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RECEIVED 27 April 2023

ACCEPTED 16 October 2023

PUBLISHED 30 November 2023

CITATION

Sun D, Chen Z and Zhu S (2023) What affects
second language vocabulary learning?
Evidence from multivariate analysis.
Front. Educ. 8:1210640.
doi: 10.3389/educ.2023.1210640

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What affects second language vocabulary learning? Evidence from multivariate analysis

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Introduction: Vocabulary acquisition is crucial in second language (L2) learning and can be affected by multi-variables. The fact that all these variables have typically been investigated separately (or, at best, in pairs) potentially obscures important interactions between them. This study comprehensively examines the intricate factors affecting vocabulary knowledge among Chinese learners studying English as a foreign language (EFL).

Methods: We conducted an investigation involving 200 Chinese EFL learners to identify the relationships between L2 proficiency, vocabulary learning strategies, age of acquisition (AoA), classroom exposure, and their relationships and predictive power on L2 vocabulary breadth and vocabulary depth.

Results: L2 proficiency emerged as the most robust predictor of vocabulary knowledge, closely trailed by vocabulary learning strategies, AoA, and classroom exposure. Notably, the use of metacognitive learning strategies such as self-regulated and self-aware learning, was found to be significant. Earlier L2 exposure resulted in a more sufficient vocabulary knowledge. However, the conventional belief that longer classroom sessions lead to enhanced vocabulary knowledge was challenged.

Discussion: Our findings suggest the interconnectedness between L2 proficiency and L2 vocabulary knowledge. The investigation highlights the need for increased cognitive involvement and self-discipline in L2 vocabulary learning. This study also emphasizes the necessity to maximize the efficacy of classroom sessions, together with the benefits for an earlier age of L2 acquisition. Guidance for L2 researchers and instructors in second language vocabulary acquisition is offered.

KEYWORDS

Chinese EFL learners, vocabulary knowledge, age of acquisition, L2 proficiency, classroom exposure, vocabulary learning strategies

1 Introduction

Vocabulary plays a fundamental role in second language acquisition (SLA) and foreign language acquisition (Nation, 1990). Although a large vocabulary size does not always mean an adept EFL learner, deficiency in vocabulary may restrict one's ability in test performance and communication. Therefore, mastering a large vocabulary becomes the initial goal for many English as Foreign Language (EFL) learners, and it has also been regarded as the threshold for a higher English proficiency test score in the EFL context.

The most widely accepted framework for understanding vocabulary knowledge (VK) has divided it into two main dimensions: vocabulary breadth and vocabulary depth (Anderson and

Freebody, 1981; Schmitt, 2008). Vocabulary breadth pertains to the number of words a language learner is familiar with, while vocabulary depth involves the learner's understanding of a word's paradigmatic and syntactic relationships with other words, as well as its contextual usage. Researchers have explored the relationship between these two dimensions, arguing that they are strongly correlated yet can still assess distinct aspects of vocabulary knowledge (Schmitt, 2014).

Researchers have developed and tested various hypotheses to gain insights into how proficiency in second language vocabulary develops. These hypotheses often consider factors such as exposure to language input in the classroom (Brevik and Rindal, 2020), L2 proficiency (Lu and Dang, 2023), strategies employed during learning (Fan, 2020), and, to a lesser extent, age of acquisition (Granena and Long, 2013). These studies on second language vocabulary learning illuminate how various factors can impact a learner's success in acquiring vocabulary knowledge. However, many studies in SLA tend to focus exclusively on one of these aspects, with few taking an integrated perspective (but see Lu and Dang, 2023 and Van Mensel and Galand, 2023).

Acquiring vocabulary in a second language is a more intricate process than mere memorization and repetition. Achieving success in building vocabulary can be challenging due to potential issues such as the failure to retain words in long-term memory or an inefficient manipulation of learning strategies. Hence, it is advisable to adopt a comprehensive approach that incorporates various aspects of individual differences to uncover even the subtlest influences on second language vocabulary acquisition. Understanding and comparing how these different variables contribute to the acquisition of vocabulary knowledge among Chinese EFL learners hold significant importance in the context of English language instruction.

2 Literature review

2.1 Vocabulary knowledge

Research on defining and interpreting L2 lexical knowledge and L2 lexical attainment has reached a consensus that L2 vocabulary knowledge (hereinafter VK) can be measured by vocabulary depth (VD) and breadth (VB), which are two interconnected but distinct dimensions of equal importance (Qian, 1999, 2002; Schmitt, 2014). Breadth can be described by the number of words that L2 learners have mastered and does not restrain the extent to which they have mastered these words (e.g., Nation, 2001, 2006). A similar definition of vocabulary breadth is also put forward by other scholars such as Laufer and Goldstein (2004) and Schmitt (2010), arguing that vocabulary breadth knowledge is distinguished into four categories, namely active recall (form recall), passive recall (meaning recall), active recognition (form recognition), and passive recognition (meaning recognition).

In contrast, the lexical network approach conceptualizes depth as a complex lexical network within the mental lexicons of L2 learners, primarily exploring the interconnectedness of words (Read, 1998). Assessments within this approach often involve tasks requiring learners to identify words corresponding to target words, such as Read's Word Associates Format (WAF) or the written Word Association Test developed by Qian and Schedl (2004). Another approach adopts an alternative perspective by characterizing depth through the lexical network in L2 learners' mental lexicon. In this vein, assessments have been designed to measure knowledge of

vocabulary depth by collocation tests (Gyllstad, 2009) and word parts or derivatives tests (Sasao and Webb, 2017; Mizumoto et al., 2019). These approaches collectively underscore the multifaceted nature of vocabulary knowledge, making a clear distinction between its breadth and depth.

Furthermore, EFL learners can acquire new vocabulary through various means, including reading, listening, and diverse input modes (Feng and Webb, 2020). This acquisition of vocabulary, in turn, has implications for their L2 receptive skills, such as reading (Sen and Kuleli, 2015) and listening (Cheng and Matthews, 2018), as well as their speaking performance (Janebi Enayat and Derakhshan, 2021). Notably, research has revealed that EFL learners can incidentally acquire vocabulary through different input modes, such as reading-while-listening and captioned viewing (Teng, 2018; Teng and Mizumoto, 2023; Webb et al., 2023). Specifically, a study focused on the impact of reading-only versus reading-while-listening conditions on EFL learners' incidental vocabulary learning demonstrated that the latter was more effective, particularly concerning word form and grammar. This study emphasized the importance of word exposure frequency and in-depth word processing for successful vocabulary acquisition in both conditions (Teng, 2018). Moreover, by examining 87 minority L2 English speakers in Australia, Teng and Mizumoto (2023) concluded that captioned videos facilitate incidental vocabulary learning, with the learners' ability to acquire vocabulary incidentally influenced by their existing vocabulary knowledge. In sum, these studies collectively underscore the multifaceted nature of EFL vocabulary acquisition across various input modes.

2.2 Age of acquisition and VK

Work in this field focused on the effect of the Age of Acquisition (hereinafter AoA) of L2 acquisition on the eventual proficiency level of the learner and failed to reach a consensus. One of the representative studies of age effect on vocabulary acquisition in the natural setting was conducted by Spadaro (2013). By comparing native and non-natives' performances on the word association test and seven specifically designed written tasks, the author concluded that AoA played a role in L2 vocabulary attainment, with those who started learning English before six outperforming those who started learning later. This also supports idea of Hyltenstam's (1992) that the critical period for lexical development is around 6 years old. Related studies in classroom settings report a prevalence of age effects in second language learning. A negative correlation or a significant difference in L2 learning efficiency between early and late learners (early learners outperforming late learners) can be detected, but its specific manifestations differ (Hakuta et al., 2003; Granena and Long, 2013).

The study of Xue et al. (2021) attributed this divergent result to the complex foreign language teaching context. It argued that a later AoA not only meant later exposure to a foreign language but also a longer immersion in their first language. They took 85 Chinese EFL learners who learned English for 2–10 years as participants, and the study suggested that not all domains of L2 attainments secured an age effect. The ineffectiveness of age on English vocabulary learning was further confirmed that, in the foreign language context, earlier AoA was no longer a robust indicator for significant learning outcomes in the long term if amounts of input between natural and classroom settings were similar (Muñoz, 2011). Other than Chinese EFL learners, relevant

studies in different countries (e.g. Switzerland and Australia) also report similar results that not all aspects of foreign language proficiency confer to “the earlier, the better” (the Critical Period Hypothesis, [Lenneberg, 1967](#)) in the classroom setting ([Pfenninger, 2014](#); [Fitzgerald et al., 2015](#)). The study of [Unsworth \(2016\)](#) found no significant difference between English-speaking learners of Dutch (AoA 1–3 and 4–7 years) in the acquisition of verb morphology.

2.3 Vocabulary learning strategies and VK

Efforts have been made to investigate the exploratory power of vocabulary learning strategies (VLS) on second language learning outcomes. It is defined as “part of an ongoing process of vocabulary learning.” [Gu and Johnson \(1996\)](#) constructed the first version of VLS for Chinese EFL learners at the tertiary level, and it included several taxonomies such as selective attention, self-initiation, guessing, dictionary use, note-taking, memorization strategies, and activation. The most popular VLS among Chinese EFLs is rote-based strategies ([Li and Cutting, 2011](#)). Since then, further validation work has continuously been carried out through the years, and the latest version of [Gu \(2013\)](#), known as VLQ5, covers taxonomies from metacognitive components (beliefs and self-regulation), cognitive components (i.e., guessing, dictionary use, and note-taking), consolidation and reinforcement (i.e., rehearsing and encoding), and finally to the activation.

The use of VLS is assumed to be conducive in that the use of some particular strategies is positively correlated with that vocabulary size (e.g., [Gu and Johnson, 1996](#); [Kojic-Sabo and Lightbown, 1999](#)). Specifically, [Fan \(2020\)](#) found that the use of Attention and Guessing significantly positively predicted vocabulary size and word association test, while socializing strategies significantly but negatively predicted the breadth and depth of vocabulary knowledge, and DictNote, Association, and Repetition had no significant relationship with any of the vocabulary knowledge. Additionally, [Gu and Johnson \(1996\)](#) pointed out that metacognitive strategies (e.g., self-initiation, selective attention), inferencing, dictionary use, taking notes, and encoding, were significantly positively associated with both vocabulary size and language proficiency, whereas visual repetition of new words strategies were negatively correlated with vocabulary size. As for Chinese EFL learners, the two related studies are [Fan \(2020\)](#) and [Zhang and Lu \(2015\)](#). [Fan \(2020\)](#) analyzed the predictive power of VLS over VK and WAT by taking 409 sophomores as participants. The study reached a conclusion that the predictive power of Attention, Guessing, and Socializing over VST was detected because of the mediating effects of proficiency. Similarly, [Zhang and Lu \(2015\)](#) took advantage of questionnaire of [Schmitt \(1997\)](#) and also investigated the relationships between VLS and VK. They maintained that the use of word-structure strategies was positively correlated and predictable with VK, whereas using a wordlist negatively predicted the breadth of VK. Notably, they merely focused on the encoding and rehearsal strategies and overlooked other cognitive and metacognitive strategies that were also well-known and validated ([Gu, 2018](#)). Besides, although study of [Fan \(2020\)](#) included as many learners’ factors as possible, it still failed to integrate some other cognitive factors associated with their English learning experience. Consequently, further research is required to examine learner variables’ moderating and mediating effects in the relationship between VLSs and vocabulary learning outcomes.

2.4 Classroom exposure and VK

Recent research suggests that the critical factors influencing foreign language learning are not the early commencement of learning but rather the duration and intensity of instruction, as measured by hours per week ([Muñoz, 2011, 2014](#); [Graham et al., 2017](#)). Studies of [Muñoz \(2011\)](#) have highlighted that the length of instruction and exposure to foreign language input, rather than an early start, significantly predict learners’ speaking proficiency ([Muñoz, 2014](#)) and overall language skills and vocabulary knowledge ([Muñoz, 2011](#)). [Peters et al. \(2019\)](#) conducted a cross-sectional study that examined how length of instruction and out-of-school exposure to foreign language input affected receptive vocabulary knowledge in French and English. The results indicated that while longer instruction positively correlated with vocabulary knowledge in both languages, English proficiency was notably higher, attributed to extensive out-of-school exposure. On the other hand, study of [Van Mensel and Galand \(2023\)](#) on French-speaking Belgian children and adolescents highlighted the relevance of the input learners received from their teachers, and this was independent of several background and individual variables.

Notably, most of the relevant studies emphasize informal contact with a foreign language, rather than classroom instruction and immersion. What is more, it is essential to note that existing research has predominantly focused on vocabulary knowledge outside the Chinese EFL context. Learning English under non-cognate first language (L1) background are more demanding since the transfer from their L1 may not be that beneficial or even slow down the L2 improvement ([De Wilde et al., 2019](#); [Peters, 2019](#)). Therefore, the Chinese EFL context exhibits a unique language learning and teaching environment, requiring more empirical attention to explore how much the students can acquire through classroom teaching. Future studies are warranted to gain a more comprehensive understanding of how the duration of instruction impacts vocabulary knowledge and its interaction with other exposure factors.

2.5 L2 proficiency and VK

The relationship between second language (L2) proficiency and vocabulary knowledge has been a topic of considerable research interest. The results of [González-Fernández and Schmitt’s \(2015\)](#) study were remarkable, as they established that participants’ L2 proficiency significantly contributed to their vocabulary depth within the 5,000 most frequently used words. However, it is important to note that the self-rated assessments of L2 proficiency by the participants themselves, via a multiple-choice questionnaire, introduced a subjective element into the evaluation process. Another investigation, conducted by [Gui \(2015\)](#), delved into this connection among a cohort of 96 Chinese EFL learners, specifically focusing on the concept of vocabulary breadth, which pertained to their comprehension of the form-meaning relationship of words. To assess L2 proficiency, the study utilizes scores obtained from the College English Test Band 4 and Band 6, both of which are national assessments designed for non-English major university students in China. The study illuminated the degree to which CET4 scores primarily gauged vocabulary breadth. It was observed that these test scores exhibited a positive correlation with scores on vocabulary size

tests (VB). Furthermore, the research revealed a robust association between CET4 scores in the reading and listening sections and VB, indicating that individuals who performed well on the CET4 exam also excelled in the VB test. This finding highlights an important and effective strategy for individuals at relatively lower proficiency levels in English, such as those preparing for the CET4 examination, to enhance their overall second language proficiency through the expansion of their vocabulary breadth. These findings are thought-provoking, as they unveil a significant correlation between the vocabulary breadth of Chinese EFL learners and their scores on the CET-4. However, this association does not hold true for participants in the Band 6 category, suggesting a potential leveling off in vocabulary expansion among those with higher proficiency levels. Notably, Gui (2015) did not explore the relationship between participants' collocational knowledge (VD) and their L2 proficiency, leaving this aspect relatively underexplored. As far as current knowledge goes, Lu and Dang (2023) took a step further by pointing out that L2 proficiency significantly contributed to Chinese EFL learners' receptive knowledge of form-meaning connection (VB) and collocations of high-frequency words (VD) from the high-frequency level.

Despite this, there is still uncertainty about the robustness and predictive ability of EFL learners' L2 proficiency on L2 vocabulary acquisition compared to other individual factors. These endeavors will comprehensive comprehension of the intricate relationships within the field of vocabulary acquisition.

2.6 Gaps and research questions

Overall, vocabulary knowledge can be affected by multi-variables and many of them may be a predictor of Chinese EFL learners' vocabulary knowledge acquisition. The assessment of such an issue is a contribution that is missing from the literature, and the fact that all these variables have typically been investigated separately (or, at best, in pairs) potentially obscures important interactions between them (Diependaele et al., 2013). To the best of our knowledge, to date, sole study (Lu and Dang, 2023) investigated the impact of current second language (L2) exposure, length of study, and L2 proficiency on the receptive knowledge of high-frequency words in English among Chinese EFL postgraduate students. The findings revealed that current L2 exposure and length of study did not significantly affect their knowledge of these words, but L2 proficiency played a significant role, particularly for the high-frequency word, where form-meaning connection knowledge (VB) also influenced collocational knowledge (VD). However, as the authors mentioned, they did not include any cognitive factors, which indicates a gap in vocabulary research. Factors that may influence L2 learning, such as input and exposure, VLS, and AoA can be interconnected (Pessoa, 2009). Examining these factors in isolation does not assist us in unraveling their interconnections and their individual impacts on second language learning (Van Mensel and Galand, 2023).

Thus, we assessed the relationships and predictive effects of age of acquisition, vocabulary strategies, classroom exposure, and L2 language proficiency on L2 vocabulary knowledge.

3 Methods

3.1 Participants and research context

A total of 206 students were recruited from a "985 Project (top-tier)" university in China to participate in the study. These students took part in the research by utilizing the web-based questionnaire platform known as *wenjuan*,¹ in accordance with the institution's ethical guidelines. The data from 200 students (comprising 86 males and 114 females, aged between 18 and 21, $Mean = 19.41$, $SD = 1.52$) were used for subsequent analysis. All participants shared a common background of learning English within an English as a Foreign Language (EFL) context. Chinese was their native language, and none of them had prior experience living in an English-speaking country. Consequently, their English learning experience predominantly occurred within the framework of L2 classroom instruction. Additionally, they had all achieved a minimum Band 4 score on the College English Test, which was equivalent to an IELTS score of 5. Importantly, these students were not pursuing English as their major; instead, they had voluntarily enrolled in English courses taught by native English speakers. The frequency varied from once a week to five times a week, with each session lasting one and a half hours and spanning a duration of 16 weeks. Given their commitments to non-liberal arts studies, beyond the scheduled in-class hours, these students had limited time available for additional English language learning activities.

3.2 Instruments

3.2.1 Vocabulary knowledge test

The online vocabulary size test (VST) was conducted at <https://www.vocabularytester.com/vocabulary-test-english>. It was an adaptive test that assessed L2s' receptive and productive vocabulary size and benchmarked the results against CEFR (European Framework of Reference for Languages: Learning, Teaching, and Assessment). The test was adopted to measure participants' vocabulary breadth and it consisted of two stages. In the first stage, participants were asked to choose words that they knew well from 35 words (receptive vocabulary). In participants answered 10-40 adaptive questions (based on level) about choosing the word with the same meaning as the word given. This online vocabulary size test lasted for 10 min at most. Results of the vocabulary size raw number and its corresponding CEFR level would be displayed by the end of the second stage. The CEFR level provided the test taker with descriptions and active/passive word range at each level. Figure 1 is an example of one item.

The study employed the COLLEX (collocating lexis) assessment tool to investigate participants' grasp of collocational knowledge (i.e., vocabulary depth) pertaining to frequently used words, as outlined by Gyllstad (2009). This assessment was adapted into a web-based format using the *wenjuan* platform, featuring multiple-choice questions (refer to Figure 2 for a sample test item and Appendix I for the full version). The assessment primarily comprised three-word sequences, specifically Verb+NP combinations. To maintain a high level of focus

¹ <https://www.wenjuan.com/list/?from=home>

Choose the most appropriate word.

What does mean?

1. Skillful

ability power weakness talented brilliant I don't know.

FIGURE 1
Example of online vocabulary size test.

a. do damage b. make damage c. run damage

a. turn out a fire b. put out a fire c. set out a fire

FIGURE 2
Example of COLLEX.

and prevent dictionary use, the assessment was time-limited to 5 min. Participants were required to choose the correct option from the three choices presented, with each option including one authentic collocation commonly used by native speakers and two pseudo-collocations acting as distractors. The selection of the COLLEX assessment tool was guided by two key considerations. Firstly, it was grounded in the British National Corpus (BNC; Oxford University, 2005), which housed the most widely established and frequently used collocations, ensuring that the distractors were not commonly employed, as verified by the BNC. Secondly, COLLEX had undergone meticulous validation by Gyllstad (2009), resulting in a commendable level of internal consistency reliability (close to 0.9 according to Gyllstad, 2009).

3.2.2 Vocabulary learning questionnaire

A questionnaire aimed at assessing participants' vocabulary learning experiences was employed to gather data related to their L2 proficiency, English classroom exposure duration, and vocabulary learning strategies (see Appendix II in Supplementary material). The participants' L2 proficiency was indicated by their CET-4 scores, which, as per official guidelines (www.cet.edu.cn; Syllabus for College English Test, 2016, p.13), were categorized into three levels (425–500, 500–600, and 600–710), representing elementary, intermediate, and advanced English proficiency levels. These scores have long served as a reliable measure of English proficiency for undergraduate students, as they are an integral part of the graduation requirements.

The extent of English exposure was gauged by calculating the cumulative number of weekly class sessions in which the participants were currently enrolled. Amid our research context, the length of classroom English instruction varied from once a week to more than 5 a week. Hence, we computed the classroom exposure by hours, ranging from 1.5 to 7.5 h a week. The Age of Acquisition (AoA) was also documented, counting from the time (by number of years) when participants commenced learning English. Typically, the length of learning was 12–15 years (from primary school), with a few participants reporting 7–10 years (from junior high school). Extracurricular English courses in pre-school were also included (15 years or more).

To assess vocabulary learning strategies, we employed a Vocabulary Learning Strategies Questionnaire (VLS Questionnaire Version 6.4) designed and validated by Gu (2018). While this was a self-reported questionnaire, which offered the advantage of being cost-effective and straightforward to administer (Cohen et al., 2018), it presented potential challenges for participants in interpreting the meaning of individual items. Consequently, prior to conducting the survey, researchers meticulously reviewed all items, and some were rephrased to enhance clarity. The VLQ6.4 consisted of 62 items, graded on a seven-point Likert scale ranging from 1 (extremely untrue of me) to 7 (extremely true of me). These items were categorized into eight subscales, including Beliefs about vocabulary learning (10 items), metacognitive strategies (seven items), inferencing (seven items), dictionary usage (seven items), note-taking (six items), rehearsal techniques (nine items), encoding strategies (12 items), and activation strategies (four items). The VLQ6.4, as developed by Gu (2018), has been widely adopted to explore the vocabulary learning strategies of Chinese EFL learners and has consistently yielded reliable results. The internal consistency reliability of the questionnaire indicates it as a reliable instrument (c.f. Gu, 2018, pp.340 Table 1), with an average Cronbach's alpha coefficient of the eight subscales ranging from 0.627 to 0.884 (Mean = 0.798, SD = 0.078).

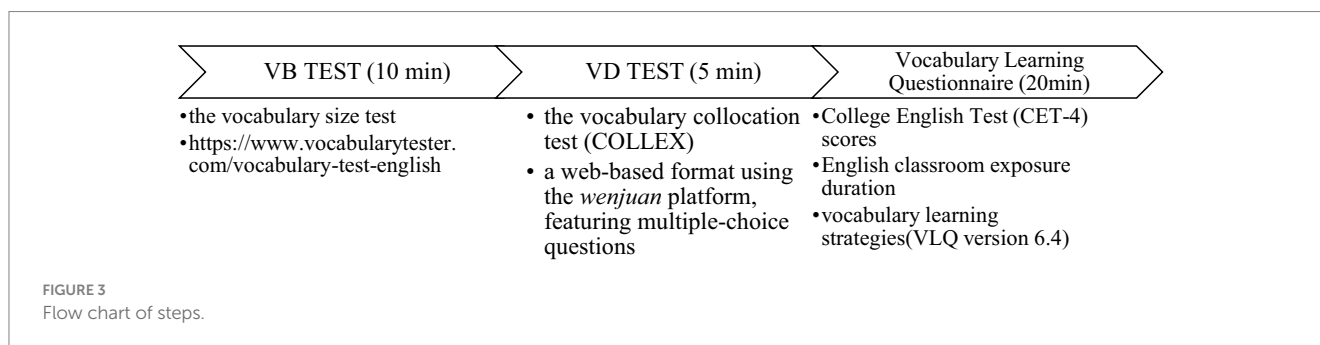
3.3 Procedure

This research was conducted around the final season. The sequence of activities involved the participants initially completing the online vocabulary size test (also referred as VB test), followed by the vocabulary collocation test (COLLEX, also referred as VD test), and ending with the vocabulary learning questionnaire. These assessments and questionnaires were administered in a web-based format. The time required for participants to complete the vocabulary size test, COLLEX, and questionnaire was approximately 10, 5, and 20 min, respectively. To mitigate the potential impact of fatigue, scheduled breaks were implemented between the tests. Additionally, considerable care was exercised throughout the data collection process to ensure that

TABLE 1 Descriptive statistics of score on VB test and VD test ($n = 200$).

Variables	MPS	Min.	Max.	Mean	SD	Skewness	Kurtosis	Reliability
VB	60	10	60	33.10	17.230	0.207	-1.214	0.77
VD	40	12	29	20.10	3.157	0.099	-0.105	0.99
AoA (years)		7.0	18.0	13.54	3.451			
Classroom exposure (h)		1.5	7.5	5.034	1.898			
VLS		2.398	6.746	4.730	0.890			

MPS, Max possible score; SD, Standard deviation.



participants possessed a comprehensive understanding of the questionnaire's purpose and content. Participants were informed that the VB and VD tests were quizzes, and their scores would be recorded. This helped to reduce the risk of random guessing or careless responses. The research purposes were debriefed to them after they completed the entire procedure. The course facilitators (usually Chinese lecturers) administered the questionnaire during students' class sessions and closely oversaw the process to ensure that participants provided sincere and diligent responses. Furthermore, comprehensive explanations were provided regarding the definitions of the variables related to current English exposure and AoA, as adopted in our study, and any participant inquiries were addressed promptly. A flow chart of the research procedure is provided in Figure 3.

3.4 Data analysis

Data from 200 out of 206 participants entered the data analysis stage. Two out of the six participants withdrew from the research and the other four data points were excluded due to being outliers (VB/VT scores deviated more than two SD from the mean). The vocabulary size was scored by uploading a screenshot of the result, containing the CEFR levels. The scoring system of the test was as follows: since there were six levels provided by the CEFR guideline (see more detail at <https://www.englishprofile.org/images/pdf/GuideToCEFR.pdf>), from A1 to C2 (for each level and its corresponding vocabulary size, please visit <https://www.vocabularytester.com/vocabulary-test-english>), A1 was given a credit of 10 points, and an additional 10 points for each level improvement (max = 60 points). For the vocabulary collocation test, a correct response was given one point whereas an incorrect response was given 0 in the COLLEX test (max = 40 points).

The methodology involved employing R studio 4.3.1 to conduct various analyses. These analyses were carried out separately for two aspects of vocabulary: breadth (VB, vocabulary size scores) and depth

(VD, COLLEX test scores). The test of normality was checked using the Kolmogorov–Smirnov test, and the results indicated that both VB and VD test scores were not normally distributed ($p < 0.05$). To examine the factors influencing L2 vocabulary knowledge, our analysis proceeded in three stages. Initially, the L2 proficiency was divided into three levels (CET 4 score 425–500, 500–600, and 600–710) and we assessed the impact of L2 proficiency on VB and VD using the Kruskal–Wallis test. Subsequently, we conducted a series of correlations involving all chosen continuous variables between VB/VD. Spearman correlation coefficients were calculated for these sets of scores. Finally, in the third stage, we performed a path analysis using *Lavaan* Package in R by following data analysis method of [Janebi Enayat and Derakhshan's \(2021\)](#) data analysis method to mitigate the issue of multicollinearity bias with the VB and VD serving as dependent variables.

4 Results

4.1 Preliminary analyses

Preliminary descriptive statistics of the data were first conducted to have an overview of the participant's performance on the VB and VD. The results were summarized in Table 1. Table 1 demonstrated that within the scope of this study, second language (L2) learners exhibited familiarity with approximately 50% of the items in the VD test and approximately 55% of the items in the VB test. These findings unequivocally highlighted discernible deficiencies in both VB and VD among the learners, contributing to a relatively lower proficiency level. Table 1 also presented the descriptive statistics of the amount of time that they have been exposed to classroom English construction and the age of acquisition of their English learning.

A Kruskal–Wallis test was performed with VB and VD test scores as dependent variables, and proficiency levels as independent variable, with

each group had a sample size of $n=63$ (elementary), $n=70$ (intermediate), $n=67$ (advanced). The statistical result showed that there was a statistically significant difference in VB score between the different L2 proficiency levels, [$\chi^2(2)=122.35, p<0.000$]. On top of this, the pairwise *post hoc* comparison by Wilcox test was conducted. Because three comparisons were made, the Bonferroni correction set the α to $0.05/3=0.0167$. Results showed a significant effect of L2 proficiency on VB between level 1 and level 2 ($p<0.000$), level 1 and level 3 ($p<0.000$), as well as between level 2 and level 3 ($p<0.000$). Similarly, a significant effect of L2 proficiency on VD was detected [$\chi^2(2)=112.9, p<0.000$]. The *post hoc* comparison with Bonferroni correction at $\alpha=0.0167$ also showed a significant effect between each proficiency level.

Figure 4 presented the descriptive statistics of the VLS adopted by the participants. It can be seen from Figure 4 that the participants tended to use some strategies for English vocabulary learning. Inferencing was the most used VLS ($M=4.82, SD=1.30$), participants often tried to guess meaning by making use of the logical development in the context. Metacognitive strategies (self-initiation and selective attention) about vocabulary learning ranked second. Other frequently used VLS include notetaking: participants reported that they often put new words in the notebook and decide what information goes into notes. As far as the least popular VLS, mostly were about rehearsal strategies such as visual and oral repetition, as well as activation, which was to apply the newly learned word into daily communication.

4.2 Correlations

Table 2 showed the correlations between the various predictor variables and the outcome variables (the correlations between the eight subscales of VLS and VB/VD are provided in Table A1 in Appendix III). The following predictors were

TABLE 2 Spearman correlation coefficients among the vocabulary breadth and depth.

Variables	Mean	SD	VB	VD
VLS (Likert scale)	4.730	0.889	0.665**	0.475**
Classroom exposure (h)	5.034	1.990	-0.233**	-0.216**
AoA (years)	13.535	3.451	0.424**	0.402**

* $p<0.05$; ** $p<0.01$.

TABLE 3 Results of multivariate regression analysis with R.

Dependent	Predictor	Estimate	S.E.	Z-value	p	R ²
VB	AoA	0.631**	0.207	3.053	0.002	0.818
	Classroom exposure	-0.778*	0.353	-2.206	0.027	
	Proficiency	11.770***	0.983	11.980	0.000	
	VLS	6.106***	0.870	7.018	0.000	
VD	AoA	0.129**	0.046	2.773	0.006	0.643
	Classroom exposure	-0.174*	0.079	-2.195	0.028	
	Proficiency	2.184***	0.220	9.908	0.000	
	VLS	0.593**	0.195	3.041	0.002	

*** $p<0.001$; ** $p<0.01$; and * $p<0.05$.

significantly correlated with L2 vocabulary breadth: the VLS had the strongest correlation with both vocabulary breadth and depth, among which the use of metacognitive strategies was significantly associated with a higher score of vocabulary knowledge, followed by the use of inference and rehearsal strategies. Overall, the use of vocabulary learning strategies was significantly associated with a higher score in vocabulary knowledge; still, the statistically significant relationship between AoA and classroom exposure and VK cannot be overlooked. A Spearman correlation analysis conducted between Vocabulary Breadth (VB) and Vocabulary Depth (VD) yielded a statistically significant result ($r=0.693, p<0.000$). This outcome further underscores the interrelated yet distinct nature of these two aspects of vocabulary knowledge.

4.3 Regression analyses

To account for existing covariances and enhance result accuracy, a path analysis employing multiple regression techniques was conducted using the *Lavaan* Package within the R studio. Standardized estimates resulting from this analysis were presented in Figure 5, while a comprehensive summary of the regression findings was provided in Table 3. Based on the outcomes detailed in Table 3, the joint influence of the four distinct factors was able to collectively account for 81.8% of the variability observed in the overall vocabulary breadth scores of the participants ($R^2=0.818, p<0.001$). Furthermore, the four factors jointly accounted for 64.3% of the variability in vocabulary depth scores ($R^2=0.643, p<0.001$). It was noteworthy that classroom exposure, while uniquely significant, exhibited a negative relationship with both vocabulary breadth (VB) and vocabulary depth (VD), contrary to the conventional belief of “the more, the better.” As anticipated, the primary predictor of vocabulary knowledge remained L2 proficiency, closely followed by the utilization of vocabulary strategies. Lastly, age of acquisition emerged as a predictor for both VB and VD.

When examining each subgroup of Vocabulary Learning Strategies (VLS) separately, several noteworthy observations can be drawn (eight subscales detailed in Table A2 and Figure A1 in Appendix III). Standardized estimates revealed that the utilization of metacognitive strategies emerged as the most robust predictor for both of the outcome variables. Furthermore, the capacity of L2 learners to deduce word

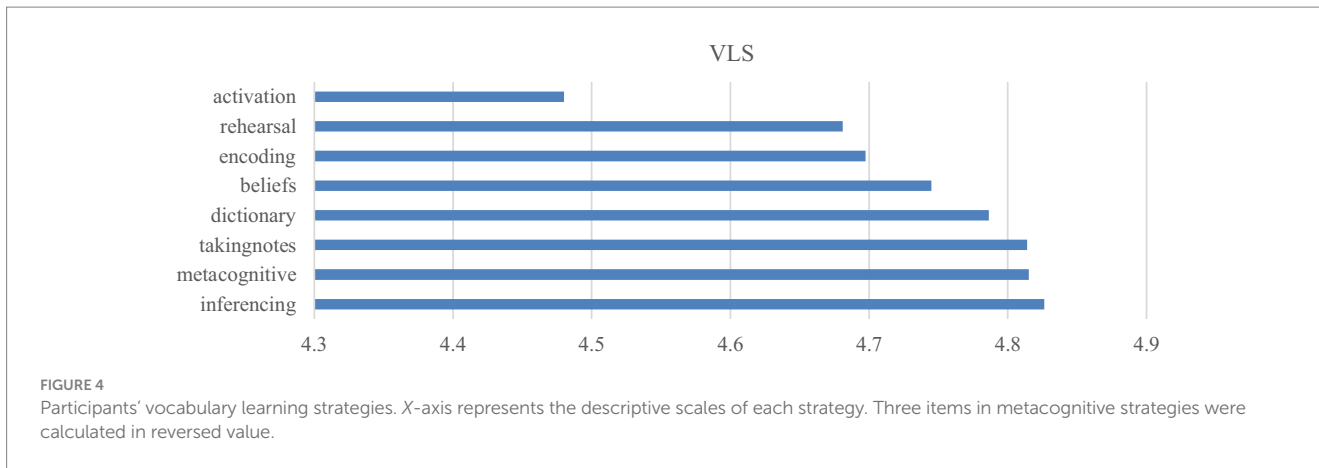


FIGURE 4 Participants' vocabulary learning strategies. X-axis represents the descriptive scales of each strategy. Three items in metacognitive strategies were calculated in reversed value.

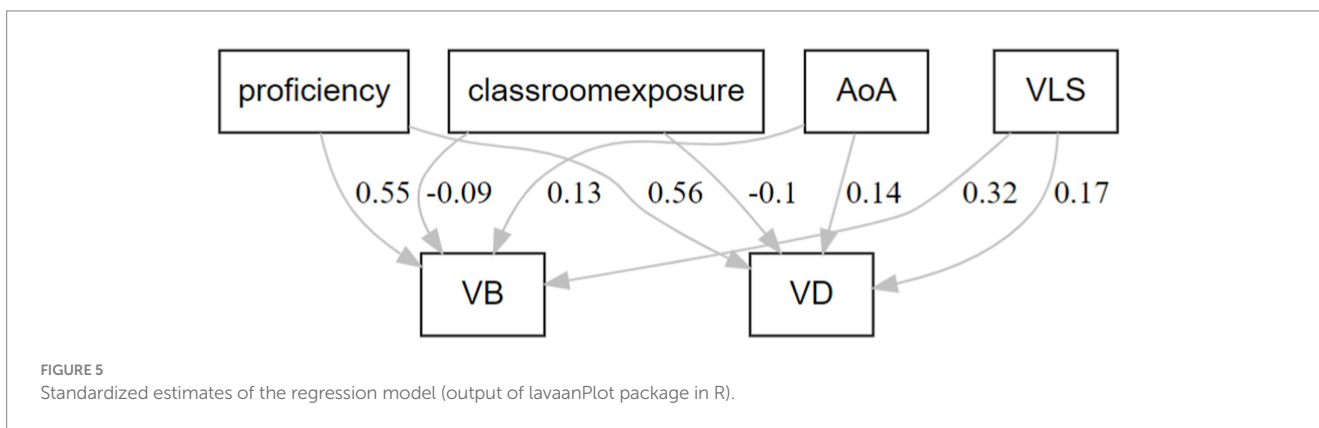


FIGURE 5 Standardized estimates of the regression model (output of lavaanPlot package in R).

meanings through discourse, common sense, or guessing predominantly influenced their vocabulary breadth scores. Conversely, the adoption of a dictionary for acquiring new words significantly predicted both VB and VD, while strategies such as note-taking and rehearsal (compiling word lists or incorporating words into a notebook) did not yield substantial benefits in terms of vocabulary acquisition. An approach that focused on word structure during word encoding demonstrated its efficacy in expanding vocabulary size. It was notable that holding a positive belief towards vocabulary learning did not exhibit a predictive relationship with vocabulary knowledge. Notably, the motivational factor of activation emerged as a significant contributor to predicting both VB and VD. This underscored the importance of L2 learners actively engaging with new words in real-world contexts and maximizing their usage, as such practices demonstrated to be conducive to the development of vocabulary knowledge.

5 Discussion

The present study embarked on a thorough exploration of various factors impacting vocabulary knowledge (VK) in EFL learners. It stands out due to its integrative analysis of the effects of age of acquisition, L2 proficiency, English classroom instruction exposure, and vocabulary learning strategies on both the breadth and depth of vocabulary knowledge.

5.1 The effect of age of acquisition on VK

The findings of our current research demonstrate a significant and correlational relationship between the age at which individuals acquire English and their vocabulary breadth (VB) and vocabulary depth (VD). This outcome aligns with the consensus in the majority of prior studies, which have consistently reported a substantial link between the age of language acquisition and one's vocabulary knowledge (Peters et al., 2019; Saito, 2022). This discovery furnishes fresh empirical support for the validity of the Critical Period Hypothesis. However, it contradicts the findings of Xue et al. (2021) which suggests a tendency for enhanced English vocabulary proficiency among those who acquires English at a later stage. The present study also contrasts with study of Lu and Dang (2023) which report a non-predictability over receptive knowledge. This discrepancy can be attributed to disparities in the composition of the study samples. In our study, we recruited participants who were not English majors and had exclusively acquired English through classroom instruction. Conversely, their study featured Chinese-English bilingual participants whose first and second languages consistently competed with each other during vocabulary acquisition. Moreover, all our participants were native Chinese speakers who had not been exposed to an L2 environment outside of classroom teaching, and their English classes, conducted by a native speaker, represented their primary immersion experience

in the L2. Prior research has indicated that learners who engage in intensive English instruction over a shorter duration may outperform their peers who receive the same amount of instruction spread out over a longer period (Collins et al., 1999). This phenomenon may have been at play in the study of Xue et al. (2021). Another plausible explanation for the age of acquisition (AoA) emerging as a significant predictor could be the considerable heterogeneity observed within our study group in terms of AoA, as indicated by a standard deviation of 3.451, whereas the participants in Lu and Dang (2023) were all postgraduates students with a longer AoA.

Our results confirm the significant relationship between the age of language acquisition and vocabulary breadth and depth. This aligns with the Critical Period Hypothesis, suggesting that there is an optimal age range for language acquisition. The variations in results across studies underscore the importance of considering the specific context and participant backgrounds. While age plays a role in vocabulary acquisition, its effect might differ based on the learners' environment and learning contexts.

5.2 The effect of VLS on VK

The present study shows that using vocabulary learning strategies is the second strongest predictor of VK, revealing the importance of cognitive aspects on L2 vocabulary learning. As for the use of VLS, the findings of this study stand in line with most of the relevant literature in that Chinese EFL learners are more exam-orientated, and they tend to use more memorization than output practice (Gu and Johnson, 1996). The popular use of guessing and encoding is also on par with findings of Schmitt (1997). Since most students gain English input from the classroom, there is no surprise that they seldom have chances to use activation strategies (Fan, 2020). What is worth mentioning here is the significant predictive power of metacognitive strategies over VK. As the taxonomy "metacognitive" is defined as metacognition as the process of "thinking about thinking", the EFL learners should be conscious about what they need to know, or what is important for them in vocabulary learning." The logic behind this prediction might be that successful Chinese EFL vocabulary learners are self-regulated enough to ask themselves whether a vocabulary is crucial in text comprehension, and they are self-initiated to find motivations in vocabulary learning; most importantly, they are also able to self-question whether remembering a particular word should be prioritized over remembering other words when faced with a coming exam. The present research also detects a significant correlation between using inferencing and encoding strategies and vocabulary depth more or less demonstrating the efficiency of certain strategies used in vocabulary acquisition. Since the present study adopts COLLEX as a vocabulary depth test, it mainly examines the learners' vocabulary network knowledge (Binder et al., 2017), emphasizing the connection between words and mental lexicon (Read, 2004). This well attests to the fact that EFL learners use inferencing and encoding strategies during VD tests because they always have to guess and visualize the context where the word should be put into actual use when choosing the correct collocation. However, the significant correlation between VLS and VK should be interpreted with cautions that learners who have acquired larger vocabularies subsequently learn to apply different strategies to cope, reflecting the opposite direction of causation.

The overall weaker predictive power of the aforementioned four variables on VD than on VB, as well as the weaker performance on the VD itself, can be ascribed to the following. In the context of vocabulary instruction in China, there has traditionally been a greater emphasis on the individual components of vocabulary, namely form and meaning, rather than on the intricate relationships between words, such as collocations (Gu, 2013). Consequently, learners may have devoted their efforts to accumulating a larger repertoire of words without delving deeply into the nuanced associations between these words.

Our study reinforces the importance of vocabulary learning strategies (VLS) in predicting VK. Emphasizing the role of metacognitive strategies suggests that successful learners employ a higher level of cognitive engagement and self-regulation in their vocabulary learning. Active, self-regulated learning and the strategic use of vocabulary acquisition techniques can enhance VK, particularly in enhancing the vocabulary depth.

5.3 The effect of classroom exposure on VK

The findings of this study have yielded intriguing insights into the impact of extensive exposure to foreign language input on the development of vocabulary depth (VK), revealing a surprising and somewhat counterintuitive result. Contrary to expectations, it is observed that extensive exposure does not significantly contribute to the growth of VK; in fact, it exhibits a negative correlation with VK. This outcome stands in contrast to the effects of out-of-class English exposure, where previous studies have reported a significant positive relationship between English as a Foreign Language (EFL) learners' exposure to L2 input outside of the classroom and their vocabulary knowledge (González-Fernández and Schmitt, 2015; Peters et al., 2019). These findings shed light on the nuanced nature of language acquisition. They suggest that, for non-major students receiving a maximum of 7.5 h of English classroom instruction, such exposure may not be conducive to fostering L2 vocabulary acquisition. What makes this observation particularly intriguing is the recognition that effective language learning relies not only on the quantity of exposure but also on the quality of engagement with the input. This aligns with the perspective put forth by González-Fernández and Schmitt (2015), suggesting that it is not merely the sheer volume of input that matters but rather the manner in which learners engage with and process that input. One potential explanation for the observed negative correlation and prediction between classroom exposure and VK could be attributed to the relatively low proficiency level of the participants and their slower pace of learning (Muñoz, 2014). Nonetheless, regression analyses underscore the importance of tailored and stratified teaching approaches for learners at relatively low proficiency levels (Van Mensel and Galand, 2023). Additionally, the relatively extended hours of classroom exposure raise concerns about the potential detrimental effects on less-proficient L2 learners subjected to an excessive duration of English classroom instruction. As suggested by Muñoz (2014), evaluating their learning aptitude and pedagogical approaches can result in more effective and efficient learning, optimizing the use of classroom learning time and potentially mitigating the negative consequences of prolonged exposure.

Contrary to expectations, extensive classroom exposure did not lead to higher VK in our study, suggesting that mere exposure is not enough. The quality of engagement and interaction with language input is pivotal. Tailored pedagogical methods are essential, particularly for learners at different proficiency levels.

5.4 The effect of L2 proficiency on VK

This investigation has revealed a significant and positive impact of L2 proficiency on participants' vocabulary knowledge, establishing itself as the most robust predictor among the variables examined. This outcome is in line with the findings of [Gui \(2015\)](#) and [Lu and Dang \(2023\)](#), who similarly identify a positive correlation between the vocabulary breadth of Chinese EFL learners and their L2 proficiency, as measured by their performance on the College English Test Band 4 (CET-4). Furthermore, our study extends this understanding by demonstrating that not only is the vocabulary breadth of L2 learners closely linked to their L2 proficiency, but their vocabulary depth also exhibits a strong association and predictability based on their L2 proficiency, echoing with the study of [González-Fernández and Schmitt \(2015\)](#) who reported a positive correlation between L2 proficiency and VD test scores. Prior research has indicated that the comprehension of both form and meaning serves as a positive predictor of EFL learners' overall L2 proficiency, even at the foundational proficiency levels ([Schmitt, 2014](#); [Miralpeix and Muñoz, 2018](#)). Consequently, it is unsurprising that a reciprocal effect is also observed in our findings. This study also provides a new perspective for further validation of the CET-4 test in terms of its high discriminant validity. As a large-scale nationwide English proficiency test for non-English major university students in China, it has been undergoing rounds of test validations and negative washback elimination these days ([Han, 2021](#)). The close relationship between EFL learners' vocabulary size and their L2 proficiency has been found by several research ([Schmitt, 2014](#); [Miralpeix and Muñoz, 2018](#)), and it is unsurprising that the reverse effect is also observed ([Lu and Dang, 2023](#)).

The current study extends the findings of [Gui \(2015\)](#) by highlighting that CET-4 test scores can effectively serve as a measure of Chinese EFL learners' VD. This assertion is grounded in the fact that the cloze and translation sections of the CET-4 exam require a strong command of extensive vocabulary knowledge, particularly in terms of depth. The correlation observed between VB and VD further supports the notion that these two aspects are closely interrelated dimensions of vocabulary knowledge, as proposed by [Schmitt \(2014\)](#). It is also evident that individuals who achieve higher scores on the CET-4 tend to possess a more extensive vocabulary knowledge. Given the prevailing emphasis on rote memorization of vocabulary in the Chinese English teaching context, it is imperative to place additional emphasis on enhancing the depth of vocabulary knowledge among Chinese EFL learners. This entails a heightened focus on acquiring words within the context of their collocations. Such an approach not only contributes to the simultaneous improvement of their second language (L2) proficiency but also yields practical benefits, including higher CET-4 scores and a more comprehensive expansion of their overall vocabulary knowledge.

Second language proficiency emerged as the most robust predictor of VK in our study. This aligns with the interconnected nature of vocabulary knowledge and overall language proficiency. Mastery in L2 proficiency significantly augments both the breadth and depth of vocabulary knowledge.

6 Pedagogical implications and conclusion

The results of this study have practical implications for EFL researchers and instructors. The results are helpful to those children's caregivers in that they can raise their awareness of bringing their children to an English environment. Besides, the EFL instructors, as well as Chinese universities, should invite more native speakers to the English classroom for comprehensible input and full immersion in the L2 context. Concerning L2 instructors, the conventional approach that predominantly prioritizes form and meaning should be supplemented with strategies and exercises that foster a deeper understanding of how words relate and collocate with one another. This shift in pedagogical emphasis holds the potential to equip EFL learners with more comprehensive and practical vocabulary skills, enhancing their language proficiency in real-world communicative contexts.

In conclusion, the results of this study have illuminated the intricate factors that contribute to the development of vocabulary knowledge of L2 learners, emphasizing the imperative need for a multifaceted approach to comprehending and enhancing L2 vocabulary acquisition. Our study highlights the multifaceted variables that influence L2 vocabulary acquisition. While age of acquisition and L2 proficiency are critical, the efficient and high-quality classroom exposure together with self-conscious and self-regulated learners are equally paramount. As such, educators and curriculum designers should adopt a holistic approach that incorporates these findings to maximize VK among EFL learners.

While this study offers valuable insights by assessing various factors' impact and predictive strength on vocabulary knowledge, it does have limitations. Primarily, it focuses solely on receptive vocabulary, neglecting productive vocabulary. Additionally, the reliance on self-reported questionnaires may compromise measurement precision. Lastly, longitudinal research employing alternative methods would yield fresh perspectives on how L2 exposure affects EFL learners' vocabulary knowledge.

Data availability statement

The dataset will be available upon request by contacting the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Committee of Southeast University. The studies were conducted in accordance with the local legislation and institutional requirements.

The participants provided their written informed consent to participate in this study.

Author contributions

DS, ZC, and SZ contributed equally to the conception and design of the study, as well as the analysis and interpretation of the data. DS took the lead in drafting the manuscript, with critical input and feedback provided by ZC and SZ throughout the writing process. ZC provided expertise in statistical analysis, including conducting complex regression analyses and interpreting the results. SZ conducted data collection and provided critical feedback and revisions to the manuscript, particularly in the areas of discussion and conclusion. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors would like to thank all the participants for their attentiveness in completing the questionnaire and the vocabulary knowledge test.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2023.1210640/full#supplementary-material>

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