Language Learning & Technology
ISSN 1094-3501 CC BY-NC-ND

2024, Volume 28, Issue 1
pp. 1–23

ARTICLE

An innovative pictographic glosses design for East Asian EFL vocabulary learners: Effects on retention performance and situational interest

Liu-Cheng Pan, Shenzhen Polytechnic University, Shenzhen, China; The Education University of Hong Kong, Hong Kong SAR

Jerry Chih-Yuan Sun, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

Abstract

Taking into account the challenges of EFL vocabulary learning for East Asian learners, this study developed a set of experimental English vocabulary material with pictographic glosses which may stimulate students' situational interest (with dimensions of exploration intention, instant enjoyment, novelty, attention demand, challenge, and total interest) in learning vocabulary and facilitate their vocabulary retention. To examine the effectiveness of the learning material, this study utilized a within-subjects quasi-experimental design. The participants were 108 graduate and college students who used the learning materials presented in text-only, text-with-picture, and pictographic formats in an online learning system. Results revealed that students' retention performance on the pictographic materials was significantly higher than on the text-only materials, while no significant differences were found between the pictographic and text-with-picture materials. The perceived situational interest in the pictographic material was significantly higher than in the other two formats. The results suggest that the pictographic vocabulary material could trigger EFL learners' situational interest and help to promote their English vocabulary learning. It could therefore serve as a novel approach to designing EFL vocabulary materials for multimedia environments.

Keywords: *Pictographic Glosses, EFL Vocabulary Learning, Retention Performance, Situational Interest*

Language(s) Learned in This Study: *English*

APA Citation: Pan, L.-C., & Sun, J. C.-Y. (2024). An innovative pictographic glosses design for East Asian EFL vocabulary learners: Effects on retention performance and situational interest. *Language Learning & Technology*, *28*(1), 1–23. https://hdl.handle.net/10125/73559

Introduction

Vocabulary teaching and learning plays a crucial role in English as a Foreign Language (EFL) education. Meanwhile, vocabulary knowledge is an important factor in EFL learners' reading comprehension and language proficiency. Although vocabulary learning encompasses a number of different and diverse research focuses and involves a wide range of pedagogical strategies, Schmitt (2008) pointed out that the very initial and fundamental task of vocabulary learning refers to the retention of the word's form-meaning link. Numerous EFL vocabulary learning studies have compared the retention and recall effects of different vocabulary presentation strategies (e.g., introducing multimedia annotations with pictures, animation, video, audio, etc.) and the powerful mnemonic effects of multimedia have been discussed by several scholars (e.g., Al-Seghayer, 2001; Chun & Plass, 1996; Yoshii & Flaitz, 2002). There are many forms of multimedia-assisted English vocabulary instruction in the category of intentional vocabulary learning and vocabulary materials with printed words and still pictorial glosses are widely used in practice, since such presentations are paper-based and do not need any electronic devices.

The concept of multimedia aids facilitating vocabulary learning is inspired by a framework of cognitive

theories such as the *Cognitive Theory of Multimedia Learning* (CTML) (Mayer, 2005) and the *Cognitive Load Theory* (CLT) (Paas et al., 2003; Sweller, 1988, 1994, 2005). A classical empirical study showed that multimedia-assisted vocabulary materials (using annotation of pictures and text) can lead to better retention of vocabulary (Chun & Plass, 1996). When learning lexical items, different modes of glosses considered redundant instructional materials could be retrieval cues for learners and could serve as a motivator for activating learners' dual channels in multimedia environments, drawing on the ideas of the *Dual Coding Theory* (Paivio, 1990). However, there are also restrictions to multimedia material design from a cognitive load perspective. Notably, the redundancy effect and the split-attention effect play eminent roles in language learning and have produced controversial findings (e.g., Diao & Sweller, 2007; Machado & Luchini, 2018; Samur, 2012; Yeung et al., 1998). It has been concluded that redundant presentation should be eliminated to free working memory for effective learning (Machado & Luchini, 2018). Therefore, many researchers have reviewed and reflected on the constraints on the use of multimedia (e.g., Abdulrahaman et al., 2020; Magner et al., 2014; Mayer et al., 2001; Molitor et al., 1989). Mayer (2005) stated that "all multimedia messages are not equally effective" (p. 31), and concluded that "presenting too many elements to be processed in visual and verbal working can lead to overload" (Mayer & Moreno, 2002, p. 111). Based on these concerns, we believe that the configuration of displaying pictorial glosses in EFL vocabulary materials should be reconsidered.

On the other hand, the process of EFL vocabulary learning is generally considered boring and painstaking, especially for the conventional learning approaches of paper-based wordlists or pair-associations (new words presented with their translations). Schmitt (2008) discussed students' engagement in learning vocabulary and stated, "even the best materials are little good if students do not engage with them" (p. 338). Some scholars have addressed the affective and motivational functions of pictures when using multimedia materials. Moreno (2006) extended Mayer's CTML (2005) and proposed the Cognitive-Affective Theory of Learning with Media, which suggested that multimedia materials with pictures could facilitate learning performance by stimulating learners' interest and positive emotion (Moreno, 2006; Park et al., 2014). Therefore, we had reason to investigate learners' affective experience (e.g., situational interest, which refers to positive emotions in response to certain stimuli or conditions) when developing and evaluating the efficacy of multimedia-assisted EFL vocabulary materials.

Considering the potential drawbacks of the traditional text-with-picture vocabulary materials, the innovation of this study is the development of EFL vocabulary materials with a pictographic design, as well as the examination of its effectiveness in terms of EFL learners' vocabulary retention and situational interest. Pictographs are used in ideographic writing systems such as ancient Chinese characters and Japanese kanji, which include semantic features that suggest the meaning of the word to be represented. Inspired by this, we developed a set of pictographic EFL vocabulary material which integrated semantic-related pictures and target English words into one compound (see Figure 1). The materials were originally designed for East Asian and especially Chinese-speaking EFL learners, as we believe that those who are familiar with ideographic writing systems have natural advantages that would allow them to grasp such presentation, since most Chinese characters carry a component of the meaning of the character according to the six categories of Chinese characters (Chen, 1993; Shen, 2010). Therefore, the concept of pictographs in this study may accord with their linguistic habits and cognitive mode. However, we did not want to underestimate the cognitive and affective effects of the pictographic glosses on those with other cultural backgrounds.

To our knowledge, no existing studies had been found that used a similar concept of pictographic glosses we proposed to aid EFL vocabulary retention performance. Besides, to gain a more comprehensive understanding, there is an urgent need to explore experimental pictographic glosses used in the EFL vocabulary learning context with a particular focus on its affective perceptions. We hoped that the pictographic glosses could avoid being merely decorative and deemed as irrelevant information for complete vocabulary retention, in accordance with the seductive details effect (Garner et al., 1989; Harp &

Mayer, 1998; Mayer et al., 2001), which refers to the hindering effect on learning induced by topical-relevant decorative elements in learning materials, and the coherent effect (Mayer, 2005; Reimann, 2003), which indicates that students learn more deeply when extraneous materials are excluded. In addition, we expected that the pictographic EFL vocabulary materials could trigger higher situational interest than either text-only glossing word lists or traditional text-with-picture vocabulary materials, leading to deeper processing during vocabulary learning. This study aimed to evaluate the pictographic EFL vocabulary materials using an immediate recognition test and situational interest self-report scale, hoping to provide insights into the theoretical research of multimedia instruction design. The following research questions were investigated:

RQ1: Can pictographic vocabulary materials enhance EFL learners' situational interest in comparison with text-only and text-with-picture vocabulary materials?

RQ2: Can pictographic vocabulary materials improve EFL learners' retention performance in comparison with text-only and text-with-picture vocabulary materials?

Figure 1

An Example of a Pictographic Vocabulary Design

Note. The pictographic item "pollution" depicts an image of exhaust fumes polluting the air. This example is only to convey the concept and was not included in the experiment materials.

Literature Review

Multimedia and Pictographic Design in Vocabulary Learning

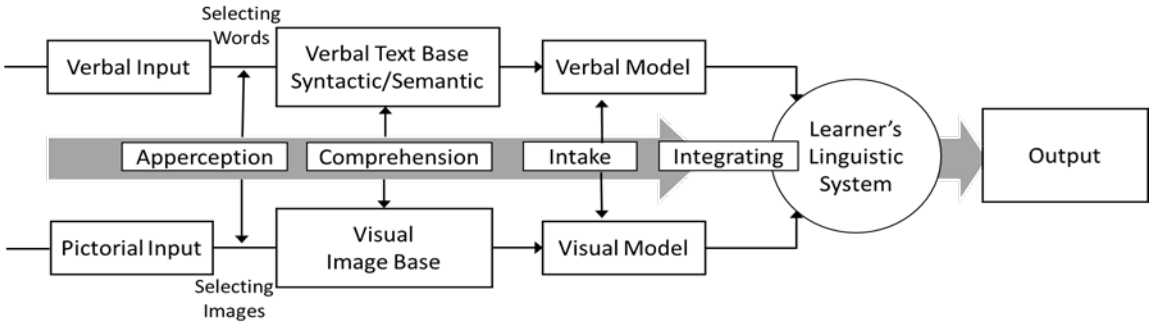
Multimedia-assisted EFL vocabulary materials and tasks were developed using a cognitive approach and based on the understanding of learners' cognitive processing of information. The mechanism by which pictorial information promotes vocabulary learning can be explained by Paivio's Dual Coding Theory (1990) and Mayer's Cognitive Theory of Multimedia Learning (2005). The dual coding theory assumes that humans have verbal and nonverbal cognitive subsystems that are specialized for the processing of verbal (or linguistic) and nonverbal (or imagery) stimuli, respectively. Recall and recognition are enhanced when information is presented in both visual and verbal form and associatively processed (Clark & Paivio, 1991; Paivio, 1990). Dual Coding Theory has been fruitfully applied to a wide range of educational issues, of which learning foreign vocabulary is an excellent example (Reed, 2006). Based on the dual-coding assumption, Mayer analyzed multimedia-based learning environments and proposed the Cognitive Theory of Multimedia Learning, which stated that multimedia with verbal and pictorial messages can facilitate problem-solving/transfer and recall/retention achievements (Mayer, 2005). To be more specific, CTML suggested that learners remember better from multimedia materials that combine words and relevant pictures than learning from words alone (see Mayer, 2005; Reimann, 2003). When presented with multimedia materials, learners can process verbal and pictorial information with visual and verbal channels, and organize selected information into coherent representations, which may optimize the use of working memory and facilitate retention performance (Mayer, 1997, 2005).

In the field of language learning, Plass and Jones (2005) proposed a model of second language acquisition

that incorporates elements of CTML, and emphasizes the important role of images in the process of language acquisition. According to this model, learners select relevant verbal input and pictorial input, and follow the procedure of apperception, comprehension, and intake. They construct verbal and visual mental models and integrate them into their linguistic system (see Figure 2). The formation of the integrated coherent mental model optimizes the use of learners' cognitive architecture, and provides learners with two types of retrieval cues of the learned material compared to only one when they learn with text alone; as a result, learning performance is enhanced.

Figure 2

The Integrated Model of Second-Language Acquisition with Multimedia



Note. From The Cambridge handbook of multimedia learning (p. 471), by J. L. Plass and L. C. Jones, 2005, Cambridge University Press. Copyright 2005 by the Cambridge University.

Applying vocabulary learning, several studies have consistently shown that students acquire vocabulary better when both visual and verbal annotations are displayed rather than when only verbal annotations are shown (Ahangari & Abdollahpour, 2010; Al-Seghayer, 2001; Chun & Plass, 1996; Emirmustafaoğlu & Gökmen, 2015; Jones, 2004; Kost et al., 1999; Yoshii & Flaitz, 2002). It is well-established that pictorial aids in vocabulary materials can facilitate learning, yet the positive effect only appears when the multimedia materials are properly designed. However, in several studies, some drawbacks of multimedia material that hinder vocabulary learning, reading, and comprehension processes emerged in certain circumstances (Acha, 2009; Boers et al., 2017; Samuels, 1967, 1970; Saunders & Solman, 1984; Solman et al., 1992).

One possible reason that has been discussed is that the effectiveness of multimedia instruction is sensitive to cognitive load. This echoes Mayer's (2005) limited capacity hypothesis that learners' limited working memory capacity blocks them from processing multiple representation materials, especially for those with limited prior vocabulary knowledge. Effective learning occurs when learners' verbal and non-verbal cognitive subsystems are simultaneously activated; meanwhile, the perceived cognitive load does not exceed the cognitive capacity of either of the learner's subsystems when interacting with the multimedia materials (Mayer, 2005; Mayer & Moreno, 2003; Plass et al., 2003; Sweller, 2005). Some scholars have claimed that the modality could be a source of extraneous cognitive load, and could hinder learning when students are forced to split their visual attention while processing the text-with-picture materials (Park et al., 2015). In some cases of ineffective multimedia vocabulary learning, the role of pictorial aids is threatened by the redundancy effect and causes extraneous cognitive load (Liu et al., 2012). If the verbal annotation is self-explanatory for learners to build a form-meaning link and complete word retention, the pictorial aid might merely serve as a "decorational picture" (p. 7) that shows no or little relationship to the textual content, as categorized in Carney and Levin's (2002) taxonomy of different functions of illustration. These "decorational pictures" share the similar concept of "seductive details" (pp. 41, 43) introduced by

Garner et al. (1989). These seductive pictures in learning materials are attractive but only have topical relevance, and may impose extraneous cognitive load by splitting learners' visual attention and disrupting their building of a coherent mental model, as a result leading to poorer learning performance (Park et al., 2015). However, if learners have sufficient cognitive resources, the motivating function of seductive details could emerge, since the intriguing pictures could attract learners to focus on tasks and thus lead to higher performance (Park et al., 2015; Park et al., 2011). Therefore, Park et al. (2011) argued that the impact of pictorial information on learning outcomes lies in whether the level of the cognitive load caused by the seductive details is excessive. Considering the notions of CTML and cognitive load theory, designing vocabulary materials with pictorial aids should be undertaken with caution. Pictures in vocabulary materials should not be merely decorative. The words and pictures should be highly semantically related, and the associations between them should be well-elaborated. In this case, although the verbal annotations are self-contained, the pictorial aids provide similar information but in different modalities, and learners' visual channel could be activated, thus facilitating their learning.

Addressing this concern, this study provided a configuration of displaying EFL vocabulary material by borrowing the concept of Chinese pictographic characters. Pictographic design in English vocabulary materials is novel; however, the concept of pictographs is quite familiar to those who use logographic languages such as Chinese. The pictographic materials were designed by integrating the word form and pictorial information into a single compound; we expected that learners would not need to split their visual attention between the verbal and pictorial information when processing the pictographic materials, thus avoiding the split-attention effect. Moreover, the use of pictographic glosses is an application of the multimedia effect, which has the same essence as traditional vocabulary materials with pictorial glosses, and is expected to have facilitating effects on learning performance from a multimedia learning perspective. Additionally, the *Level of Processing Hypothesis* (Craik & Lockhart, 1972; Craik & Tulving, 1975) posits that the extent to which information is processed determines how well it is remembered. According to this hypothesis, processing information at a deeper level (i.e., semantic processing) leads to better retention than processing it at a shallower level (i.e., phonemic or structural processing). In the context of this study, spatially integrated word-picture compounds may provide a well-elaborated form-meaning link, which could encourage learners to perform deeper-level encoding operations and predict better retention.

Research into Situational Interest

Many researchers have argued that the design of multimedia material should consider the learner's affective status (Chen & Sun, 2012; Chen & Wang, 2011). There is empirical evidence that multimedia design can initiate positive emotions and support cognitive processing (Plass et al., 2014; Um et al., 2012). Due to this point, the learner's interest in the material is an important criterion for evaluating the effectiveness of the material. Interest is described as positive emotion and engagement in an activity (Schraw & Lehman, 2001). According to motivation theory, interest is categorized into situational interest and personal interest (Hidi & Renninger, 2006; Schiefele, 2009).

Situational interest refers to a positive emotional response to particular conditions or stimuli in a learning environment with uncertain duration (Eccles & Wigfield, 2002; Hidi, 1990; Hidi & Renninger, 2006; Mitchell, 1993; Schraw et al., 2001). In contrast with individual interest, situational interest is assumed to be environmentally activated, context-specific, and easier to manipulate (Schraw & Lehman, 2001). As Hidi and Renninger's (2006) four-phase model of interest development states, situational interest can be triggered initially by features of the learning task, and then maintained, and at best developed into relatively stable individual interest for a particular subject matter.

It seems self-evident that situational interest positively affects learning and academic achievement (Schiefele, 2009; Schiefele et al., 1992). The mechanism of situational interest mediating learning in multimedia environments can be explicated as follows: (a) motivational aspects such as situational interest are relevant to high cognitive engagement, thereby facilitating cognitive processing (Flowerday et al., 2004;

Moreno et al., 2001; Park et al., 2015); (b) Anderson (1982) and Reynolds and Anderson (1982) proposed a hypothesis of allocating attentional resources; that is, attention is a limited resource, and learners will allocate more attention to the materials that induce stronger interest; and (c) Students who perceive a high level of situational interest will use metacognitive strategies such as self-regulation to allocate sufficient cognitive resources during learning (Moreno, 2006, 2009). Some scholars have investigated the effects of situational interest on reading and have suggested that the interest stimulated by reading text encourages students to adopt deeper processing strategies and to perform better in comprehension and recall (Fransson, 1977). As for recall and retention, Naceur and Schiefele (2005) provided empirical evidence and indicated (situational) interest as an independent predictor that is related to text recall and retention. Focusing on the field of vocabulary learning, researchers have addressed motivation as a positive indicator of successful vocabulary learning processes (Gardner & MacIntyre, 1991; Tanaka, 2017; Tseng & Schmitt, 2008). Some other studies have focused on designing more intriguing EFL vocabulary instruction using game-based methods to stimulate learners' motivation and flow experience with the intention of improving vocabulary achievement (Li, 2021; Li et al., 2021). Therefore, we should take into account triggering learners' interest when developing multimedia vocabulary materials. It is also logical to assume that situational interest, as a context-specific motivational factor, will facilitate vocabulary learning outcomes based on the abovementioned findings.

Many characteristics of learning material can potentially trigger situational interest. Pintrich and Schunk (1996) suggested that features of material (e.g., novelty and surprise) and features of the environment (e.g., the interestingness of classrooms, media, computers, and textbooks) could generate situational interest. Deci (1992) proposed a theoretical model that defines three sources of situational interest: activity, mental disposition, and interactive experience. Based on this framework, Chen et al. (1999) developed a scale of situational interest measurement with factors of exploration intention, instant enjoyment, novelty, attention demand, challenge, and total interest. We adopted Chen et al.'s situational interest scale as a measurement tool to identify the learners' perceived situational interest when interacting with the learning materials we proposed in our study.

Method

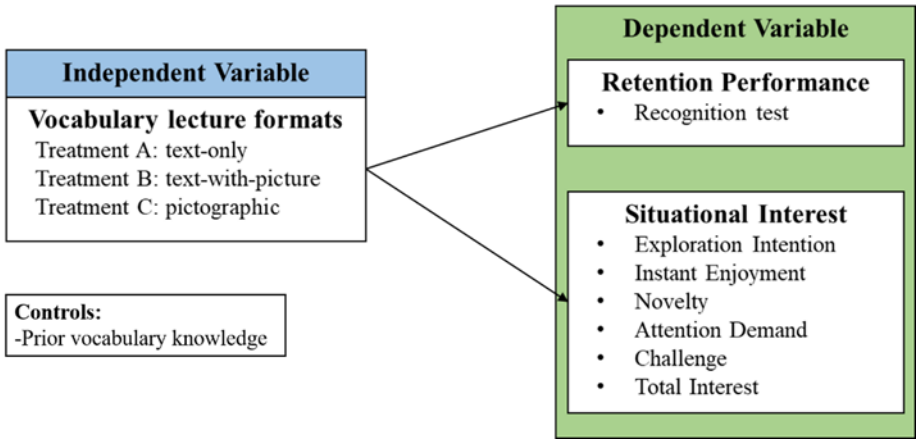
Participants and Design

Situational interest is characterized by personal subjectivity, which means that the observation of situational interest depends on a person's comparative preference for comparable learning activities (Chen et al., 1999; Deci, 1992). Also, learners' vocabulary knowledge and prior vocabulary size can significantly affect their vocabulary learning capacity. Based on the aforementioned factors, we used a within-subject experiment design instead of a between-subject design, and the equivalency of each treatment was carefully considered (see Procedure).

A total of 142 Chinese-speaking graduate and college students from two large research universities in Taiwan voluntarily participated in the study, 108 of whom comprised the valid cases. There were 44 male and 64 female participants with an average age of 22.08 years (SD = 3.62). Participants were asked to complete three treatments of learning English vocabulary presented as text-only, text-with-picture, and pictographs in an online learning system. The object of the learning task was to remember the pair-association of the target word and its definition. An instant recognition test and situational interest scale were administered to assess the retention performance and perceived situational interest in the three treatments. The research variables and the framework are shown in Figure 3.

Figure 3

Research Model



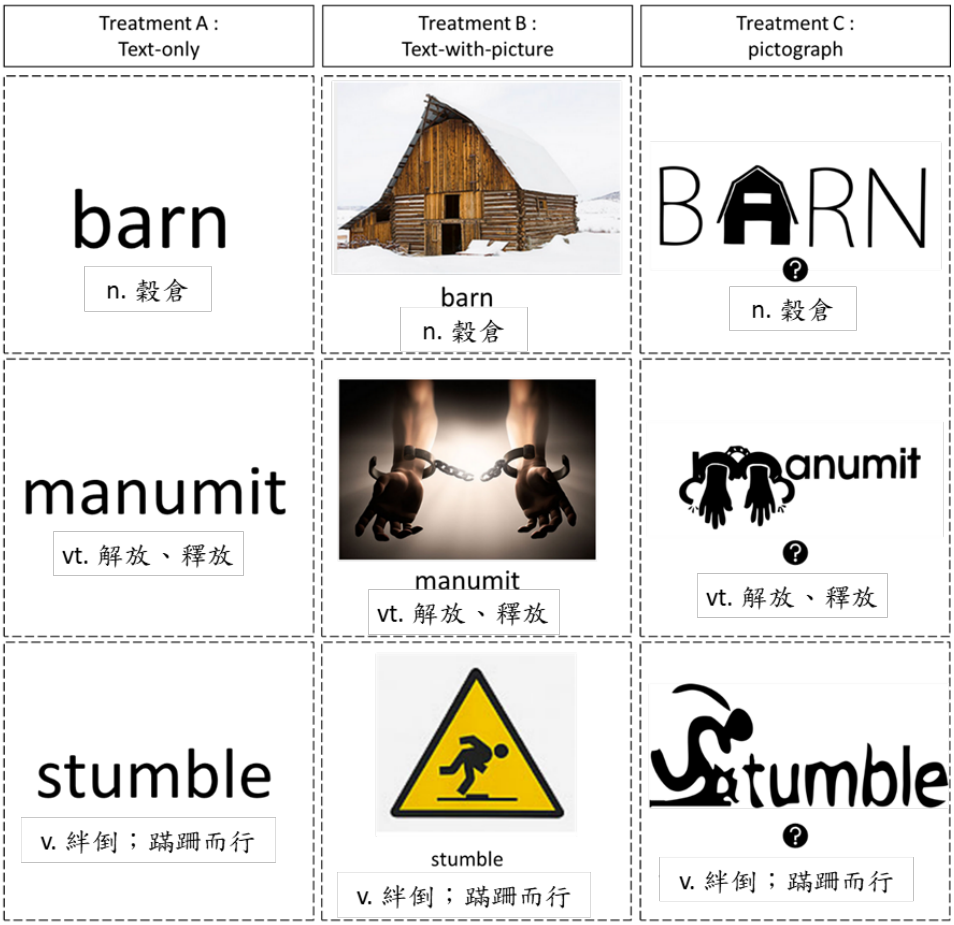
Materials and Apparatus

To match the aim of the experiment, the words that form the learning materials should be moderately challenging for most participants. We recruited 108 undergraduate and graduate students as the participants (66 reported having English proficiency test experience and 5 had TOEFL/IELTS experience); the vocabulary knowledge of the participants was taken into account before the experiments. TOEFL and IELTS are reliable and popular standard tests and widely used to assess English proficiency worldwide. We evaluated the participants' vocabulary knowledge and decided to select target words from a TOEFL/IELTS book published for Chinese EFL learners. The difficulty of the target words was carefully reviewed, and no sight words were included. Considering the number of previous known words for each participant that would be excluded in the following stage as well as the scale and duration of the experiment, we planned that each treatment with different presenting formats ought to have 14 words; thus, we selected a total of 70 words to form a word list.

Each word was designed and presented in three formats: text-only, text-with-picture, and pictograph (as shown in Figure 4). The text-only format included a target English word with textual L1 (Chinese) definition, which implies no multimedia strategies to promote retention. The text-with-picture format is a commonly used presentation of multimedia EFL vocabulary materials, consisting of the target word, L1 definition, and a static semantic-related picture. The pictographic format is a presentation designed for this study, which integrates pictorial information into the word form. Criteria for designing the pictographic material were as follows: (1) the pictograph should combine verbal information and pictorial information into one element; (2) the pictograph should be designed from the form of the word; (3) the pictograph should be legible, so that it is easy to make out the letters; and (4) the pictorial information should be semantically related to the word. The difficulty of the word and the presenting design were reviewed by three English teaching experts.

Figure 4

Examples of the Three Vocabulary Material Formats



Vocabulary Online Learning System

We developed a custom online learning system and deployed it on our own web server exclusively for collecting data, presenting materials, recording the learning experience, administering the retention test, and conducting the survey of situational interest. We employed multiple rounds of usability tests and user access control regarding system robustness and security. We used several design features in the system to ensure the equivalency of each treatment: (1) the words that had been previously acquired were removed from the pre-test for that participant, thereby eliminating the effect of students' prior knowledge of these target words; (2) the words to be learned (14 for each treatment) were randomly assigned to each treatment, therefore ensuring that the difficulty of each treatment was roughly equal; and (3) a counterbalancing design was used, thereby avoiding the order effect caused by within-subject design—the sequence of treatments presented for participants was cycled in the order of ABC, ACB, BAC, BCA, CAB, and CBA (treatment A = text-only, treatment B = text-with-picture, treatment C = pictograph). Illustrations of the learning materials in each treatment are presented in Figures 5, 6, and 7.

Figure 5

An Illustration of the Text-Only Vocabulary Material

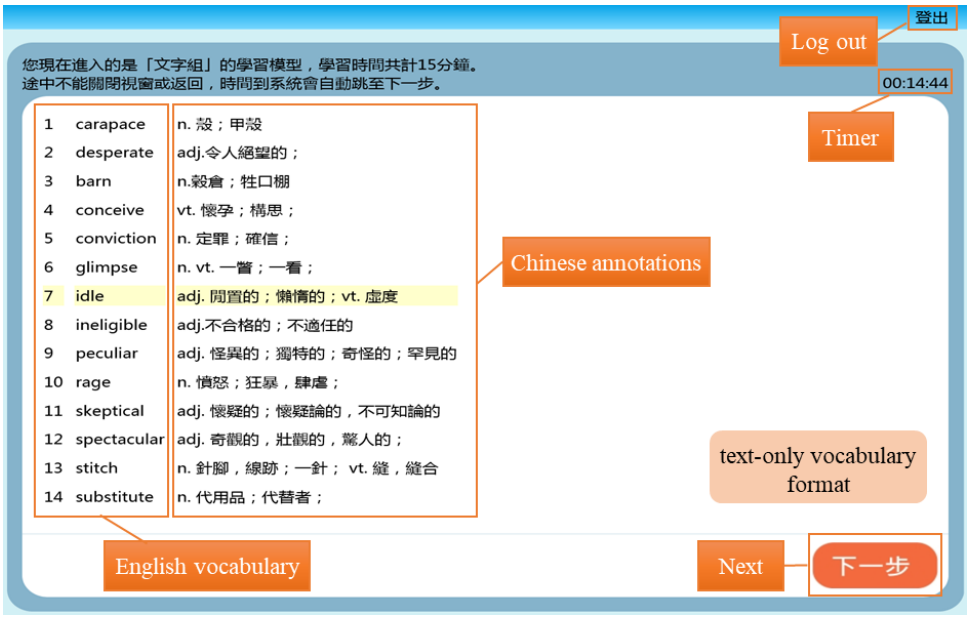


Figure 6

An Illustration of the Text-with-Picture Vocabulary Material

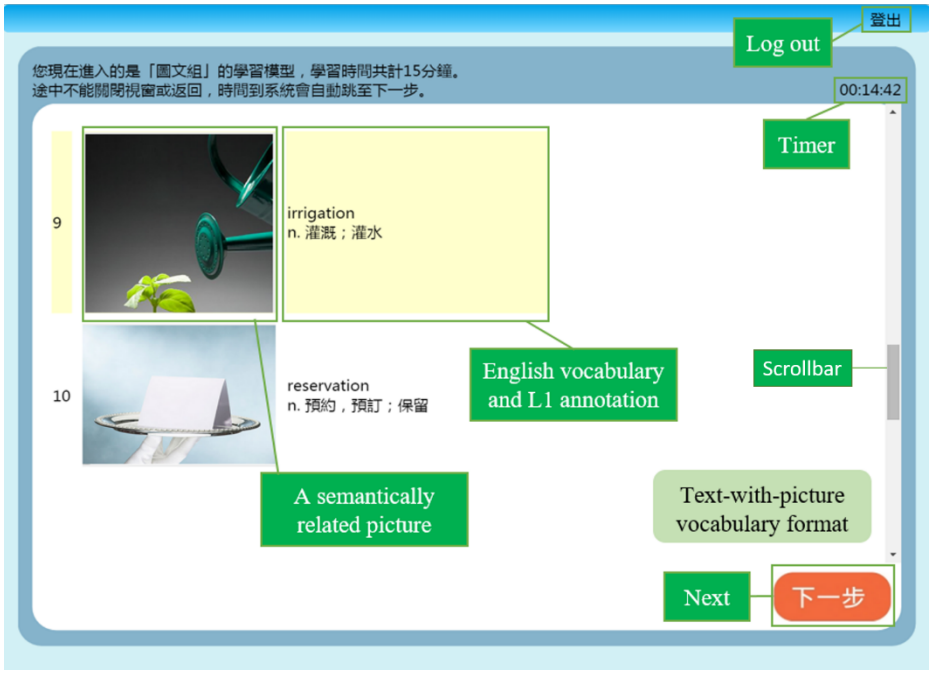
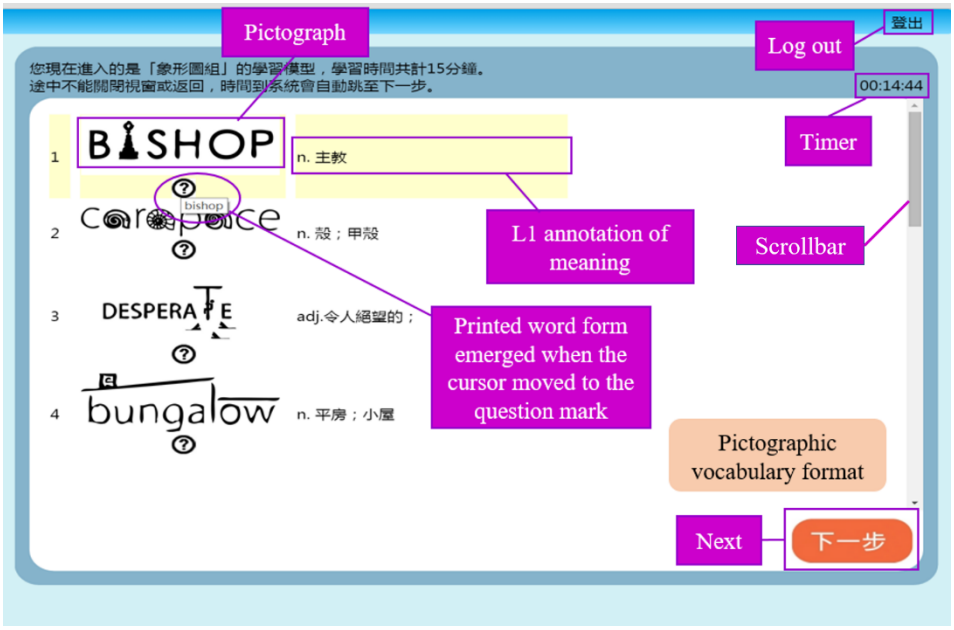


Figure 7

An Illustration of the Pictographic Vocabulary Material



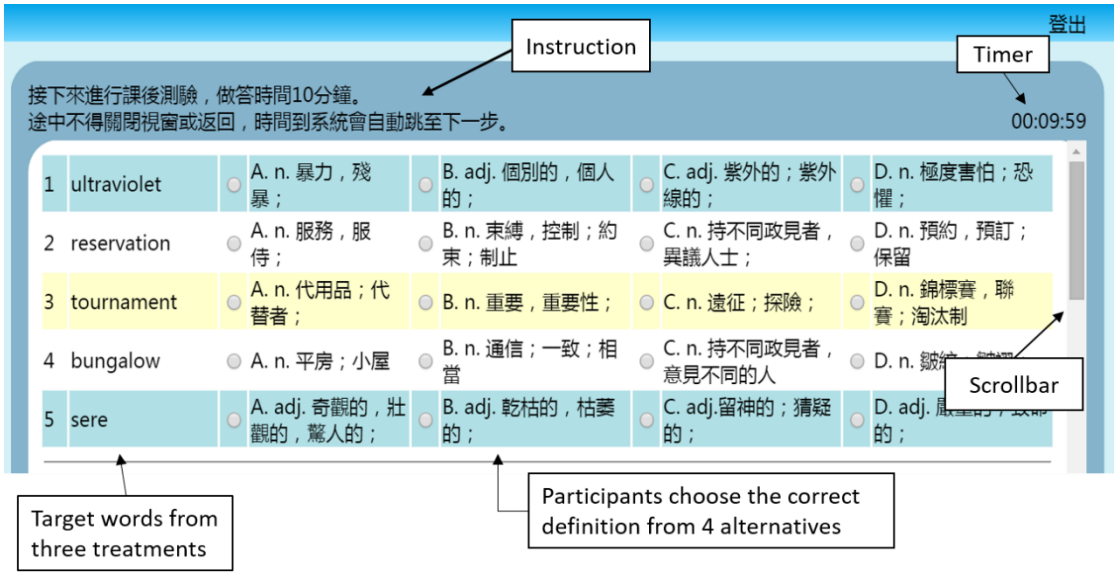
Measures

Performance Test

An immediate recognition test was used to examine participants' vocabulary retention performance. It included a series of multiple-choice questions of the 42 words whereby students selected the correct definition of the target word from four alternatives. Since the target words varied by individual, the test sheets were automatically generated by the system, and the presentation order of the items in the tests was consistent with the order of the target words presented in the previous treatments. The items were previously developed and reviewed by three experts in the field of English education. The distractors came from (1) other words' definitions that have the same part of speech as the target word from the selected wordlist, and (2) another word's definition that has a similar form to the target word (for example, one of the distractors of the target word "sere" is "adj. severe"). The binominal scoring of 1 (correct) and 0 (incorrect) was applied for the recognition tests, with a perfect score of 42 for each participant. The test score was calculated by the system and recorded as three scores for the three treatments. An illustration of the performance test is presented in Figure 8.

Figure 8

An Illustration of the Performance Test with a Sample of Five Items



Situational Interest Scale

The Situational Interest Scale used in this study was developed by Chen et al. (1999). The scale has a construct of six dimensions: exploration intention ("I want to analyze it to have a grasp of it"), instant enjoyment ("It is an enjoyable activity for me"), novelty ("This activity is new to me"), attention demand ("My attention was high"), challenge ("It is a complex activity"), and total interest ("This activity is interesting"). There was a total of 24 Likert-type items in the scale, and four items in each dimension. The items were adapted to be applicable for the context of this study and were presented using a 7-point Likert scale (where 1 was *strongly disagree*, and 7 was *strongly agree*). The scale's internal consistency coefficient (Cronbach's α) in the "pictographic" treatment was .91 (Cronbach's α in the "text-only" treatment was .91; Cronbach's α in the "text-with-picture" treatment was .90). The Cronbach's α values of each dimension in the three treatments were all above .90. Results of confirmatory factor analyses using data in the "pictographic" treatment indicated a fair fit to the data and the proposed model (CFI = .95, TLI = .95, RMSEA = .08, SRMR = .048). CFA was also implemented using data in the "text-only" treatment (CFI = .92, TLI = .91, RMSEA = .096, SRMR = .077) and in the "text-with-picture" treatment (CFI = .944, TLI = .935, RMSEA = .075, SRMR = .058).

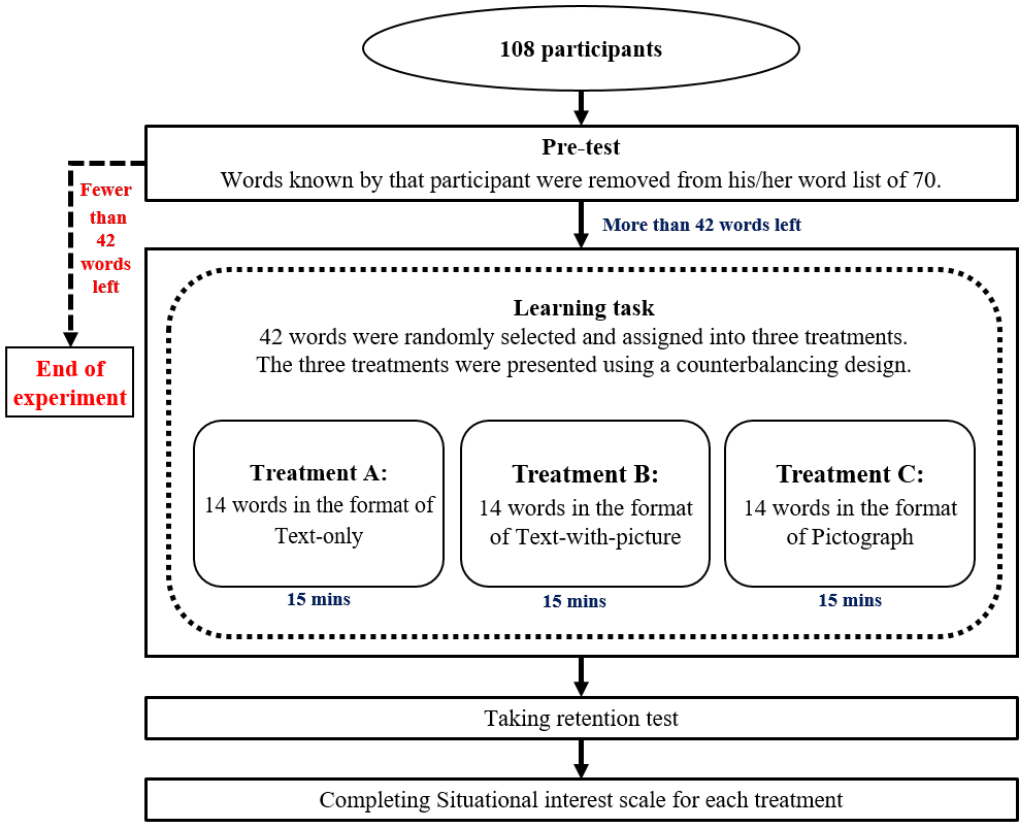
Procedure

For the purpose of this study, we set deliberate vocabulary list learning as the learning task. Participants were asked to memorize English word-meaning links within a limited amount of time. The experiment consisted of three stages. In the first stage, participants registered in the online learning system and read the instructions for the experiment procedures. As a pre-test, participants checked the words in a list of 70 and excluded those words that they had already acquired so that they would not be presented in the following treatments. Thus, we could ensure that the target words were completely unfamiliar to those learners. However, if there were fewer than 42 words left in the list, the experiment procedure would be terminated for that participant. In the second stage, 42 words from the word list were randomly selected and assigned into three treatments; therefore, each treatment consisted of 14 target words with different presentation formats. In other words, the materials of each treatment presented to each participant were automatically generated by the system and varied by individual. In the third stage, each participant viewed and attempted

to learn the vocabulary from the three treatments in different formats. The order of the treatments presented to participants was in a cycle of six patterns (i.e., ABC, ACB, BAC, BCA, CAB, and CBA). Each treatment was limited to 15 minutes but could be ended earlier autonomously. After that, the recognition test and the situational interest scale were administered. The experiment procedure is presented in Figure 9.

Figure 9

Experiment Design



Results

Data Analysis

All quantitative data were exported from the online learning system and prepared for statistical analysis using the IBM SPSS Statistics 19 software. Several repeated measures analyses of variance (RM-ANOVA) were conducted to test whether there were significant differences between participants' retention performance and situational interest for the three treatments. Mauchly's sphericity test was conducted in advance to decide whether the revised data needed to be used instead. We also performed post-hoc comparisons with the LSD method to investigate the effect of the pictographic materials on retention performance and situational interest compared to the text-only and text-with-picture materials.

Effects of Retention Performance

The descriptive statistics of retention performance with the three vocabulary material formats are shown in Table 1. Note that there was one case deleted because the recognition test was not completely finished, leaving 107 cases.

Table 1

Descriptive Statistics of Retention Performance with the three Vocabulary Material Formats

Learning Performance	*M*	*SD*	*N*
Text-only	27.77	5.78	107
Text-with-picture	28.78	5.20	107
Pictograph	29.09	4.29	107

Table 2

RM-ANOVA Summary Table of a Comparison of Retention Performance with the three Vocabulary Material Formats

Source	*SS*	*df*	*MS*	*F*	Sig.	η^2	Post hoc
Between group	102.75	2	51.38	5.02	.01	.05	(B) > (A)*
Within group							(C) > (A)**
Between subjects	6174.93	106	58.25				
Error	2169.91	212	10.24				
Total	8447.60	320					

Note. * $p < .05$. ** $p < .01$. (A) = text-only; (B) = text-with-picture; (C) = pictograph.

The results of Mauchly's sphericity test show that none of the sample data violated the sphericity test hypothesis ($\chi^2 = .99$, $p = .61$); therefore, the repeated measures ANOVA could be conducted. As shown in Table 2, there were significant differences among learners' retention performance in the three treatments ($F_{(2,212)} = 5.02$, $p = .01$), indicating that learners' retention differed when learning vocabulary materials in different formats. The results of the pairwise comparison revealed that participants who learned with the vocabulary materials in the text-with-picture and pictographic formats reported higher retention performance than those who learned with the text-only format, while no significant difference was found between the text-with-picture and pictograph formats.

Effects of Situational Interest

The descriptive statistics of situational interest with three vocabulary material formats are shown in Table 3. Prior to repeated measures ANOVA, we found that the data violated the Mauchly's sphericity test hypothesis ($\chi^2 = 17.18$, $p < .001$). The Greenhouse-Geisser correction was used to offset sphericity violations. The results of repeated measures ANOVA presented in Table 4 show a strong significant overall effect: $F_{(1.74,186.15)} = 119.32$, $p < .001$. This result indicated that there was a significant difference in the situational interest that the learners perceived from the different material formats. The pairwise comparison showed that their situational interest was significantly higher when learning from the pictographs than from both the text-only and text-with-picture formats.

Table 3

Descriptive Statistics of Situational Interest with the three Vocabulary Material Formats

Situational Interest	*M*	*SD*	*N*
Text-only	2.97	1.15	108
Text-with-picture	4.65	0.88	108
Pictograph	5.16	1.09	108

Table 4

RM-ANOVA Summary Table of a Comparison of Situational Interest with the three Vocabulary Material Formats

Source	*SS*	*df*	*MS*	*F*	Sig.	η^2	Post hoc
Between group	284.11	1.74	163.31	119.32	< .001	.53	(B) > (A)***
Within group							(C) > (A)***
Between subjects	96.14	107	0.90				(C) > (B)***
Error	254.76	186.15	1.37				
Total	635.01	294.89					

Notes. *** $p < .001$. (A) = text-only; (B) = text-with-picture; (C) = pictograph.

In addition, the Situational Interest Scale has six dimensions of exploration intention, instant enjoyment, novelty, attention demand, challenge, and total interest. We conducted one-way repeated measures MANOVA to determine whether there was a statistically significant difference in the abovementioned dependent variables. The result suggested that there was a difference in the combined dependent variables for the three treatments (Wilks' Lambda = 0.229, $F = 37.941$, $p < .001$). Therefore, multiple RM-ANOVAs of each dimension were conducted to further investigate where the differences were between treatments. In the aspects of exploration intention, novelty, attention demand, and total interest, results revealed that learners perceived the highest level from the pictographic format compared with either the text-only or the text-with-picture formats ($M_C > M_B > M_A$). As for instant enjoyment, the comparison revealed that learners perceived significantly higher instant enjoyment from both the text-with-picture and pictographic formats than from the text-only format, while no significant difference was detected between the pictographic and text-with-picture formats. Interestingly, we found that learners perceived a significantly higher level of challenge from the text-only format than from the pictographic format, and the level of challenge was significantly higher for the pictographic format than for the text-with-picture format ($M_A = 4.34 > M_C = 3.72 > M_B = 3.21$). The results of the RM-ANOVA of each dimension and pairwise comparison of the different material formats are summarized in Table 5.

Table 5

Comparison of Dimensions of Situational Interest Perceived from the three Vocabulary Material Formats

Variable	Treatment A *M* (*SD*)	Treatment B *M* (*SD*)	Treatment C *M* (*SD*)	*F* (*p*-value)	Post hoc
Exploration Intention	3.29 (1.50)	4.67 (1.26)	5.11 (1.44)	57.25 (< .001)	(B) > (A)*** (C) > (A)*** (C) > (B)**
Instant Enjoyment	3.01 (1.60)	5.12 (1.22)	5.00 (1.64)	62.16 (< .001)	(B) > (A)*** (C) > (A)***
Novelty	1.84 (1.17)	3.70 (1.41)	5.62 (1.40)	231 (< .001)	(B) > (A)*** (C) > (A)*** (C) > (B)***
Attention Demand	3.86 (1.53)	4.84 (1.17)	5.16 (1.31)	30.49 (< .001)	(B) > (A)*** (C) > (A)*** (C) > (B)*
Challenge	4.34 (1.89)	3.21 (1.30)	3.72 (1.55)	15.69 (< .001)	(A) > (B)*** (A) > (C)* (C) > (B)**
Total Interest	2.38 (1.40)	4.82 (1.34)	5.56 (1.49)	149.93 (< .001)	(B) > (A)*** (C) > (A)*** (C) > (B)***

Notes. * $p < .05$. ** $p < .01$. *** $p < .001$. (A) = text-only; (B) = text-with-picture; (C) = pictograph.

Discussion

The first research question in this study sought to determine the effect of different vocabulary material formats on retention performance. The results suggest that both the text-with-picture and pictographic formats may foster vocabulary retention compared to the text-only format without any pictorial aids. As mentioned in the literature review, the multimedia effect proposed by Mayer (2005) suggests that learners learn more deeply from words and pictures than from words alone. The findings in this study are consistent with prior studies that focused on the field of vocabulary learning, concluding that the pictorial glosses enhanced vocabulary learning (e.g., Al-Seghayer, 2001; Kost et al., 1999; Yoshii & Flaitz, 2002).

When comparing the text-with-picture and pictographic formats, the mean score of retention performance of the pictographic format was higher than that of the text-with-picture format (see Table 1); however, it did not reach a significant difference. The possible reasons may be as follows: the pictographic materials proposed in the current study, by nature, could be classified into multimedia glosses as defined by Mayer (2005) and shared common attributes with text-with-picture materials from a multimedia learning perspective. Both pictographic and traditional text-with-picture vocabulary materials provide verbal and pictorial representation for learners, which help to organize them into concrete mental representations of the meaning of the word, as stated by Plass and Jones (2005), both of which apply strategies for facilitating deep semantic processing. Therefore, the effectiveness of these two sets of multimedia materials emerged

to facilitate vocabulary retention. However, we should differentiate these two by stating that the pictograph was more self-contained by compounding the semantic function and form of the word into one element so that the learners could tell the definition and word form when shown the pictograph alone, whereas the text-with-picture format did not have this feature when learners were shown the picture alone without textual information. The absence of significant differences in retention performance between these two formats suggests the need for caution when drawing any firm conclusions about the general comparative pedagogical superiority of the pictographic materials for vocabulary learning. Nevertheless, the findings, albeit on a descriptive level, indicated potentially effective vocabulary materials. Additionally, the motivational function revealed by these two materials performed significantly differently, an issue which is discussed as follows.

The second research question aimed to discover the affective function of the pictographic material format. We chose situational interest as the dependent variable. Consolidating the findings of the situational interest scale, it seems that the multimedia EFL vocabulary materials with pictorial glosses could successfully trigger learners' situational interest and increase their enjoyment and motivation. On the contrary, the single modality using only textual glosses did not have such effects. The statistical results also revealed that materials combining pictographic glosses had better motivational effects than materials with text-with-picture glosses. The reasons for the results are straightforward and can be specified by Chen et al.'s (1999) theoretical articulation of the multidimensional construct of situational interest—the use of pictographic glosses can significantly increase learners' novelty, exploration intention, instant enjoyment, attention demand, and total interest. According to Hidi et al. (1992), novelty and positive feelings generated by novel tasks or information are two major components of situational interest. The sub-scale score of "novelty" showed that only the pictographic materials could serve as a novel vocabulary material setting for participants. On the contrary, learners did not report a sense of novelty from either the text-with-picture or the text-only materials (the mean scores were 1.84 and 3.7 on a 7-point Likert scale, respectively). One possible reason is that the traditional vocabulary materials with semantically related static pictorial glosses are widely used since the multimedia principle is widely applied in the EFL field; therefore, learners are familiar with this kind of presentation. Data revealed that learners perceived high levels of instant enjoyment when interacting with the text-with-picture materials as well; however, they did not consider it as a novel presentation scheme, which may have resulted in the lower levels of situational interest reported by the scale.

Notably, the dimension of "challenge" with four items negatively correlated to other dimensions, as revealed by the CFA on the Situational Interest Scale conducted in this study, which is inconsistent with the original scale construct proposed by Chen et al. (1999). Chen defined "challenge" as the difficulty of the task, where a higher degree of challenge may attract learners' involvement in the task. However, our study suggested that a higher degree of challenge might lead to learners' frustration, thereby decreasing their situational interest in the vocabulary learning materials. The same finding was also revealed in other studies when testing learners' perceived situational interest with novel learning tools or strategies (Yu et al., 2019). Results indicated that learners perceived a significantly higher degree of challenge in the pictographic materials than in the text-with-picture materials, but neither set of materials caused too much challenge (the mean scores were 3.72 and 3.21 on a 7-point Likert scale, respectively). Taking the previous finding into account, pictographic materials can impose the proper amount of challenge that matches learners' skill level; it can thus be suggested that learners would more likely enter into a flow state according to flow theory (Csikszentmihalyi, 2000; Nakamura & Csikszentmihalyi, 2009).

Gardner and Lambert (1972) grounded motivation research in a socio-psychological framework and illuminated the significance of motivation in successful second language acquisition. As we know, learners would have to study over an extensive period of time to attain an adequate vocabulary size to function in a second language. The current study addressed a context-specific and environmentally activated motivating vocabulary learning experience, which was mainly evoked by the experimental materials with pictographic

glosses, and could serve as a simulation of the real-world vocabulary learning task for EFL learners. To the best of the authors' knowledge, it is the first study to apply pictographic glosses in EFL vocabulary learning, and also contributes to the very limited body of research into the effects that the different materials may have on both retention performance and situational interest by directly comparing the learning from different materials. The present findings, while preliminary, indicated a satisfactory pedagogical and motivational feature of the vocabulary learning materials, and thus could encourage EFL practitioners to apply the idea of pictographs in the design of EFL instructional materials.

Conclusion and Limitations

The benefits of multimedia glosses for L2 vocabulary learning encourage instruction designers to manipulate different modalities in multimedia materials (i.e., text, images, voice narrations, animations, video clips, etc.), especially considering the tendency of the widespread use of computer-assisted language learning. However, vocabulary materials with the glosses of voice narrations and video clips require hardware devices and an e-learning environment; thus, the multimedia vocabulary design with static pictures and words has its advantage in pedagogical practice due to its economy and convenience, and is thus worth discussing.

The present study investigated the motivational and retention effects of EFL vocabulary materials with pictographic glosses compared to text-only and traditional text-with-picture materials. Results revealed that dual-modality materials (i.e., text-with-picture and pictographic gloss formats) are more effective than single modality materials (i.e., text-only L1 glosses) in terms of vocabulary retention, which is consistent with what the multimedia principle predicted, and also contributes to the body of literature on the effects of multimedia glosses in L2 vocabulary learning. Additionally, the proposed pictographic materials can effectively enhance learners' interest when learning vocabulary, which is beneficial for creating a novel and motivating vocabulary learning environment for EFL learners. The present study provides powerful evidence of the superiority of the affective functions of pictographic glosses.

Several limitations should be addressed. A major limitation of this study is the lack of criteria for designing the pictographic glossing vocabulary materials. Although we set a number of principles to design the pictographic glosses, there was no instructional rationale provided by previous studies, which made it more difficult to design the pictographic materials than the traditional text-and-picture vocabulary materials. In the vocabulary learning publishing market, we did find an EFL vocabulary textbook using the concept of pictographs published in mainland China, which intended to trigger Chinese EFL learners' interest and better memory of vocabulary learning for those preparing for the TOEFL and IELTS. Another significant limitation is that only an immediate recognition test was performed in our study, which did not include information on the future retention effect of learning using the pictographic glossing vocabulary material. Therefore, we recommend a delayed retention test in future work to better understand the long-term effect of pictographic materials on memory performance. It is also necessary to highlight that the intentional word-list vocabulary retention task conducted in this study was not sufficient to explain the vocabulary acquisition process in all its complexity from a linguistic perspective.

Additionally, various factors need to be taken into consideration to better understand the potential pedagogical values of the pictographic glossing vocabulary materials: learners' verbal ability, cognitive load imposed by the materials, and so on. Future research can expand the scope of research variables mentioned above. Despite its exploratory nature, this study offers insights in the field of elevating motivation in vocabulary learning, and provides a new approach for designing English vocabulary materials in multimedia environments.

Acknowledgements

This research was supported by the National Science and Technology Council (formerly Ministry of Science and Technology) in Taiwan through Grant numbers NSTC 112-2410-H-A49-019-MY3, MOST 111-2410-H-A49-018-MY4 and MOST 110-2511-H-A49-009-MY2. We would like to thank NYCU's ILTM (Interactive Learning Technology and Motivation, see: http://ILTM.lab.nycu.edu.tw) Lab members and the students for helping conduct the experiment, as well as the reviewers for providing valuable comments.

References

Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, *6*(11), e05312. https://doi.org/10.1016/j.heliyon.2020.e05312

Acha, J. (2009). The effectiveness of multimedia programmes in children's vocabulary learning. *British Journal of Educational Technology*, *40*(1), 23–31. https://doi.org/10.1111/j.1467-8535.2007.00800.x

Ahangari, S., & Abdollahpour, Z. (2010). The effects of multimedia annotations on Iranian EFL learners' L2 vocabulary learning. *Journal of English Language Pedagogy and Practice*, *3*(6), 1–18.

Al-Seghayer, K. (2001). The effect of multimedia annotation modes on L2 vocabulary acquisition: A comparative study. *Language Learning & Technology*, *5*(1), 202–232. https://scholarspace.manoa.hawaii.edu/bitstream/10125/25117/05_01_alseghayer.pdf

Anderson, R. C. (1982). Allocation of attention during reading. *Advances in Psychology*, *8*, 292–305.

Boers, F., Warren, P., He, L., & Deconinck, J. (2017). Does adding pictures to glosses enhance vocabulary uptake from reading? *System*, *66*, 113–129. https://doi.org/10.1016/j.system.2017.03.017

Carney, R. N., & Levin, J. R. (2002). Pictorial illustrations still improve students' learning from text. *Educational Psychology Review*, *14*(1), 5–26. https://doi.org/10.1023/a:1013176309260

Chen, A., Darst, P. W., & Pangrazi, R. P. (1999). What constitutes situational interest? Validating a construct in physical education. *Measurement in Physical Education and Exercise Science*, *3*(3), 157–180. https://doi.org/10.1207/s15327841mpee0303_3

Chen, C. M., & Sun, Y. C. (2012). Assessing the effects of different multimedia materials on emotions and learning performance for visual and verbal style learners. *Computers & Education*, *59*(4), 1273–1285. https://doi.org/10.1016/j.compedu.2012.05.006

Chen, C. M., & Wang, H. P. (2011). Using emotion recognition technology to assess the effects of different multimedia materials on learning emotion and performance. *Library & Information Science Research*, *33*(3), 244–255. https://doi.org/10.1016/j.lisr.2010.09.010

Chen, M. J. (1993). A Comparison of Chinese and English Language Processing. In J. Altarriba (Ed.), *Advances in Psychology* (Vol. 103, pp. 97-117). North-Holland. https://doi.org/10.1016/S0166-4115(08)61659-3

Chun, D. M., & Plass, J. L. (1996). Effects of multimedia annotations on vocabulary acquisition. *The Modern Language Journal*, *80*(2), 183–198. https://doi.org/10.1111/j.1540-4781.1996.tb01159.x

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, *3*(3), 149–210. https://doi.org/10.1007/BF01320076

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*(6), 671–684. https://doi.org/10.1016/S0022-5371(72)80001-X

Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, *104*(3), 268–294. https://doi.org/10.1037/0096-3445.104.3.268

Csikszentmihalyi, M. (2000). *Beyond boredom and anxiety*. Jossey-Bass.

Deci, E. L. (1992). The relation of interest to the motivation of behavior: A self-determination theory perspective. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 43–70). Lawrence Erlbaum.

Diao, Y., & Sweller, J. (2007). Redundancy in foreign language reading comprehension instruction: Concurrent written and spoken presentations. *Learning and Instruction*, *17*(1), 78– 88. https://doi.org/10.1016/j.learninstruc.2006.11.007

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Emirmustafaoğlu, A., & Gökmen, D. U. (2015). The effects of picture vs. translation mediated instruction on L2 vocabulary learning. *Procedia-Social and Behavioral Sciences*, *199*, 357–362. https://doi.org/10.1016/j.sbspro.2015.07.559

Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *The Journal of Experimental Education*, *72*(2), 93–114. https://doi.org/10.3200/JEXE.72.2.93-114

Fransson, A. (1977). On qualitative differences in learning: IV–Effects of intrinsic motivation and extrinsic test anxiety on process and outcome. *British Journal of Educational Psychology*, *47*(3), 244–257. https://doi.org/10.1016/j.sbspro.2015.07.559

Gardner, R. C., & Lambert, W. E. (1972). Attitudes and motivation in second-language learning. In K. Brown (Ed.), *Encyclopedia of Language & Linguistics (Second Edition)* (pp. 348–355). Elsevier. https://doi.org/10.1016/B0-08-044854-2/00625-8

Gardner, R. C., & MacIntyre, P. D. (1991). An instrumental motivation in language study: Who says it isn't effective? *Studies in Second Language Acquisition*, *13*(1), 57–72. https://doi.org/10.1017/S0272263100009724

Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of "seductive details" on macroprocessing and microprocessing in adults and children. *Cognition and Instruction*, *6*(1), 41–57. https://doi.org/10.1207/s1532690xci0601_2

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, *90*(3), 414–434. https://doi.org/10.1037/0022-0663.90.3.414

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research*, *60*(4), 549–571. https://doi.org/10.3102/00346543060004549

Hidi, S., Anderson, V., Renninger, K., Hidi, S., & Krapp, A. (1992). Situational interest and its impact on reading and expository writing. *The role of interest in learning and development*, *11*, 213-214. Psychology Press.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

Jones, L. (2004). Testing L2 vocabulary recognition and recall using pictorial and written test items.

Language Learning & Technology, *8*(3), 122–143. https://scholarspace.manoa.hawaii.edu/bitstream/10125/43998/08_03_jones.pdf

Kost, C. R., Foss, P., & Lenzini Jr, J. J. (1999). Textual and pictorial glosses: Effectiveness on incidental vocabulary growth when reading in a foreign language. *Foreign Language Annals*, *32*(1), 89–97. https://doi.org/10.1111/j.1944-9720.1999.tb02378.x

Li, R. (2021). Does Game-Based Vocabulary Learning APP Influence Chinese EFL Learners' Vocabulary Achievement, Motivation, and Self-Confidence? *SAGE Open*, *11*(1), 215824402110030. https://doi.org/10.1177/21582440211003092

Li, R., Meng, Z., Tian, M., Zhang, Z., & Xiao, W. (2021). Modelling Chinese EFL learners' flow experiences in digital game-based vocabulary learning: the roles of learner and contextual factors. *Computer Assisted Language Learning*, *34*(4), 483–505. https://doi.org/10.1080/09588221.2019.1619585

Liu, T. C., Lin, Y. C., Tsai, M. J., & Paas, F. (2012). Split-attention and redundancy effects on mobile learning in physical environments. *Computers & Education*, *58*(1), 172–180. https://doi.org/10.1016/j.compedu.2011.08.007

Machado, C., & Luchini, P. L. (2018). Cognitive Load Theory, Redundancy Effect and Language Learning. In R. J. Ponniah & S. Venkatesan (Eds.), *The Idea and Practice of Reading* (pp. 177-190). Springer Singapore. https://doi.org/10.1007/978-981-10-8572-7_11

Magner, U. I. E., Schwonke, R., Aleven, V., Popescu, O., & Renkla, A. (2014). Triggering situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. *Learning & Instruction*, *29*(4), 141–152. https://doi.org/10.1016/j.learninstruc.2012.07.002

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist*, *32*(1), 1–19. https://doi.org/10.1207/s15326985ep3201_1

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). Cambridge University Press.

Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, *93*(1), 187–198. https://doi.org/10.1037/0022-0663.93.1.187

Mayer, R. E., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction*, *12*(1), 107–119. https:/doi.org/10.1016/S0959-4752(01)00018-4

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 43–52. https://doi.org/10.1207/S15326985EP3801_6

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology*, *85*(3), 424–436. https://doi.org/10.1037/0022-0663.85.3.424

Molitor, S., Ballstaedt, S. P., & Mandl, H. (1989). Problems in knowledge acquisition from text and pictures. *Advances in Psychology*, *58*, 3–35.

Moreno, R. (2006). Does the modality principle hold for different media? A test of the method-affects-learning hypothesis. *Journal of Computer Assisted Learning*, *22*(3), 149–158. https://doi.org/10.1111/j.1365-2729.2006.00170.x

Moreno, R. (2009). Learning from animated classroom exemplars: The case for guiding student teachers' observations with metacognitive prompts. *Educational Research and Evaluation*, *15*(5), 487–501. https://doi.org/10.1080/13803610903444592

Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction*, *19*(2), 177–213. https://doi.org/10.1207/S1532690XCI1902_02

Naceur, A., & Schiefele, U. (2005). Motivation and learning–The role of interest in construction of representation of text and long-term retention: Inter-and intraindividual analyses. *European Journal of Psychology of Education*, *20*(2), 155–170. https://doi.org/10.1007/BF03173505

Nakamura, J., & Csikszentmihalyi, M. (2009). Flow Theory and Research. In S. J. Lopez & C. R. Snyder (Eds.), *The Oxford Handbook of Positive Psychology* (p. 0). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195187243.013.0018

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, *38*(1), 1–4. https://doi.org/10.1207/S15326985EP3801_1

Paivio, A. (1990). *Mental representations: A dual coding approach*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195066661.001.0001

Park, B., Flowerday, T., & Brünken, R. (2015). Cognitive and affective effects of seductive details in multimedia learning. *Computers in Human Behavior*, *44*, 267–278. https://doi.org/10.1016/j.chb.2014.10.061

Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior*, *27*(1), 5–10. https://doi.org/10.1016/j.chb.2010.05.006

Park, B., Plass, J. L., & Brünken, R. (2014). Cognitive and affective processes in multimedia learning. *Learning and Instruction*, *29*, 125–127. https://doi.org/10.1016/j.learninstruc.2013.05.005

Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications*. Merrill Englewood Cliffs.

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (2003). Cognitive load in reading a foreign language text with multimedia aids and the influence of verbal and spatial abilities. *Computers in Human Behavior*, *19*(2), 221–243. https://doi.org/10.1016/S0747-5632(02)00015-8

Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction*, *29*, 128–140. https://doi.org/10.1016/j.learninstruc.2013.02.006

Plass, J. L., & Jones, L. C. (2005). Multimedia learning in second language acquisition. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 467–488). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.030

Reed, S. K. (2006). Cognitive architectures for multimedia learning. *Educational Psychologist*, *41*(2), 87–98. https://doi.org/10.1207/s15326985ep4102_2

Reimann, P. (2003). Multimedia learning: Beyond modality. *Learning and Instruction*, *13*(2), 245–252.

Reynolds, R. E., & Anderson, R. C. (1982). Influence of questions on the allocation of attention during reading. *Journal of Educational Psychology*, *74*(5), 623–652. https://doi.org/10.1037/0022-0663.74.5.623

Samuels, S. J. (1967). Attentional process in reading: The effect of pictures on the acquisition of reading responses. *Journal of Educational Psychology*, *58*, 337–342. https://doi.org/10.1037/h0020045

Samuels, S. J. (1970). Effects of pictures on learning to read, comprehension and attitudes. *Review of Educational Research*, *40*(3), 397–407. https://doi.org/10.3102/00346543040003397

Samur, Y. (2012). Redundancy effect on retention of vocabulary words using multimedia presentation:

Colloquium. *British Journal of Educational Technology*, *43*(6), E166–E170. https://doi.org/10.1111/j.1467-8535.2012.01320.x

Saunders, R. J., & Solman, R. T. (1984). The effect of pictures on the acquisition of a small vocabulary of similar sight-words. *British Journal of Educational Psychology*, *54*(3), 265–275. https://doi.org/10.1111/j.2044-8279.1984.tb02590.x

Schiefele, U. (2009). Situational and individual interest. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 197–222). Routledge.

Schiefele, U., Krapp, A., & Winteler, A. (1992). Interest as a predictor of academic achievement: A meta-analysis of research. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 183–212). Erlbaum.

Schmitt, N. (2008). Instructed second language vocabulary learning. *Language Teaching Research*, *12*(3), 329–363. https://doi.org/10.1177/1362168808089921

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, *13*(3), 211–224. https://doi.org/10.1023/A:1016619705184

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review*, *13*(1), 23–52. https://doi.org/10.1023/A:1009004801455

Shen, H. H. (2010). Imagery and verbal coding approaches in Chinese vocabulary instruction. *Language Teaching Research*, *14*(4), 485-499. https://doi.org/10.1177/1362168810375370

Solman, R. T., Singh, N. N., & Kehoe, E. J. (1992). Pictures block the learning of sightwords. *Educational Psychology*, *12*(2), 143–153. https://doi.org/10.1080/0144341920120205

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295–312. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 19–30). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.003

Tanaka, M. (2017). Examining EFL vocabulary learning motivation in a demotivating learning environment. *System*, *65*, 130–138. https://doi.org/10.1016/j.system.2017.01.010

Tseng, W. T., & Schmitt, N. (2008). Toward a model of motivated vocabulary learning: A structural equation modeling approach. *Language Learning*, *58*(2), 357–400. https://doi.org/10.1111/j.1467-9922.2008.00444.x

Um, E., Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. *Journal of Educational Psychology*, *104*(2), 485-498. https://doi.org/10.1037/a0026609

Yeung, A. S., Jin, P., & Sweller, J. (1998). Cognitive Load and Learner Expertise: Split-Attention and Redundancy Effects in Reading with Explanatory Notes. *Contemporary Educational Psychology*, *23*(1), 1–21. https://doi.org/10.1006/ceps.1997.0951

Yoshii, M., & Flaitz, J. (2002). Second language incidental vocabulary retention: The effect of text and picture annotation types. *CALICO Journal*, *20*(1), 33–58. https://doi.org/10.1558/cj.v20i1.33-58

Yu, S. J., Sun, J. C. Y., & Chen, O. T. C. (2019). Effect of AR-based online wearable guides on university students' situational interest and learning performance. *Universal Access in the Information Society*, *18*(2), 287–299. https://doi.org/10.1007/s10209-017-0591-3

About the Authors

Liu-Cheng Pan works as a Research Fellow and Programme Officer for UNESCO Chair on Digitalization in TVET at Shenzhen Polytechnic University in Shenzhen, China. Additionally, he is a doctoral student at the Education University of Hong Kong, Hong Kong SAR, with research interests in ICT in education and educational psychology.

E-mail: panliucheng@szpu.edu.cn

ORCiD: https://orcid.org/0009-0006-8716-4236

Jerry Chih-Yuan Sun (corresponding author) is a Distinguished Professor at the Institute of Education at the National Yang Ming Chiao Tung University in Taiwan, where he leads the Interactive Learning Technology and Motivation Lab (see http://ILTM.lab.nycu.edu.tw). His research focuses on assessing innovative feedback technologies and their effects on student learning and motivation. Jerry Chih-Yuan Sun is the corresponding author.

E-mail: JerrySun@nycu.edu.tw

ORCiD: https://orcid.org/0000-0002-7892-4313