology. On average, they had

already studied English for ten years, mastering 3,000–3,500 English words, which is the basic requirement for passing the National College Entrance Exam. Although they were from different departments or schools, and in different grades, they studied the same course titled "Academic English (An Integrated Course)" and were instructed by the same teacher during the experimental semester. In addition, based on the scores gained by the two groups in both the post-test and the delayed post-test, the Kolmogorov-Smirnov tests failed to reject the null hypothesis that the values came from a standard normal distribution. For the purpose of this study, the teacher taught the two groups target words under the computer-based systematic vocabulary teaching mode and the traditional paper-based mode, respectively. In order to guarantee its validity, the target words were chosen based on their formality level and use frequency. Before the commencement of the experimental semester, the teacher chose 28 academic words from the first five units in the textbook. The words are shown in Table 1.

Table 1. Academic words selected from the first five units in the textbook

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
devout	incentive	*ruminate*	escalate	synthesize
nourishment	*incur*	*surmountable*	*align*	indistinguishable
dislocation	obligate	aptitude	*upheaval*	perplexity
testify	*accountable*	debilitating		divergence
incorporate		submissive		*purview*
deter		nurture		perennial
monopoly				*promulgation*
comparative				

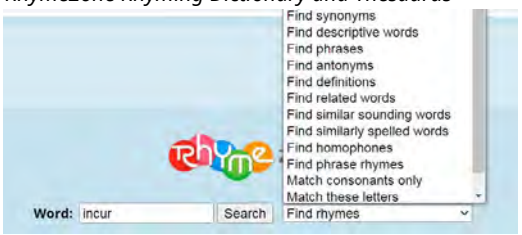
Then, the participants were invited to attend a questionnaire survey in the previous lecture before the start of each unit, which helped determine whether they knew the chosen words from each unit. Even if they ticked the item "I know the word", the Chinese translation was required. The word would be judged unfamiliar if the translation was filled out incorrectly. Consequently, ten words (italic words in Table 1) were targeted based on statistical analyses and they were considered the most unfamiliar to both groups. This can ensure that the two groups were at the same level when the teacher taught them the target words.

4.2 Teaching materials

Two versions of teaching materials on the same target words were adopted for the study. For the group under the computer-based systematic vocabulary teaching mode, computer technology was applied in the three teaching phases to build up meaningful tasks, which encouraged the students to experience different vocabulary learning processes and utilize diversified vocabulary learning strategies. Table 2 provides the meaningful tasks for one of the target words – "incur".

Table 2. Computer-based vocabulary teaching tasks ("incur" as an example)

Phase	Process	Strategy	Computer-based task example
Preview before class	Word concentration	Advanced organizer	*Lecture PPT* INCUR Still, some argue that the costs imposed on BP are insufficient to cover 44 the damages that were **incurred**, and that the theory of constrained profit maximization is inadequate. (Text A Para. 4)
	Word construction	Contextual guessing	*Corpus of Contemporary Amercian English (COCA)* 
Classroom teaching	Word confirmation	Image or video	*http://smallbusiness.chron.com/factored-companys-ordinary-loss-77649* **What Is Factored Into a Company's Ordinary Loss?** by Jackie Jackson  Jackie Jackson Senior Financial Analyst **What Is Factored Into a Company's Ordinary Loss?** There are two types of losses that a company can incur, an ordinary loss and a capital loss. Find out what is factored into a company's ordinary loss with help from a senior financial analyst in this free video clip.
		Dictionary use	*Online Longman Dictionary of Comtemporary English* From Longman Dictionary of Contemporary English **in·cur** /ɪnˈkɜː $ -ˈkɜːr/ verb (incurred, incurring) [transitive] *formal* 1 if you incur a cost, debt, or a fine, you have to pay money because of something you have done **incur expenses/costs/losses/debts etc** If the council loses the appeal, it will incur all the legal costs. the heavy losses incurred by airlines since September 11th 2 if you incur something unpleasant, it happens to you because of something you have done **incur somebody's displeasure/wrath/disapproval etc** She wondered what she'd done to incur his displeasure this time.
		Word formation	*Online Etymology Dictionary* **incur (v.)** c. 1400, "bring (an undesirable consequence) upon oneself;" mid-15c. as "become liable for (payment or expenses)," from Anglo-French *encurir*, Old French *encorir* "to run, flee; commit, contract, incur" (Modern French *encourir*), from Latin *incurrere* "run into or against, rush at, make an attack;" figuratively, "to befall, happen, occur to," from *in-* "upon" (from PIE root ***en*** "in") + *currere* "to run" (from PIE root ***kers-*** "to run"). Related: *Incurred*; *incurring*.

Classroom teaching	Word connection	Semantic mappings	*Visual Dictionary and Thesaurus | Graphwords.com*  
		Group words	*RhymeZone Rhyming Dictionary and Thesaurus* 
Review after class	Word consolidation	Make grammatical sentences	*Some Students' Work* What have you done to incur such a huge amount of debt? (Cai) I have developed the habit of procrastinating which sometimes incurs some criticism from my superior. (Cao) Heavy losses have been incurred because of his irresponsibility. (Hu) She wondered what she had done to incur his anger this time. (Li) Students who were found to cheat in exams must incur grave consequences. (Lin) A company may incur losses if it produces something of low quality. (Liu) The tsunami incurred a considerable loss to the seaside city, and fortunately no one was injured throughout this natural disaster. (Mi) You would better not do this thing in that it might incur a big loss to you. (Xi) Such behaviors will just incur more jealousy from others. (Xiang) Your carelessness can incur a big disaster. (You) The dishonesty of the man incurred his girlfriend's anger. (Zhou)

For the group under the traditional paper-based mode, the teacher employed direct and simple teaching materials and strategies as before. A questionnaire survey on the strategies used by students in the preview and review under the traditional mode was conducted to investigate how the students previewed and reviewed the target words under the traditional mode. Based on descriptive analyses, the three most frequently used strategies in the preview and review were discovered. Table 3 highlights the strategies.

Table 3. Three most frequently used strategies in the preview and review under the traditional mode

Preview		Review	
look up electronic or book dictionaries	89.3%	memorize by rote	50.0%
understand words from textual contexts	53.6%	transcribe or dictate words	32.1%
check new word lists	21.4%	check new word lists	25.0%

It indicated that most students resorted to mechanical and monotonous vocabulary learning strategies.

4.3 Instruments

For achievement comparisons between the two groups, two vocabulary tests were carried out immediately after and one month after the treatment. Because the participants were not informed of the post-test and the delayed post-test beforehand, the two tests were almost the same with only alterations made in the sequence of question items. The test was designed to examine word form, meaning and usage. It specifically includes dictation, choosing the correct spoken forms of target words and providing Chinese translations, finding out the synonyms, filling the gaps of contextual sentences, and making up grammatical sentences. Analyzed from the scores gained by the students in both the post-test and the delayed post-test, the results showed acceptable coefficients ($\alpha 1 = 0.859$; $\alpha 2 = 0.830$).

Moreover, the students under the computer-based systematic vocabulary teaching mode were invited to attend a questionnaire survey, reflecting on their satisfaction levels towards the newly constructed teaching mode, especially the conditions provided by computer technologies. The items are listed in Appendix A. For the convenience of statistical analyses, the 5-point Likert scale was employed from "not helpful" to "very helpful" in the questionnaire. Different values from 1 to 5 were attached to the choice items. Based on the questionnaire results, a good reliability was highlighted with a coefficient ($\alpha = 0.845$), and the value of Kaiser-Meyer-Olkin (KMO) equals 0.748, which indicates an acceptable validity.

4.4 Data collections and analytical methods

Both groups participated in the post-test immediately after the treatment and the delayed post-test one month after the treatment. The time limit for each test was about 30 minutes. Fifty eight valid test papers were received afterwards in each test. The same teacher graded the two groups randomly against the scoring criteria. All the raw data collected from those tests were analyzed statistically via SPSS V21.0. The scores of both groups gained in the post-test and the delayed post-test were then compared to identify whether the computer-based systematic vocabulary teaching could greatly promote teaching quality and

then cause detectable differences in word knowledge gain between the two groups either immediately after or one month after the treatment.

Immediately after the treatment, a questionnaire survey (see Appendix A) was conducted among the group taught under the computer-based systematic vocabulary teaching mode. It was intended to investigate whether the learning strategies initiated in this mode were conducive to students' vocabulary learning. The survey was carried out within 20 minutes. All the questionnaires were well completed.

4.5 Procedure

The whole teaching experiment lasted 10 weeks within one semester, including 5 sessions. During the teaching weeks, the group under the computer-based systematic vocabulary teaching mode was instructed by the teacher using the computer-assisted materials prepared for the 5 units throughout the three teaching phases, i.e. previewing before class, classroom teaching, and reviewing after class. The students were required to preview the target words before the lectures of each unit. Then in the lecture, the teacher explained the relevant knowledge of the words by using diversified vocabulary learning strategies, as displayed above, in the part of teaching materials, and gave reviewing assignments at the end. Another group under the traditional paper-based vocabulary teaching mode also experienced those three teaching phases. Before the lectures of each unit, the teacher required the students to preview the target words. In the lecture, the teacher explained the word knowledge solely with several examples isolated from contexts. At the end, the students were asked to drill those words by doing some mechanical exercises in the textbook after class. Additionally, there were two assessment weeks. A post vocabulary test and a questionnaire survey were conducted during the first assessment week immediately after the teaching weeks, and a delayed post-test was carried out during the second assessment week one month later.

5. Results and discussions

First, the scores gained by the two groups in the post-test were compared in Table 4.

Table 4. Independent samples t-test on the scores of two groups gained in the post-test

Group	N	Mean	SD	t	df	Sig. (two-tailed)
The computer-based systematic mode	30	81.43	13.33	2.778	54	.007**
The traditional paper-based mode	28	70.96	15.35			

**p<0.05

The mean score of the group taught under the computer-based systematic

vocabulary teaching mode (81.43) was much higher than that of the group under the traditional paper-based mode (70.96) immediately after the treatment. Moreover, the independent samples t-test result indicated a significant difference between the two groups of mean scores. The t-test value of 2.778, with 54 degrees of freedom, was significant at the 5% level ($p = 0.007<0.05$). Therefore, the superiority of the computer-based systematic vocabulary teaching over the traditional paper-based teaching was detectable immediately after the treatment, which indicated the significant improvement of both teaching quality and learning efficiency. The effect size value (Cohen's $d = 0.73$) also showed a relatively large effect of the computer-based systematic vocabulary teaching mode on the students' vocabulary achievement immediately after the treatment.

The comparison between the scores of the two groups achieved in the delayed post-test is revealed in Table 5.

Table 5. Independent samples t-test on the scores of two groups gained in the delayed post-test

Group	N	Mean	SD	t	df	Sig. (two-tailed)
The computer-based systematic mode	30	82.80	10.15	2.490	54	.016**
The traditional paper-based mode	28	75.18	13.07			

**p<0.05

The mean score of the group taught under the computer-based systematic vocabulary teaching mode (82.80) was still higher than that of the group under the traditional paper-based mode (75.18) one month after the treatment. Furthermore, the independent samples t-test result showed that the t-test value of 2.490 with 54 degrees of freedom was significant at the 5% level ($p = 0.016<0.05$). The superiority of the computer-based systematic vocabulary teaching was reinforced. It was implied that compared with the traditional paper-based teaching mode, the computer-based systematic vocabulary teaching mode could not only help students gain more word knowledge but also retain it for a longer time, both of which showed significance. Meanwhile, the effect size value (Cohen's d = 0.65) suggested that the computer-based systematic vocabulary teaching mode still had a moderate effect on the students' vocabulary achievement one month after the treatment.

In addition, the results of the questionnaire survey conducted in the group taught under the computer-based systematic vocabulary teaching mode are displayed in Table 6.

Table 6. The questionnaire survey conducted in the group taught under the computer-based systematic vocabulary teaching mode

	Items	N	Mean	SD
1	Teacher highlighted target words with the help of PPT in class.	30	4.13	0.900
2	Students inferred the meanings of target words based on different authentic contexts extracted from *COCA* before class.	30	4.23	1.006
3	Students understood the usages of target words based on different authentic contexts extracted from *COCA* before class.	30	4.33	0.922
4	Teacher helped students understand the historical origins of target words by using *Online Etymology Dictionary.*	30	3.67	1.061
5	Teacher helped students understand the meanings and usages of target words by using *Online Longman Dictionary*.	30	3.87	1.042
6	Teacher helped students understand the meanings of target words by displaying the relevant images in class.	30	3.90	0.845
7	Teacher helped students understand the meanings of target words by playing the relevant videos in class.	30	4.17	0.791
8	Teacher helped students know about the related words to target words via *RhymeZone Rhyming Dictionary and Thesaurus* in class.	30	3.77	0.971
9	Teacher helped students know about the related words to target words via *Visual Dictionary and Thesaurus* in class.	30	3.73	0.868
10	Students made grammatical sentences with target words and saved them in the electronic form after class.	30	4.33	0.884

The results indicated that most of the participants favored the computer-based systematic vocabulary teaching mode, especially the vocabulary learning strategies initiated by the teacher in the mode. Among them, five strategies were considered by the students greatly helpful to their vocabulary learning (mean>4.00), including "Teacher highlighted target words with the help of PPT in class", "Students inferred the meanings of target words or understood their usages based on different authentic contexts extracted from COCA before class", "Teacher helped students understand the meanings of target words by playing the relevant videos in class", and "Students made grammatical sentences with target words and saved them in the electronic form after class". It was discovered that the survey results were in line with those from the previous research on the effect of particular vocabulary learning strategy use, the usefulness of computer technology in one particular aspect of vocabulary teaching or learning, or the combined effect of them. Firstly, the teacher is responsible to orientate students towards the noticing of target words through highlighting them in various forms. Numerous studies (Mackey, 2006; Radwan, 2005; Schmidt, 2001) agree that noticing plays a significant role in the process from knowledge input to its intake during language development. In comparison with the traditional paper-based mode, the applications of computer technologies can make target words salient in a more vivid and distinct way, which may help students notice those words immediately. Lexical inferencing is considered one of the most important strategies in vocabulary learning by some researchers (Ke & Koda, 2019; Pulido, 2007; Wesche & Paribakht, 2010). Guessing word meanings from

contexts is a more effective way to guarantee elaborative processing than presenting word knowledge directly because greater cognitive efforts are made so that long-term word retention can be achieved. However, it is not always easy for learners to make successful inferences mostly due to insufficient contextual cues in reading texts. Then, the teacher can instruct students to retrieve abundant authentic examples with rich contexts from corpora, discovering and constructing target word knowledge (word meaning and usage) by observation. Plenty of research (Alsehibany & Abdelhalim, 2023; Lee & Lin, 2019; Lee et al., 2019; Liu & Lei, 2018) indicates that FL teaching quality and learning efficiency can be enhanced with the help of corpora and a concordancer. In addition, a generative theory of multimedia learning proposed by Mayer (1994) stresses that meaningful learning only occurs when learners are engaged in active thinking, including visual and verbal thinking, in the different phases of cognitive processing. Animations or videos embedding both target words and visual images are considered the best candidates to improve FL vocabulary teaching or learning (Arndt & Woore, 2018; Montero Perez et al., 2014; Peters et al., 2016). Finally, in the light of the Comprehensible Output Hypothesis put forward by Swain (1985), learners need the opportunities for meaningful use of their language knowledge in order to attain grammatical competence. Making up grammatical sentences may provide such opportunities for vocabulary teaching or learning, which is a process of transferring a new word from a receptive word to a productive one. During the process, students not only pay attention to the semantic knowledge of the new word but also its syntactic knowledge. As a result, its meaning and form become increasingly linked. It is also viewed as the necessary step towards real communication. Moreover, students can save the sentences they have made up in an electronic form so that they can use them for later review or as reference at any time.

Other five strategies were also approved by the students (mean>3.50), i.e. "Teacher helped students understand the historical origins of target words by using *Online Etymology Dictionary*", "Teacher helped students understand the meanings and usages of target words by using *Online Longman Dictionary*", "Teacher helped students understand the meanings of target words by displaying the relevant images in class", and "Teacher helped students know about the related words to target words via *RhymeZone Rhyming Dictionary and Thesaurus* or *Visual Dictionary and Thesaurus* in class". The survey results also conform to those of previous research on the effect of particular strategy use, the usefulness of computer technology or the combined effect of them. First, etymology investigates the history of a word, such as when it entered a language and how its form and meaning have been derived over time. It not only helps students confirm word meanings but also enlarges their vocabulary. With regard to online dictionaries, research (Fan, 2011; Lo, 2024; Peters, 2007) mentions that using online dictionaries could strengthen students' memory of a new word. Particularly, the students with low language ability could benefit from the provision of an online dictionary. Then, based on the Dual Coding Theory (Paivio, 1990), which proposes that a combination of imagery and verbal information improves information processing, many studies (Al-Seghayer,

2001; Khezrlou et al., 2017; Yanguas, 2009) indicate that images are typically better remembered than words so that students may remember words better if they are tightly associated with images. Finally, the teaching method of using *RhymeZone Rhyming Dictionary and Thesaurus* or *Visual Dictionary and Thesaurus* is originated from concept maps. Dexter and Hughes (2011) state that the use of concept mapping can increase vocabulary knowledge. Concept mapping enables students to construct a mental model, which supports learning processes (Amadieu & Salmerón, 2014). It can stimulate students' metacognitive awareness in information processing, which assists them to monitor their learning and retrieve knowledge (Liu, 2011; Liu et al., 2010). Also, concept mapping may increase students' learning interest (Shirzadeh et al., 2014), elevate their motivation (Soleimani & Nabizadeh, 2012), and facilitate their logical thinking (Ritchhart et al., 2009).

Regarding the overall evaluation towards the computer-based systematic vocabulary teaching mode, a majority of students believed that it could help achieve high teaching efficiency (mean = 4.00). In other words, the integrated mode can help students develop different vocabulary learning strategies in a series of systematic vocabulary learning processes as well as in the favorable teaching conditions created by computer technology.

6. Conclusion

Owing to the importance of vocabulary teaching in FL teaching and the serious problems with its traditional practice, a computer-based systematic vocabulary teaching framework was formulated in this study. In comparison with the group taught under the traditional paper-based mode, the group studying in the computer-based systematic vocabulary teaching mode received significantly higher scores in both the post-test and the delayed post-test. It indicated that the latter group could not only gain more word knowledge but also retain the knowledge for a longer time, and more importantly, the effects that the integrated mode brought were detectable. Furthermore, based on the results of the questionnaire survey, the computer-based systematic vocabulary teaching mode was thought to be satisfactory in promoting the efficiency of FL vocabulary teaching by enhancing students' use of different vocabulary learning strategies during a series of vocabulary learning processes. In short, from a theoretical perspective, the new established computer-based systematic vocabulary teaching framework provides comprehensive insights into FL vocabulary teaching from an integration of teaching phases, processes, strategies, and methods with assistance of computer technology. Meanwhile, the application of the new framework into the real teaching justifies its efficiency as well as efficacy from a practical perspective for further exploration on it.

It needs to be acknowledged that this study has several potential limitations. First, the research objectives could be more insightful. Besides the study on an overall effect of the integrated vocabulary learning mode, the respective effects of three involving factors, i.e. vocabulary learning processes, vocabulary learning strategies, and computer technology, can be further investigated. The future

work aims to discover which of the three factors plays a more vital role in the promotion of teaching efficiency so that the integrated mode in this study can be optimized. Another limitation is that the design of computer-based teaching materials used in the experiment could be further improved. For instance, the teaching task initiating the strategy of using words in authentic speaking and writing, which was excluded in this study due to limited practical conditions, should be created under the medium role of computers because it is a crucial step for students to produce the target words in real communication. Lastly, another English course could be targeted in anticipation of more students selecting it for the purpose of enlarging the sample size, and a longitudinal study could be carried out to include more target words and extend the period from the immediate post-test to the delayed post-test, which can better differentiate between word memorization and acquisition. Overall, with more prudent considerations, the computer-based systematic vocabulary teaching mode is attempted to be optimized in the future work and thus a more satisfactory FL vocabulary teaching outcome can be achieved.

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Appendix A

Questionnaire on computer-based systematic vocabulary teaching

Part I. Personal information

Gender: □ Male □ Female

Department: _____

College English courses you've taken before: _____

Part II. Attitudes toward computer-based systematic vocabulary teaching

Not helpful ← □ 1—□ 2—□ 3—□ 4—□ 5 → Very helpful

1. Teacher highlighted target words with the help of PPT in class.

2. Students inferred the meanings of target words based on different authentic contexts extracted from *COCA* before class.
3. Students understood the usages of target words based on different authentic contexts extracted from *COCA* before class.
4. Teacher helped students understand the historical origins of target words by using *Online Etymology Dictionary*.
5. Teacher helped students understand the meanings and usages of target words by using *Online Longman Dictionary*.
6. Teacher helped students understand the meanings of target words by displaying the relevant images in class.
7. Teacher helped students understand the meanings of target words by playing the relevant videos in class.
8. Teacher helped students know about the related words to target words via *RhymeZone Rhyming Dictionary and Thesaurus* in class.
9. Teacher helped students know about the related words to target words via *Visual Dictionary and Thesaurus* in class.
10. Students made grammatical sentences with target words and saved them in the electronic form after class.

Overall, I think the computer-based systematic vocabulary teaching is _____.

□ Very Poor □ Poor □ Fair □ Good □ Very Good

* These items were originally written in Chinese for the convenience of respondents.