Using a Mobile Vocabulary Application to Enhance L2 Learners' Vocabulary Acquisition: Possibilities and Challenges

Qian Xu
Purdue University, USA

Jennifer C. Richardson
Purdue University, USA

Zhuo Zhang
Towson University, USA

Zui Cheng
Shenzhen University, China

Fengping Guo
Southeast University, China

Abstract

The use of mobile technologies has increasingly changed how students learn in the digital age. This study examined the effectiveness of using a mobile application called Shanbay Dan-Ci (SBDC) for acquiring new English vocabulary. Participants included 70 Chinese undergraduate L2 learners. Following a quasi-experimental design, two groups of L2 learners were randomly assigned to two conditions: using the mobile-assisted language learning (MALL) application or using traditional wordlists. A mixed methods approach examined the effectiveness of using MALL applications in developing L2 learners' vocabulary knowledge and exploring L2 learners' vocabulary learning experiences. Results indicated that L2 learners who used SBDC outperformed those who used wordlists, though the difference was not statistically significant. The results also revealed that L2 learners' SBDC learning experiences were highly impacted by certain learning features and strategies such as personalized learning, rich content, and collaboration. The discussion concludes with possible reasons for the statistically insignificant findings, the challenges of learning in a mobile environment, and implications and directions for future research.

Keywords: English as a second language (L2), vocabulary learning, mobile learning, mobile-assisted language learning (MALL)

Xu, Q., Richardson, J. C., Zhang, Z., Cheng, Z., & Guo, F. P. (2025). Using a mobile vocabulary application to enhance l2 learners' vocabulary acquisition: Possibilities and challenges. *Online Learning, 29*(3), 66-102. https://doi.org.10.24059/olj.v29i3.4918

Introduction

The rapid development of mobile technologies has provided rich opportunities for embedding diverse resources and communicative features into second language (L2) learning. Using mobile devices to learn languages has gained popularity among language-teaching practitioners and researchers (Chwo et al., 2018). Mobile-assisted language learning (MALL) has the potential to cease limitations of physical location and time (Kukulska-Hulme, 2009) and facilitate learning in a more collaborative, authentic, and natural way (Komppa & Kotilainen, 2018; Lotherington, 2018).

Scholars regard vocabulary as a key component for achieving proficiency in a second language (Schmitt, 2008; Nation, 2022; Masrai, 2023). Unfamiliarity with certain words may slow or even stop the flow of information processing, as learners' attention might be focused on single words rather than full sentences (Nation, 2022). Thus, vocabulary learning is necessary to optimize L2 acquisition (Nation, 2022), and L2 teachers, researchers, and learners continuously seek effective strategies to learn vocabulary (Schmitt & Schmitt, 2020; Nation, 2022). As Castañeda and Cho (2016) observed, research on mobile-assisted language learning (MALL) tends to follow two primary trajectories: (a) descriptive studies that detail the implementation of mobile learning interventions, and (b) outcome-focused studies that examine the learning gains facilitated by MALL. However, beyond implementation and learning outcomes, learners' perceived learning experiences remain underexplored. In particular, there is a need to investigate which mobile app features learners find most useful and how they engage with these features to support vocabulary acquisition. While the iPAC framework (Kearney et al., 2019) has identified key design principles (i.e., personalization, authenticity, and collaboration) that can optimize mobile learning strategies, little is known about how learners perceive and interact with these features during vocabulary learning.

Moreover, several challenges in vocabulary instruction have been identified, such as limited instructional time, the need for repeated exposure and rehearsal, and constrained peer interaction (Nation, 2022), especially in large classroom settings common in Chinese L2 learning contexts. These barriers raise questions about whether mobile-assisted vocabulary learning can effectively address such limitations by enhancing both vocabulary learning outcomes and learners' learning experience. To address these gaps, the present study investigates the effectiveness of a mobile-assisted vocabulary learning tool and explores learners' perceptions of its features in supporting explicit vocabulary learning among native Chinese speakers learning English.

Literature Review

Second Language Vocabulary Learning Strategies

Research has summarized some persistent and well-documented challenges in learning vocabulary including (a) the large amount of vocabulary necessary to enable L2 learners' successful use of the language; (b) the different levels of knowledge needed for recognizing and using a word; and (c) the time necessary for sufficient rehearsal and consolidation of vocabulary to avoid forgetting (Nation, 2022; Schmitt, 2010). To overcome these barriers, two main vocabulary learning strategies have demonstrated success: *implicit* and *explicit* vocabulary acquisition (Ellis, 2015; Schmitt, 2010). Implicit vocabulary acquisition argues that vocabulary is

acquired unconsciously through exposure to varying contexts, while explicit vocabulary acquisition indicates that the new vocabulary acquisition process can be effectively facilitated by metacognitive strategies: (a) identifying unfamiliar words; (b) attempting to infer words from contexts by using dictionaries or consulting experts; and (c) consolidating the new vocabulary by repetition, semantic, or imagery mediation techniques. Further, Ellis (1995, 2015) argued that vocabulary acquisition involves complex learning processes; for example, perceptual vocabulary knowledge such as phonetic and pattern recognition will likely be acquired implicitly via exposure while semantic knowledge will likely be learned explicitly. Semantic elaboration and imagery mediation are used as "deep processing" strategies for better learning results (Ellis, 1995).

Recent research focuses on both implicit and explicit vocabulary teaching. Specifically, implicit vocabulary teaching includes lexical glosses and dictionary use, whereas explicit vocabulary teaching involves reading plus exercise and explicit instructions (Nation, 2022). According to Ma (2009), the implicit method provides richer contexts for learners but often results in a low retention rate. Although researchers advocate implicit vocabulary learning as the main source for acquiring new words in contexts, studies indicated that explicit vocabulary learning strategies are also important supplementary resources to help L2 learners build an adequate vocabulary. Mobile-assisted L2 vocabulary learning has been shown to enhance both affective learning (e.g., self-regulatory and metacognitive skills) and cognitive learning (e.g., word decoding, automation through repetitive practice) (Elaish et al., 2019; Fathi et al., 2018; Kohnke, 2020; Okumuş, 2023). These improvements are often achieved by integrating technology features such as goal setting, peer interaction and competition, and personalized learning plans (Castañeda & Cho, 2016).

Vocabulary Knowledge and Learning Outcomes

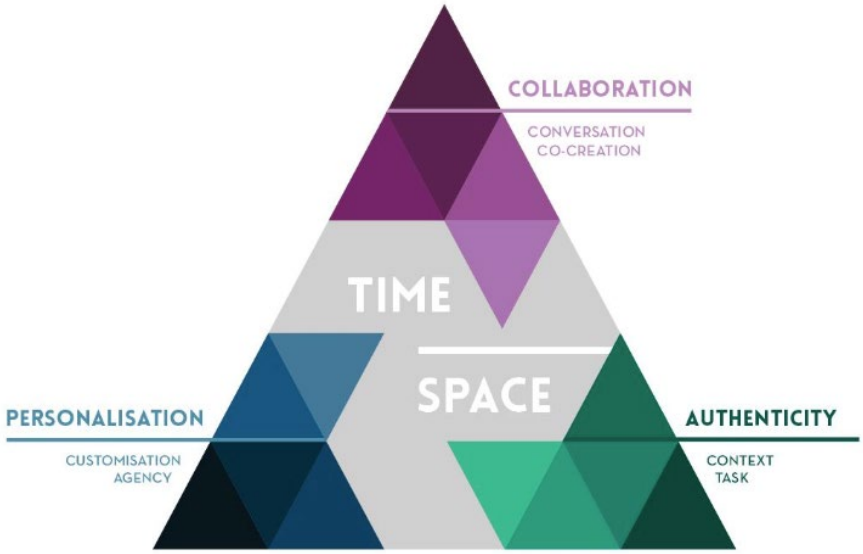
Anderson and Freebody (1981) first developed the concepts of *breadth* (i.e., how many words are known) and *depth* (how well those words are known) of vocabulary knowledge as two fundamental dimensions to measure vocabulary knowledge. As Nation (2022) explained, receptive vocabulary use is the ability to perceive the form and retrieve its meaning in reading and listening contexts, while productive vocabulary use is the ability to retrieve and produce the spoken or written form and express one's meaning. Nation (2022) found that knowing a word generally involves three levels: form, meaning, and use. Form includes spoken, written and word parts; meaning covers form and meaning, concept and referents, and associations; and use refers to the word's grammatical functions, collocations, and constraints on use. Receptive vocabulary knowledge refers to the ability to recognize the form-meaning linkage of a word, which represents an initial stage of the vocabulary depth dimension. Common assessment techniques for measuring form-meaning linkage include matching tasks, multiple-choice questions, translation exercises, and gap-filling activities (Sonbul, 2012). Linking form and meaning is beneficial, as it assesses whether learners can recall the meaning of a target word during reading or listening and retrieve its form or pronunciation when seeking to express the meaning (Nation, 2022). Thus, our study investigates how a mobile app serves as an explicit vocabulary learning tool improving L2 learners' form-meaning linkage knowledge, focusing on receptive vocabulary knowledge. Specifically, the dimension of vocabulary breadth.

The Personalization, Authenticity, and Collaboration (iPAC) Framework

This study used iPAC mobile learning as the framework (Kearney et al., 2020). Grounded in sociocultural theory, the iPAC framework highlights the unique affordances of mobile learning and consists of three dimensions: personalization, authenticity, and collaboration (PAC) (Kearney et al., 2020). Each dimension includes two sub-dimensions: the personalization dimension includes agency and customization; the authenticity dimension captures context and task; the collaboration dimension consists of conversation and co-creation.

Figure 1

The iPAC Framework



Note. The triangulate framework comprises three key components: personalization, authenticity, and collaboration. Positioned at the center of this framework are the interconnected elements of time and space.

This framework focuses on mobile learning beyond the tools (e.g., mobile devices, educational applications) and emphasizes the impact of learners' interaction. Stemming from Vygotsky's (1978) sociocultural learning theory, the iPAC framework suggests that learning is a social endeavor that can be modified through the mediation of mobile tools (Kearney et al., 2012). This study adopted the iPAC framework to explore learners' vocabulary learning experiences within a mobile environment. It was deemed an appropriate fit for the study based on the following: (a) the intervention activity occurred in a mobile environment that matches the distinction of the iPAC framework; (b) this study's embedded apps had several interactive features that allowed learners to engage and communicate within the learning community; (c) the application afforded personalized plans and supported adaptive learning for learners to interact with the content based on their learning progress. Table 1 outlines how the design of this study aligns with the iPAC framework. Key indicators are detailed in the fourth column.

Table 1

Dimensions and Key Indicators of the iPAC Framework as Applied in the Current Mobile-Assisted Vocabulary Learning Study

Dimensions	Sub-dimensions	Definition	Indicators elucidating the alignment of the study with the framework
Collaboration	Conversation	"The extent to which learners hold conversations around or through the mobile device with peers, teachers and other experts" (Kearney et al., 2019, p.753).	A social media group was created comprising consenting participants. Within the social media group, learners could ask questions and communicate with both instructors and peers.
	Co-creation	"The extent to which learners use a mobile device to co-create digital content and share information, data and artefacts" (Kearney et al., 2019, p. 754).	Learners were prompted to post their achievement badges, learning trajectories, or questions within the established social media group.
Personalization	Agency	"The extent to which learners have control over the place (physical and/or virtual), pace and time they learn, and autonomy over their learning content" (Kearney et al., 2019, p. 754).	Learners had the flexibility to access vocabulary learning content anytime and from any location through their mobile devices.
	Customization	"The extent to which learners can customise their m-learning experience, both at the level of the tool (e.g., choice of apps, or the device itself) and the activity (e.g., adaptations of activity or challenge levels automatically provided by the app to suit the learner)" (Kearney et al., 2019, p. 754).	In this study, all learners used the same application. They configured their vocabulary study agendas and objectives based on their individual needs and requirements. The application also devised a vocabulary revision schedule based on the learner's proficiency.
Authenticity	Context	"The extent to which learners' mobile learning experiences are enhanced by	Audio, pronunciations and multiple example sentences were made available to assist

	realistic, meaningful content, or through 'in situ' learning in relevant physical and/or virtual settings" (Kearney et al., 2019, p. 754).	learners in understanding the target term in various contexts.
Task	"The extent to which the mobile learning activities are realistic and offer activities relevant to the real world; and the extent to which the tasks and associated processes require use of apps and tools that replicate those of real-world practitioners." (Kearney et al., 2019, p. 754)	For each target word, the application incorporated example sentences from past CET 6 readings, aiding learners in their preparations for subsequent examinations.

The Ambiguous Impact of Mobile Assisted L2 Vocabulary Learning

As mentioned earlier, L2 teachers have limited class time to teach vocabulary (Nation, 2022). Thus, it is necessary for both L2 teachers and learners to find an efficient self-directed strategy to learn vocabulary outside of the classroom. Mobile learning is recognized as an effective approach to bridging formal classroom instruction and informal situated learning experiences (Cochrane & Narayan, 2016). The personal and portable nature of mobile devices, as Kukulska-Hulme (2008) noted, enables continuous access to learning materials across various contexts. Learners find mobile learning more convenient, allowing them to access materials anytime, anywhere, so they can divide the learning into small chunks (Sung et al., 2016). This flexible structure aligns with cognitive principles such as microlearning and the spacing effect, both of which have been shown to enhance retention and long-term memory.

In addition, learners' perceived learning perceptions toward a learning tool were found to be a crucial factor that impacts learning effectiveness and motivation (Habib et al., 2022; Li et al., 2021). For example, Castañeda and Cho (2016) found improvements in language accuracy and learning confidence among students using mobile applications. Li et al. (2021) also found that learners' enjoyment while interacting with the mobile app positively influenced their perceived learning. However, Sharples (2006) noted that initial motivation might wane over time, highlighting the need for exploring sustained engagement strategies.

Despite the growing body of research, MALL studies face several challenges. Burston and Giannakou (2022) pointed out many studies are limited by small sample sizes (i.e., $N < 10$) or short treatment durations (i.e., $T < 4$ weeks), which can affect the reliability of results. In addition, with the continuous evolution of mobile technologies, the effectiveness of mobile-assisted vocabulary learning remains varied. While some research reports positive outcomes (e.g. Castañeda & Cho, 2016; Wu, 2015; Chen et al., 2019), others find no significant results (Stockwell, 2007, 2010; Tosun, 2015). Stockwell (2010) noted that learning on mobile devices

requires more time compared to PCs. The increased time demand may contribute to user fatigue or reduced attention span, which are important factors to consider when evaluating the effectiveness and sustainability of mobile-assisted language learning, especially when discussing learners' engagement and persistence over time.

Recent studies have begun to address some of these gaps. Polakova and Klimova (2022) demonstrated the potential of mobile apps to enhance vocabulary performance and motivation in blended learning environments. Li and Hefner (2022) found that students using mobile tools outperformed those using traditional paper word lists in vocabulary acquisition. Our research builds on this by examining vocabulary learning behaviors outside the classroom in an informal setting, which demands higher self-directed learning skills (Cheng et al., 2025). We explore how students interact with mobile apps outside the classroom and manage their learning in non-formal contexts.

The field of MALL remains uncertain, necessitating additional empirical research for deeper exploration (Burson, 2014; Lin & Lin, 2019). The current study aims to build on this foundation by focusing on informal, self-directed learning outside the classroom. It examines mobile-assisted vocabulary learning through the iPAC framework, which considers personalization, authenticity, and collaboration. This research addresses several gaps in the field, including the need for longer treatment durations, exploration of informal learning contexts, and the application of the iPAC framework to MALL. SBDC, one of the most popular applications ranked in the iOS store's top 13 educational apps, was selected due to its popularity among Chinese college students for English vocabulary learning (Li & Wang, 2019). A survey by Wang (2020) and Su & Su (2015) revealed SBDC's appeal stems from its extensive vocabulary catalogs, gamification, robust scaffolding, learning analytics, attractive UI, and minimal advertisements. This study examined L2 students' form-meaning linkage of the target vocabulary and adopted the Shanbay Dan-Ci (扇贝单词) application (SBDC) as an explicit vocabulary learning approach.

Research Questions

1. Does the usage of the mobile-assisted vocabulary learning App SBDC improve L2 learners' vocabulary form-meaning linkage (VFML) knowledge compared to traditional paper wordlists?
2. What are L2 learners' perceived learning experiences (e.g., perceived satisfaction toward the app features, mobile learning perceptions, vocabulary learning goals, and strategies) of using SBDC?

Methods

Research Design

An explanatory sequential mixed methods design was adopted to examine the effect of SBDC on L2 learners' VFML and explore their experiences within the mobile application of SBDC (Clark & Ivankova, 2016). In the quantitative strand, a quasi-experiment was conducted to examine the effect of SBDC on L2 learners' VFML through pre- and post-word matching

tests. Subsequently, qualitative data from questionnaires and interviews provided insights into learners' experiences and contextualized the quantitative findings.

Context and Participants

This study was conducted in a 16-week English course at a large university in Northern China in the spring of 2021. Clustered convenience sampling was applied to ensure participants had comparable intermediate-level English proficiency prior to the commencement of the intervention. They had passed the College English Test 4 (CET 4) before the study and were preparing for the College English Test 6 (CET 6) during their participation. A total of 74 freshmen were enrolled in two sections of the course and each section included the same instructor and content (e.g., materials, activities, assessments). Students were invited to participate in this study before the course started; all students agreed to participate and provided a signed consent form. However, four students missed the post-test and were therefore excluded from the study. The remaining 70 participants included 53 (76%) males and 17 (24%) females ranging from 18–21 years of age (M = 19.08). Following a quasi-experimental design, participants were assigned two conditions based on course sections. One section used the SBDC mobile application (experimental group), and the other section used a traditional wordlist (control group) to learn English vocabulary. The experimental and control groups included 32 and 38 participants, respectively. Human subject concerns have been addressed by obtaining the approval of Institutional Review Board (IRB).

Pre-Test Setup and Post-Test Timeline Overview

Within 10 weeks, both groups completed identical word matching pre-tests via Wenjuanxing (an online survey platform that allows users to create, distribute and manage survey data), which were randomly selected from the list of CET 6 vocabulary. All participants were provided with the same list of English vocabulary words, which were associated with the CET 6. The CET 6 is a national test that examines Chinese undergraduates' English proficiency according to the National College English Teaching Syllabuses (Zheng & Cheng, 2008).

Participants were not given in-class time to learn English vocabulary but were encouraged to do so outside of class. The control group was encouraged to share photos of their learning notes, while the experimental group was encouraged to share digital learning badges within the group. To increase participants' likelihood of learning English vocabulary either through SBDC or the wordlist, a social media group was created for each group (experimental and control), which allowed learners to voluntarily share their daily vocabulary learning badges (see Figure 3, Screenshot C). It is important to note that social media groups were created for both the experimental and control groups to eliminate potential confounding effects of social media use on the study outcomes. This decision was made because the badge-sharing activity was not a built-in feature of the SBDC app but was instead facilitated through external social media platforms. Therefore, to maintain methodological rigor, equivalent social media environments were established for both groups.

Shanbay Dan-ci (SBDC) Application Features

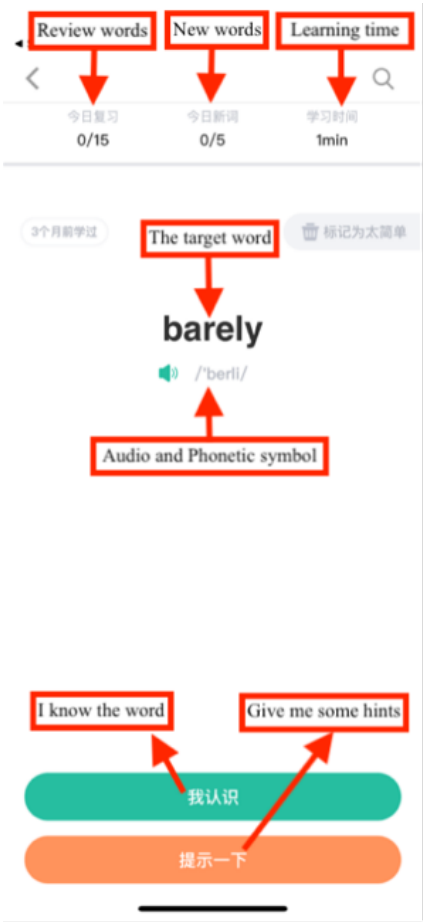
The SBDC mobile application was used to facilitate the vocabulary learning intervention in the experimental group. The interface screenshots of the SBDC were captured in Figure 2 and Figure 3, and the authors obtained permission to publish the screenshots from the company. Key

features employed in the study include personalized learning plans, audio pronunciations, Chinese translations, example sentences, a learning progress dashboard, and badge-sharing options. The app also tracks progress and generates reports on vocabulary mastery, learned words, and unfamiliar or unknown words. Social features encourage sharing digital badges on social media when daily goals are met. For this study, social media groups on QQ were set up for badge sharing among participants. Additionally, a digital calendar tracks login and badge sharing activities.

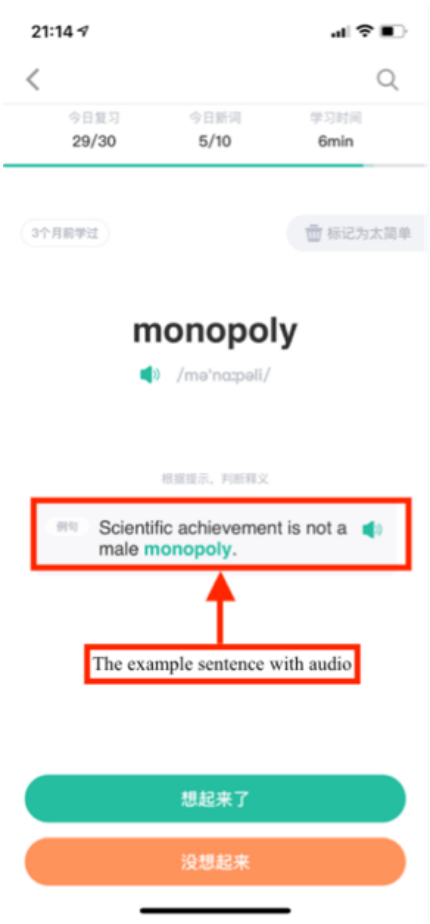
Figure 2

Shanbay Dan-Ci (SBDC) Vocabulary Learning Mobile Interfaces and Involved Social Media Groups

Screenshot (a)
Goal-setting page



Screenshot (b)
Recognition test page



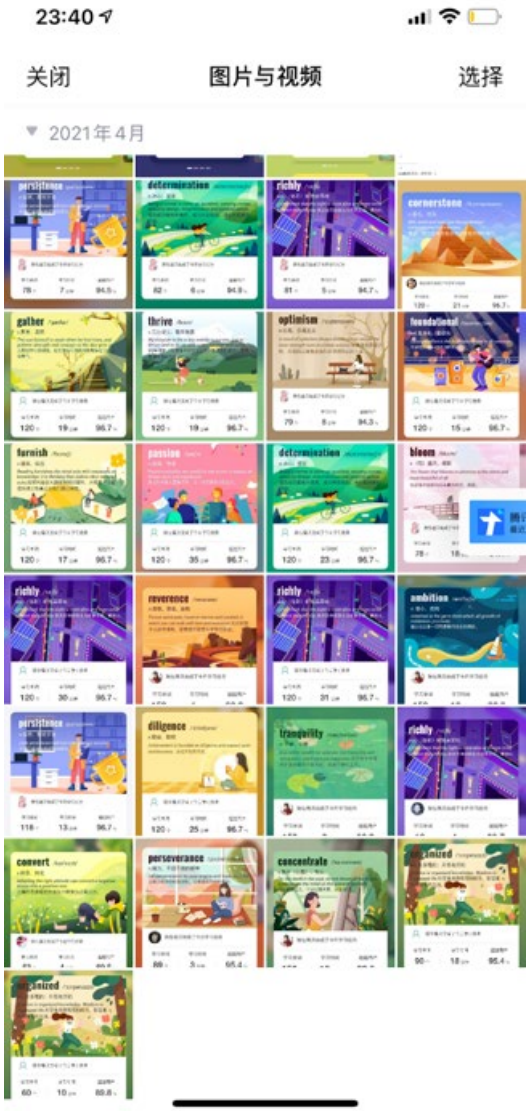
Screenshot (c)
Recognition test page with example sentence as hint

Screenshot (d)
Learning page with translations and example sentences

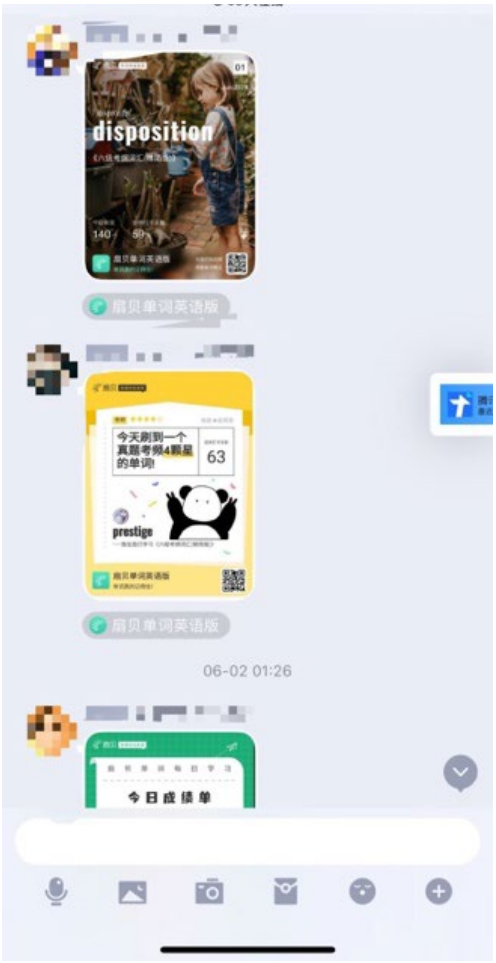
Figure 3

Learning Data and Activities

Screenshot (a)
Learning progress dashboard



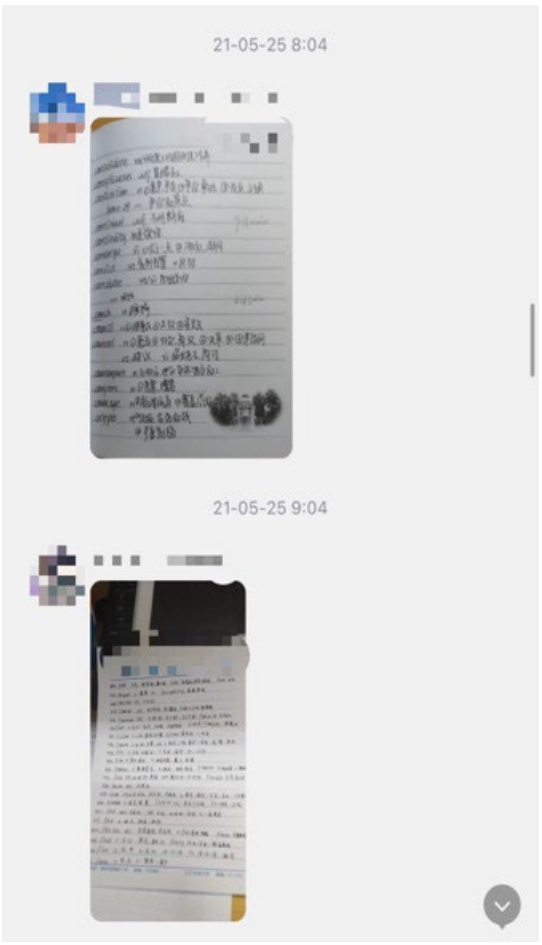
Screenshot (b)
Daily accomplishment badge sharing



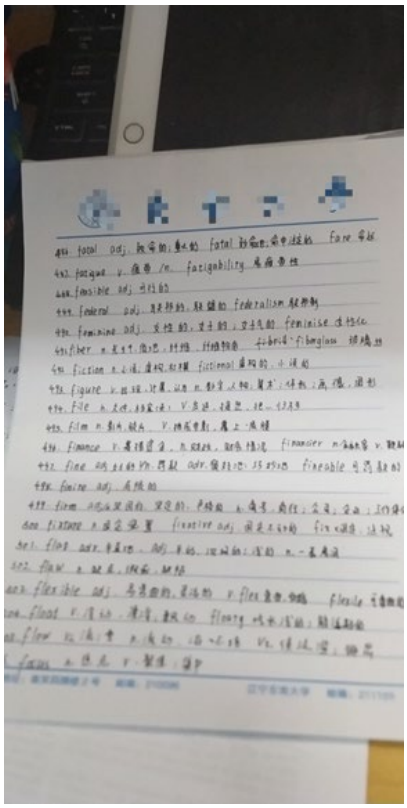
Screenshot (c)
Social media group

Screenshot (d)
Log data dashboard

Screenshot (f)
Learning report



Screenshot (g)
Control group accomplishment sharing



Screenshot (h)
Control group learning notes example

Data Collection

Quantitative Strand: Vocabulary Form Meaning Linkage (VFML) Knowledge

Quantitative data were collected through pre-and post-VFML tests (see Appendix B for sample questions), which assessed 75 randomly selected words from the 2416 CET wordlist, with each test using a different set of words. These tests were validated by three professors and demonstrating acceptable reliability (Cronbach's Alpha = .77) (George & Mallery, 2003). The test format was adapted from Webb et al. (2017), which used cluster matching format to increase transparency.

Qualitative Strand: L2 Learners' Perceived Learning Experiences using SBDC

To understand the influence of SBDC on learners' experiences, we conducted qualitative analyses guided by the iPAC framework, involving only the experimental group. After analyzing the quantitative data, an open-ended survey to evaluate and reflect on features of the mobile application was distributed to the experimental group (N = 32), from which eight participants were invited with their agreements for a post-course, semi-structured interview. Every student in the experimental group completed the open-ended survey, yielding a 100% response rate, and from this group, eight students were chosen to participate in interviews.

Open-ended survey. The survey (see Appendix C for specific open-ended questions) was distributed online via Wenjuanxing. Guided by the iPAC framework, the open-ended survey

was designed to get more insights into how features in SBDC support personalization, authenticity, and collaboration. Participants spent 10–13 minutes completing the open-ended survey.

Semi-structured interview. Eight semi-structured interviews were conducted individually with one of the researchers. The interview questions were designed to investigate how learners perceived features in SBDC from the aspects of personalization, authenticity, and collaboration (see Appendix A for interview questions). All interviews were recorded and transcribed verbatim in preparation for data analysis. Each interview lasted approximately 30 minutes and was conducted online via Tencent Meeting, a video conferencing tool. All interview sections were recorded with the informed of each participant.

Interview case selection. For the interviews, participants were selected based on their outcome change in pre- and post-word matching tests. The learning outcome change refers to the difference in learners' vocabulary knowledge between the pre-test and post-test. For the interviews, participants were categorized into four groups based on the magnitude and direction of their score change: large negative change (≥10-point decrease), slight negative change (<10-point decrease), slight positive change (<10-point increase), and large positive change (≥10-point increase). (see Appendix D for interviewees' information). Previous studies reviewed that learners' learning outcomes correlated with perceived learning perceptions (e.g., Ozer & Kılıç, 2018; Mitchell et al., 2005), as such this study selected cases from different learning outcome change levels, to determine if there were any perceptual differences among learners in these groups. Since there was only one case in the large decrease group, we ended up selecting three cases in the slight decrease group.

Data Analysis

Quantitative Strand

Analysis of covariance (ANCOVA) was used to compare post-test VFML knowledge across groups while controlling for pre-test VFML knowledge as a covariate. Assumptions, including normality (skewness and kurtosis within acceptable ranges), homogeneity of variances (confirmed by Levene's test, $F = 0.32$, $p = 0.57$), and homogeneity of regression slopes (met with an interaction analysis, $F = 2.49$, $p = 0.09$), were satisfied. Notably, although the test for homogeneity of regression slopes exceeded the typical significance threshold (0.05), the marginal value (0.09) suggests that the ANCOVA results should be interpreted with caution.

Qualitative Strand

Coding was performed by a primary researcher and verified by a second coder to enhance reliability, using NVivo for qualitative data analysis. Two cycles of coding were conducted in accordance with Miles et al., (2014). Both inductive and deductive coding approaches were guided by existing knowledge, literature, and the central research questions to ensure alignment and trustworthiness in the findings (Braun & Clarke, 2006). Five predetermined aspects (collaboration, authenticity, personalization, time, and space) were generated from the iPAC framework and guided the coding process.

In the first cycle of coding, the primary coder adopted a holistic coding approach to first comprehend the general meaning of the responses to each question. Then a descriptive coding

(Saldaña & Omasta, 2016) strategy was used to generate the initial set of codes. We adopted In Vivo coding, using words or short phrases from the participants to generate first-level codes. Each code assigns related sentences or short paragraphs as data chunks. A total of 31 first-level codes were generated to cluster the segments relating to the research questions. The researchers grouped the codes into eleven categories (see Appendix E for the codes and the eleven categories).

In the second cycle of coding, the pattern coding strategy (Saldaña & Omasta, 2016) was used to revise, categorize, and summarize the codes generated from the first cycle. The categorization of the initial codes led to four themes related to different aspects of the learning experience within SBDC. First, the application features enhanced participants' learning experiences with regard to (1) Personalized learning within SBDC, (2) Collaboration supported by SBDC, and (3) Rich content. Second, from the interview data, (4) limitations and challenges experienced by participants emerged. Next, the identified themes were compared with the iPAC framework using a pattern-matching strategy (Miles et al., 2014). We compared patterns of similarities and differences across the eight cases with regard to their change-level differences.

Triangulation and Trustworthiness

To enhance face validity, two learners with similar characteristics and SBDC experience, along with a faculty member in educational technology, reviewed the learning outcomes test, open-ended survey, and interview protocol to ensure accurate representation of learners' perceptions using SBDC (Polit & Beck, 2006). Data from open-ended surveys and semi-structured interviews were collected to ensure triangulation (Merriam and Tisdell, 2016). After coding interviews, open-ended survey responses were compared and discrepancies were resolved through follow-up meetings with the instructor. Additionally, multiple coders were involved in the coding process to increase the internal validity (Merriam and Tisdell, 2016) and reliability. Regular research meetings were scheduled to discuss and solve questions and coding disagreements during the coding process. Both coders eventually achieved 100% agreement in the coding results. (See Appendix E for the coding scheme).

Results

Organized by the central research questions, the first set of results presents quantitative findings on the effects of SBDC's mobile-assisted vocabulary learning tool on learners' vocabulary learning outcomes. The second set of results presents qualitative findings on learners' perceptions and experiences organized by four themes: personalized learning, rich content, collaborative learning, and challenges of learning in a mobile environment.

RQ1: The effects of using SBDC on L2 learners' vocabulary form-meaning linkage (VFML) performance

The descriptive statistics in Table 1 show that L2 learners in the experimental group (M = 90.42%, SD = .06) scored an average of 1.3 percentage points higher than the control group (M = 89.12%, SD = .08) in the post-test. However, it's worth noting that, in the pre-test, L2 learners in the experimental group initially scored an average of 1.58 percent lower than the control group. These findings suggest that L2 learners who used SBDC for 10 weeks demonstrated superior performance compared to those in the control group, despite commencing the study with a lower

average entry-level of VFML than their peers in the control group. Notably, although both the control and experimental groups showed a decrease in scores from pre- to post-test, this does not necessarily indicate a negative effect of the interventions. There are two main reasons. First, within-group pre/post comparisons can be misleading, as any observed changes may stem from uncontrolled confounding variables. Second, to enhance post-test reliability, in this study we excluded pre-test words when randomly selecting items from the 2,416-word CET list, ensuring the post-test assessed new vocabulary. While both tests drew from the same source, the randomly selected word sets may have differed in difficulty, making direct comparisons problematic. Therefore, in the inferential test, we focused on comparing post-test scores between groups using ANCOVA, controlling for pre-test scores.

Table 1

Descriptive Statistics of VFML in Pre- and Post-Test Across Groups

Group	Test	N	Mean (%)	SD
Control Group (wordlist)	Pre-test	38	93.31	.06
	Post-test	38	89.12	.08
Experimental Group (SBDC)	Pre-test	32	91.73	.07
	Post-test	32	90.42	.06

Table 2 displays the inferential results of the ANCOVA used to test the effect of using the mobile-assisted vocabulary learning application SBDC on L2 learners' VFML performance after controlling for their pre-performance in VFML. Results revealed that the covariate, pre-performance in VFML accounted for significant variance in L2 learners' VFML, F (1, 67) = 4.60, $p < 0.05$, thus confirming the necessity of this variable's inclusion in the model. A non-significant effect of integration of SBDC on VFML was detected, F (1, 67) = 1.02, p = .315. The inferential findings imply that while L2 learners who employed SBDC outperformed those who used a traditional word list in the post-test, this difference did not reach statistical significance after controlling for the baseline VFML scores measured in the pre-test.

Table 2

ANCOVA Results (Dependent Variable: Post-test VFML)

Source	Sum of Squares	df	Mean Square	F	P value
Intercept	.10	1	.10	18.85	<.001
Pre-test VFML (Covariate)	.03	1	.03	4.60	.036
SBDC versus wordlist (intervention)	.01	1	.01	1.02	.315
Error	56.73	67	.01		

RQ 2: L2 learners' perceived learning experiences of using the SBDC App

Even though interview participants were selected based on their learning outcome change, interestingly, perception differences were not identified between the two groups with extreme outcome changes. The four major themes (personalized learning, rich content, collaborative learning, and challenges of learning in a mobile environment) are elucidated in the following section.

Theme 1: Personalized Learning Within SBDC

Repetition and personalized review plan. One of SBDC's pre-designed features mentioned by interviewees was the "review" function. As Fang mentioned:

> I found the review function helpful because it forced me to review. Previously, I [didn't] like reviewing. […] But this time the app put the word in front of me and [told] me, "You do NOT know this word," [which forced] me to learn it again. This is very helpful.

The review feature also helped learners correct their interpretations. As Xing indicated:

> Sometimes I think I know what it [the word] means, and then I click on "I know this word". When its translation pops up, I find it doesn't match what I think. Then when I review it the next day, I see the word and I remember that I made some mistakes on this word.

Qing also found the app to be more helpful than a paper book or wordlist:

> Previously [when using the paper book to learn vocabulary], if there was a word that I [was] not familiar with, I learned it once and after that, I didn't review it at all. On the opposite, the app will keep showing me the word that I am not familiar with until I remember it.

Self-checking and reflecting. The pre-set instructional design offered learners time to self-check and guess the meaning based on context provided by the example sentences. For example, Fang expressed:

> I look at the example sentence and guess what it means. In sum, I recall the meaning of the word according to the format, or I recall the meaning of the word in the context by using example sentences. These two are the most important to me.

Goal-setting. One of the features that interview participants mentioned was the goal-setting feature that is embedded in the app. The auto-generated plan of study provided learners with clear information for daily tasks (i.e., the number of new words to be learned and the number of review words remaining), as well as estimated finish time to help learners design the learning plan according to their needs. Fang shared,

> I know I have to learn 2,416 words in 3 months in order to make myself well prepared for the CET 6 […] I pushed myself so hard and I felt tired during the learning process.

> However, I [couldn't] finish the list if I didn't set up the plan, so I appreciate it. The learning process was tough, but I appreciate it.

Throughout the learning process, the app allowed learners to modify their goals based on their learning pace. Lu described,

> Initially, I set up 200 new words per day. I modif[ied] the daily goal to 50 new words, which [was] manageable. If I wanted to continue, I [could] click on "Continue".

Self-monitoring: Recognizing learning progress. The learning dashboard page embedded in the app recorded learners' learning data. According to the open-ended survey responses, there is a dashboard that allows learners to track learning progress, time spent, and log frequency. Four survey respondents mentioned that they felt rewarded when their persistence and progress were acknowledged between learning activities.

Further, the daily learning report page (Figure 8) provided learners the opportunity to recognize their overall progress, personal strengths, and opportunities for growth. Han found the learning report page particularly helpful and stated:

> The report page tells me how many "new words" and "review words" I have mastered. Now, my mastery rate is between 65%–75%, which means I know at least 65%-75% of CET 6 vocabulary. I think this is a good reference to know my vocabulary level.

Learning environment and time choice. Mobile learning is known for its flexibility in that learners can access the material anytime. As indicated by participants in the open-ended survey, they learned lexical knowledge in different settings including dormitory, classroom, library, bus station, and canteen.

In the interviews, some participants indicated that they did not allocate specific times for learning; rather, they occasionally used spare time to complete their daily tasks. For example, Lu said he chose different places for vocabulary learning when using a mobile device rather than paper books:

> I usually learned vocabulary in the dormitory when I was using [a] vocabulary book, which is my typical learning place for other subjects as well. When I used my mobile phone, I learn[ed] it anytime if I have time.

Theme 2: Rich Content

Multiple learning resources: Audio and example sentences. The technology-enhanced learning environment has embedded vocabulary translation, audio, and multiple example sentences to help learners develop their vocabulary knowledge. In the open-ended survey, 24 respondents indicated that they found the audio helpful because (a) it helped them correct inaccurate pronunciations and (b) it enhanced students' capability of memorizing new words. Xing explained:

> Audio and example sentences are the most helpful features of the app. By adding pronunciation and pop-up example sentence, you [as a learner] can quickly reflect the meaning and has a deep impression of the word.

Rong agreed that the audio helped activate his visual and auditory senses, which enhanced his memorization of the target word:

> I didn't pay much attention to pronunciation when I was using a book to memorize vocabulary. In the App, it will automatically pop up the word pronunciation and read the example sentence for me. I feel like not only my eyes are learning, but also my ears.

Theme 3: Collaborative Learning Supported by SBDC

Social interaction: Badge sharing. Overall, participants found badge sharing to be helpful reminders for ongoing learning. For example, Xing said:

> When I was browsing Weibo or playing games, there [were] some messages from the QQ group showing that my peers are sharing the badge. I knew it wouldn't take a long time to complete today's task, so I would rather open the app and finish it. It [was] a good reminder for me.

Interestingly, Qing found some social incentives by sharing the badge. One of QQ's features involves rewarding a "spark" icon to users who participate in the conversation for more than seven days. Qing said the "spark" icon became her motivation to persist in the learning activity and share the badge:

> If I skip[ped] my learning for a day, my spark icon disappear[ed]. […] I wanted to avoid this, so I follow[ed] the pace and complete[d] my [vocabulary learning] task on time."

Hong also found that badge sharing supported his learning persistence:

> Badge sharing push[ed] me to learn it every day. […] It was hard for me to persist. Sometimes I am just lazy to do it [vocabulary learning]. I see that everyone is sharing the badge. Then I feel like I have to complete today's learning task, and I go ahead and finish it.

Fang said he was able to finish the CET 6 vocabulary list learning goal mainly because of the badge sharing activity:

> It is very necessary for me to have the QQ group share the badge. I bought two books for my CET 4, but the final result is that I never opened them. So, I am proud that I have finished learning the vocabulary list of CET 6 this time.

Theme 4: Challenges of Learning in a Mobile Environment

Content limitation. In the interviews, learners indicated that their receptive vocabulary knowledge increased but felt that productive vocabulary knowledge was not emphasized throughout the process. For example, Han indicated, "my expectation of learning vocabulary within the app is to recognize the meaning in the reading process, but I don't think I know how

to use the new word in writing and speaking because the app didn't introduce related knowledge."

Further, Fang criticized the app's focus on connecting a word's form and meaning without providing opportunities to learn other areas of vocabulary knowledge (e.g., spelling, grammar functions, and collocation). Fang explained:

> It [the vocabulary learning activity] helped me in reading tasks, but I don't know how to use it and when to use it. How can I know if I "remember" the word?

Distractions. Participants found it hard to concentrate in a mobile learning environment. Lu shared:

> I usually finish my daily task in the dormitory or canteen because I want to use the spare time to finish the task. However, I found it hard to concentrate because there are so many distractions. Some notifications or messages are also very distract[ing].

Some learners indicated too much multimedia information was distracting and overwhelming. For example, Fang said: "I was using another app that provides pictures related to the target words. Some pictures are confusing and unspecific, so I was distracted by the picture instead of focusing on memorizing the meaning of the new word."

Usability issues. Participants were also dissatisfied with the quality of the app, which contributed to their giving up on the learning goal. Ming explained: "The app adds all newly learned vocabulary to the review list. I have to click on 'remove this word from my list' so it will remove. It is dumb."

Mobile learning acceptance. Although digital learning has gained popularity and is widely used among college students, the general acceptance of mobile learning environments varies. As Lu indicated: "I don't like learning with digital devices. I would prefer to use a paper list to learn."

Compared to paper books, mobile vocabulary learning is more flexible; however, this does not always benefit learners. For example, Han said:

> Paper books might be better for me because I would take the learning activity seriously. For example, I will allocate a specific time and find a quiet place to learn if I use a paper book. That would become a routine for me.

Discussion

This study distinguished itself from previous studies in several ways. Firstly, the treatment duration extended to 10 weeks, which could be considered a longer treatment duration (Lin & Lin, 2019). Secondly, the study was conducted in informal settings and offered learners enhanced autonomy in their learning process—a factor seldom encountered yet and was highly valued in mobile-assisted vocabulary learning research (Lin & Lin, 2019). Although mobile-assisted vocabulary learning research has proliferated since the 2000s (Burston & Giannakou, 2022; Lin & Lin, 2019), limited studies contextualized mobile-assisted vocabulary learning

within the iPAC framework, which concentrates on the personalization, authenticity and collaboration dimensions of mobile learning. This study highlights and interprets students' technological usage through the lens of iPAC. As the use of digital devices and mobile software proliferates, it is necessary to explore ways to leverage technology for learning (Kearney et al., 2020). Research question one investigated if the SBDC experimental group demonstrated significant vocabulary acquisition improvement compared to the control group. Results revealed that participants in the experimental group had a lower level of VFML performance than the control group at the beginning and ended up outperforming the control group in the post-test, although the difference in the post-test was not statistically significant. This result aligned with Burston's (2015) meta-analysis of 291 MALL studies, which found four vocabulary-focused studies that revealed no significant improvement in learning outcomes using mobile Apps. Several potential reasons may explain the insignificant results. First, vocabulary learning is an incremental process that requires long-term investments (Nation, 2022). As Lin & Lin (2019) noted, treatment duration is a key factor that moderate the effect of mobile-assisted vocabulary learning. Even though a 10-week intervention has been considered a comparatively long treatment duration in the MALL field (Burston, 2015), it is still not enough to observe a significant vocabulary acquisition improvement. In addition, observations from the social media group indicated that control group learners engaged in note-taking. Note-taking had been recognized by previous researchers as a key strategy for vocabulary learning as it allows learners to actively reflect on their learning process (Jin & Webb, 2021). This reflective practice is recognized as a self-regulatory behavior strategy, which has been shown to have a strong correlation with learning outcomes (Cheng et al., 2025). Furthermore, due to the voluntary nature of the research, students' time spent on vocabulary learning varied. Kojic-Sabo and Lightbown (1999) noted that time spent and learning independence (i.e., autonomous sourcing, practice opportunities, personalized activity preference) significantly impact the vocabulary learning outcomes. They found that increased time and effort in vocabulary study led to greater vocabulary learning success. Given the fact that this study dates back over two decades, questions arise about its applicability in the context of MALL. Do digital tools inspire L2 learners to invest more time in vocabulary study and enhance their autonomy, or does MALL lead to a more efficient learning process with less time invested but improved outcomes? Can digital tools equalize learning time and effort, or do they reinforce learner independence gaps? Further research is needed to answer these questions.

Moreover, the lasting impact of mobile-assisted vocabulary learning on learning outcomes remains unclear. As noted by previous researchers (Sung et al., 2015; Lin & Lin, 2019) on the ongoing issue of MALL: distinguishing whether the language learning improvements are genuinely due to the mobile learning intervention or just from the novelty effects of mobile technology's advanced features. Future research is called to track changes in learners' attitudes over time and consider extending the duration of the intervention for a more precise conclusion.

Regarding the second research question, while SBDC was deemed helpful for its engaging learning design, challenges and concerns were also identified. In the following section, we will explore how the findings of this study correspond to or deviate from prior literature based on the iPAC framework. Concluding thoughts, along with recommendations and implications, will be addressed at the end.

Personalization Dimension

Kearney et al. (2020) defined mobile learning personalization as the learning tool's flexibility allowing learners to tailor their learning activities by time, pace, and location based on individual needs and preferences. Findings in the qualitative part amplify the personalization dimension of the iPAC framework from the perspective of individualized goal setting; personalized review plans; repetition; self-check and monitoring; rich learning resources. These features align with criteria in Nation's Technique Feature Analysis (NTFA), which is used to evaluate the effectiveness of a vocabulary learning activity. According to the NTFA (Nation, 2022), a productive vocabulary learning activity should involve: motivation (e.g., clear vocabulary learning goals); noticing (e.g., increased awareness of new vocabulary learning); retrieval (e.g., multiple retrieval, recall, and spacing repetition opportunities); varied use (e.g., marked change that involves the use of other words); retention (e.g., meeting and linking the correct form and meaning) (p. 103).

Aligning with previous research (Cheng et al., 2025; Li et al., 2021) that emphasizes the role of goal setting and learning progress monitoring in undergraduates' learning with technologies, this study found these features fostered metacognition. Students benefited from setting goals, tracking, and reflecting on their progress, which is crucial for mobile learning's objective of enabling learning beyond classrooms (Kearney et al., 2020). The goal-setting and progress monitoring features supported learners' autonomy in managing and reflecting on their learning progress (Li et al., 2021). In addition, Xu and Richardson (2024) found that certain app features, such as badge-sharing, can effectively enhance students' self-regulation skills, such as time and environmental management, goal setting, and self-evaluation. The personalization of learning plans, particularly the tailored review of vocabulary, facilitated efficient learning by focusing on individual needs. This method leverages the spacing effect—revisiting material after intervals—for effective vocabulary acquisition (Nation, 2022), reinforcing the concept of dividing content into small chunks for improved knowledge retention (Giurgiu, 2017).

Collaboration Dimension

The study illuminated the collaboration dimension within the iPAC framework, emphasizing conversation and co-creation as described by Kearney et al. (2020). Learners were motivated by observing other peers' vocabulary learning progress in the badge sharing activity, aligning with the framework's call for collaborative, relevant activities in mobile learning. Furthermore, Consistent with social cognitive theory, observing peers' progress (i.e., behavior modeling) enhances learners' self-efficacy and learning strategies (Compeau & Higgins, 1995). This is a valuable gamification feature that facilitates L2 vocabulary learning.

Although L2 learners benefit from MALL tools in many aspects, there are challenges in leveraging the full communicative potential of mobile technologies for language learning (Kukulska-Hulme et al., 2017; Burston, 2015). In this research, students shared achievements via badges but lacked deeper interaction, such as discussing learning experiences or seeking peer or instructor support within the app. Strategies that can foster further interaction and engagement among students require further exploration.

Authenticity Dimension

Kearney et al. (2020) frame authenticity in learning through relevant context and real-world tasks. Although the mobile-assisted vocabulary learning activities in this study incorporated authentic elements, the qualitative data revealed limitations in providing comprehensive vocabulary knowledge. SBDC's design focused predominantly on receptive knowledge, leaving learners less prepared for productive application in speaking and writing. This input-centric approach resulted in superficial vocabulary acquisition, echoing concerns by Bahari et al. (2022) about the digital learning focus on receptive skills. This finding aligns with Mahdi's (2018) meta-analysis which concluded that most mobile-assisted vocabulary learning studies focus on the receptive area of knowledge. This further aligns with Schmitt & Schmitt's (2020) conclusion that learning vocabulary from a wordlist enables students to learn limited aspects of knowledge (i.e., word form, meaning, form and meaning linkage), but ignores the depth of the knowledge which makes it difficult for learners to apply target words in speaking and writing tasks. While an explicit vocabulary learning strategy is an effective way to expand vocabulary size, massive reading and implicit learning remain the main sources of acquiring new vocabulary. Both L2 learners and educators need to recognize the value of integrating explicit and implicit vocabulary learning strategies. Beyond merely using mobile-assisted vocabulary learning tools as supplemental resources, it is crucial to enhance exposure to the target vocabulary within authentic English contexts.

Overall Mobile Learning Experiences

Maintaining concentration in a mobile learning environment can be challenging. This is unsurprising given the fact that mobile devices were originally designed for entertainment and communication purposes. Using mobile devices for learning and pedagogy is an ongoing area of exploration (Kearney et al., 2020). In this study, participants had trouble concentrating on learning due to distractions in both physical and online environments. For example, some learners did not allocate a specific time or reserve a location to proceed with the learning task but instead chose to complete the daily learning task in a dormitory, bus station, or canteen. Although the informal environment provides extra flexibility for learners, it also adds distractions (Kearney et al., 2020). In addition, instant messages, notifications, and phone calls can interrupt the learning process. The challenges identified in this study echo those noted in previous research findings. For example, technological constraints, including insufficient cellular network or limited wireless access, small screen, short battery, can impede learning (Criollo et al., 2018, 2021; Dashtestani, 2016; Saikat, 2021). Personal learning choices, such as unwillingness to try new software, limited experience in using mobile devices to learn, could also hinder learners' engagement within the mobile learning environment (Dashtestani, 2016; Criollo-C et al., 2018, 2021; Saikat, 2021), particularly among aged learners (Saikat, 2021). In addition, incompatibility with social norms, such as source of distraction, fail to facilitate collaboration in real learning settings, additional efforts to facilitate mobile learning activity, privacy concerns, limited communication opportunities or technology anxiety can pose significant challenges for learners (Saikat, 2021; Criollo-C et al., 2018, 2021). Besides, several limitations of the App were also identified from the qualitative results. For example, there was a lack of opportunities for students to acquire productive vocabulary knowledge, environmental distractions posed challenges, self-evaluation opportunities were limited, and the app was not sufficiently intelligent to create personalized vocabulary study plans (see Section *6.2.4 Theme 4:*

Challenges of Learning in a Mobile Environment for more details). These findings echo previous studies indicating that mobile language learning, especially mobile vocabulary learning, should strive to create a more contextualized, personalized, and socially interactive environment to better facilitate students vocabulary learning (Kukulska-Hulme et al., 2017; Lin & Lin, 2019; Stockwell & Hubbard, 2013; Tommerdahl et al., 2024).

Limitations

Several limitations are present in this study. First, while the intervention duration of 10 weeks is considered long by some standards (Burston 2022; Lin & Lin, 2019), it may not be sufficient to assess vocabulary retention fully. Given that vocabulary acquisition is a gradual process, significant gains might not be evident within a brief four-month timeframe. Future studies might benefit from lengthening the intervention period to observe potential differences. Second, this research primarily centered on learners' passive knowledge, specifically the linkage between form and meaning. Subsequent research might broaden its focus to explore other facets of vocabulary acquisition, such as lexical depth and fluency. In addition, this study included 70 participants (N = 38 in the control group and N = 32 in the experimental group), which is a relatively small sample size for detecting statistically significant effects. While ANCOVA was employed to control for initial differences in performance, the limited sample size may reduce statistical power and increase the risk of a Type II error. However, this limitation was mitigated by our follow-up qualitative analysis, which triangulated the quantitative data and provided deeper insight into the participants' learning experiences. Nevertheless, future studies should consider recruiting a larger sample to enhance statistical power and generalizability. Lastly, despite efforts to ensure that the control group used traditional paper-based materials and the experimental group utilized the mobile app, there's a possibility that some participants in the control group accessed the app without reporting.

Conclusion

This study examined the impact of mobile applications on L2 learners' English vocabulary learning. In the digital age, mobile technology, including mobile language learning, has been applied to promote flexible, self-directed learning. Various mobile vocabulary applications are available on the market, but limited research explains how they impact the learning process and whether they are effective in improving learning outcomes. This study found that mobile application users' learning outcomes will not significantly improve in a short period. However, the mobile application's digital dashboard function facilitates peer monitoring and promotes the metacognitive learning process. The affordance of the mobile application itself supports flexible use, which allows learners to learn anywhere and anytime; in this study, participants shared their daily accomplishments within the social media group, which served as a self-monitoring process. This article provides up to date insights into the effects of mobile application use on vocabulary acquisition for L2 learners, teachers, and mobile application designers. Nevertheless, as asserted by Nation (2022), technology tools can facilitate vocabulary learning but do not magically improve vocabulary learning. L2 learners may note that expanding vocabulary size is a long-term commitment.

In addition, this article provides insight into the effects of mobile application use on vocabulary acquisition for L2 learners, teachers, and mobile application designers. Regarding implications, L2 learners should note that expanding vocabulary size is a long-term commitment. While teaching vocabulary is not the main objective during class time, L2 teachers can embed technology-based activities to enhance vocabulary acquisition beyond the classroom. This is especially true for L2 teachers who have large classes, allowing them to use mobile technology to further support personalized learning. In addition, technology can potentially help teachers create collaborative opportunities in the class, so learners can benefit from observing peers' learning strategies. Although learners in the 21st century have been recognized as "digital natives" (Prensky, 2010), they do not necessarily know how to incorporate mobile technology into their learning. Thus, when embedding mobile technology, L2 teachers should be aware of the different needs of learners and consider alternative ways for learners who are not comfortable learning in a mobile environment. Lastly, it is essential for software designers to understand the cognitive process of vocabulary acquisition and explore additional features such as multimedia resources, language contexts, and grammar usage to better assist users' vocabulary acquisition.

The study unearthed an intriguing observation: although learners in the twenty-first century have been recognized as "digital natives" (Prensky, 2010), they do not necessarily know how to incorporate mobile technology into their learning. Thus, when embedding mobile technology, L2 teachers should be aware of the different needs of learners and consider alternative ways for learners who are not comfortable learning in a mobile environment. Lastly, it is essential for software designers and mobile language learning App developers to understand the cognitive process of vocabulary acquisition and explore additional features such as multimedia resources, language contexts, and grammar usage to better assist users' vocabulary acquisition.

In the digital age, mobile language learning apps promote self-directed learning. Mayer (2020) emphasizes the flexibility of mobile apps in a special issue on mobile learning, noting their capacity to enable learning at any time and place. Users often employ social media for self-monitoring, and these apps provide tailored learning opportunities and support micro-learning, allowing students to break down knowledge into small chunks. While recognizing the value of flexibility, personalization, and micro-learning facilitated by mobile learning, Mayer (2020) notes that many studies overlook a critical aspect: learning outcomes. This study contributes to the gap by examining actual learning outcomes to determine the effectiveness of mobile learning apps in the language learning process but finds nuanced evidence. Results indicated that while mobile apps may not significantly improve learning outcomes in the short term, they support flexible learning and peer monitoring through digital dashboards and social media sharing. These findings highlight the need for further research into the long-term impact of mobile learning. As mobile technology continues to evolve, it's crucial to explore how learners' attitudes change and which psychological learning theories can be adapted to suit the unique nature of mobile learning. More comprehensive studies are essential to deepen our understanding of these issues.

Declarations

The authors declare no conflicts of interest.

References

Anderson, R. C., & Freebody, P. (1981). Vocabulary knowledge. *Comprehension and Teaching: Research Reviews*, 85–125.

Bahari, A. (2022). Affordances and challenges of teaching language skills by virtual reality: A systematic review (2010–2020). *E-Learning and Digital Media*, *19*(2), 163–188. doi: 10.1177/20427530211036583

Burston, J. (2015). Twenty years of MALL project implementation: A meta-analysis of learning outcomes. *ReCALL, 27*(1), 4–20. doi: https://doi.org/10.1017/S0958344014000159

Burston, J., & Giannakou, K. (2022). MALL language learning outcomes: A comprehensive meta-analysis 1994–2019. *ReCALL*, *34*(2), 147–168.

Castañeda, D. A., & Cho, M. H. (2016). Use of a game-like application on a mobile device to improve accuracy in conjugating Spanish verbs. *Computer Assisted Language Learning, 29*(7), 1195–1204.

Compeau, D. R., & Higgins, C. A. (1995). Application of social cognitive theory to training for computer skills. *Information systems research, 6*(2), 118–143. https://doi.org/10.1287/isre.6.2.118

Chwo, G. S. M., Marek, M. W., & Wu, W. C. V. (2018). Meta-analysis of MALL research and design. *System*, 74, 62–72. https://doi.org/10.1016/j.system.2018.02.009

Chen, C. M., Chen, L. C., & Yang, S. M. (2019). An English vocabulary learning app with self-regulated learning mechanism to improve learning performance and motivation. *Computer Assisted Language Learning, 32*(3), 237–260.

Criollo-C. S., Luján-Mora, S., & Jaramillo-Alcázar, A. (2018). Advantages and disadvantages of M-learning in current education. *2018 IEEE World Engineering Education Conference (EDUNINE)*, 1–6. https://doi.org/10.1109/EDUNINE.2018.8450979

Criollo-C. S., Guerrero-Arias, A., Jaramillo-Alcázar, Á., & Luján-Mora, S. (2021). Mobile learning technologies for education: Benefits and pending issues. *Applied Sciences*, *11*(9), 4111.

Cochrane, T., & Narayan, V. (2016). Design considerations for mobile learning. In C. M. Reigeluth, B. J. Beatty, & R. D. Myers (Eds.), *Instructional-design theories and models, Volume IV: The learner-centered paradigm of education* (pp. 385–414). Routledge.

Cheng, Z., Zhang, Z., Xu, Q., Maeda, Y., & Gu, P. (2025). A meta-analysis addressing the relationship between self-regulated learning strategies and academic performance in online higher education. *Journal of Computing in Higher Education*, *37*(1), 195–224.

Clark, V. L. P., & Ivankova, N. V. (2016). *Mixed methods research: A guide to the field* (Vol. 3). Sage Publications.

Castañeda, D. A. & Cho, M.-H. (2016). Use of a game-like application on a mobile device to improve accuracy in conjugating Spanish verbs, *Computer Assisted Language Learning, 29*(7), 1195–1204. https://doi.org/10.1080/09588221.2016.1197950

Dashtestani, R. (2016). Moving bravely towards mobile learning: Iranian students' use of mobile devices for learning English as a foreign language. *Computer Assisted Language Learning*, *29*(4), 815–832.

Ellis, N. C. (2015). Implicit and explicit learning: Their dynamic interface and complexity. In P. Rebuschat (Ed.), *Implicit and explicit learning of languages* (pp. 3–23). John Benjamins.

Elaish, M. M., Ghani, N. A., Shuib, L., & Al-Haiqi, A. (2019). Development of a mobile game application to boost students' motivation in learning English vocabulary. *IEEE Access*, *7*, 13326–13337. https://doi.org/10.1109/ACCESS.2019.2891504

Fathi, J., Alipour, F., & Saeedian, A. (2018). Enhancing vocabulary learning and self-regulation via a mobile application: An investigation of the Memrise App. *Journal of Modern Research in English Language Studies, 5*(1), 27–46.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed.). Allyn & Bacon.

Giurgiu, L. (2017). Microlearning an evolving elearning trend. *Scientific Bulletin-Nicolae Balcescu Land Forces Academy, 22*(1), 18–23. https://doi.org/10.1515/bsaft-2017-0003

Hwang, G. J., & Fu, Q. K. (2019). Trends in the research design and application of mobile language learning: A review of 2007–2016 publications in selected SSCI journals. *Interactive Learning Environments*, *27*(4), 567–581. https://doi-org.ezproxy.lib.purdue.edu/10.1080/10494820.2018.1486861

Habib, S., Haider, A., Suleman, S. S. M., Akmal, S., & Khan, M. A. (2022). Mobile assisted language learning: Evaluation of accessibility, adoption, and perceived outcome among students of higher education. *Electronics, 11*(7), 1113.

Jin, Z., & Webb, S. (2021). Does writing words in notes contribute to vocabulary learning? *Language Teaching Research, 29*(2). https://doi.org/10.1177/13621688211062184

Kukulska-Hulme, A. (2009). Will mobile learning change language learning? *ReCALL*, *21*(2), 157–165. https://doi.org/10.1017/S0958344009000202

Kukulska-Hulme, A., & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. *ReCALL, 20*(3), 271–289. doi: https://doi.org/10.1017/S0958344008000335

Kukulska-Hulme, A., Lee, H., & Norris, L. (2017). Mobile learning revolution: Implications for language pedagogy. In C. A. Chapelle & S. Sauro (Eds.), *The handbook of technology and second language teaching and learning* (pp. 217–233). John Wiley & Sons.

Kohnke, L. (2020). Exploring learner perception, experience and motivation of using a mobile app in L2 vocabulary acquisition. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT)*, *10*(1), 15–26. https://doi.org/10.4018/IJCALLT.2020010102

Komppa, J., & Kotilainen, L. (2018). Mobile assisted language learning in the workplace—developing the context-aware learning application Appla. In P. Taalas, J. Jalkanen, L. Bradley & S. Thousny (Eds.), *Future-proof CALL: Language learning as exploration and encounters —short papers from EUROCALL 2018* (pp. 147–152). Research-publishing.net. https://doi.org/10.14705/rpnet.2018.26.828

Kearney, M., Schuck, S., Burden, K., & Aubusson, P. (2012). Viewing mobile learning from a pedagogical perspective. *Research in Learning Technology, 20*(1). https://doi.org/10.3402/rlt.v20i0.14406.

Kearney, M., Burden, K., & Schuck, S. (2020). *Theorizing and implementing mobile learning*. Springer Nature.

Lotherington, H. (2018). How mobile are top-rated mobile language learning apps? *International Association for Development of the Information Society*, 121–128.

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

Li, Y. M., & Wang, Y. F. (2019) 大学生常用英语词汇学习APP的比较分析 [Comparative Analysis of Common English Vocabulary Learning Apps for College Students]. *Journal of Jimei University*, *20*(6), 53–58. https://doi.org/10.3969/j.issn.1671-6493.2019.06.010

Lin, J. J., & Lin, H. (2019). Mobile-assisted ESL/EFL vocabulary learning: A systematic review and meta-analysis. *Computer Assisted Language Learning*, *32*(8), 878–919. https://doi.org/10.1080/09588221.2018.1541359

Li, Y., & Hafner, C. A. (2022). Mobile-assisted vocabulary learning: Investigating receptive and productive vocabulary knowledge of Chinese EFL learners. *ReCALL, 34*(1), 66–80.

Miangah, T. M., & Nezarat, A. (2012). Mobile-assisted language learning. *International Journal of Distributed and Parallel Systems, 3*(1), 309–319. https://doi.org/10.5121/ijdps.2012.3126

Mahdi, H. S. (2018). Effectiveness of mobile devices on vocabulary learning: A meta-analysis. *Journal of Educational Computing Research, 56*(1), 134–154. https://doi.org/10.1177/0735633117698826

Ma, Q. (2009). *Second language vocabulary acquisition*. Peter Lang.

Mayer, R. E. (2020). Where is the learning in mobile technologies for learning? *Contemporary Educational Psychology, 60*, 101824.

Mitchell, T. J., Chen, S. Y., & Macredie, R. D. (2005). The relationship between web enjoyment and student perceptions and learning using a web-based tutorial. *Learning, Media and Technology*, *30*(1), 27–40.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook.* Sage.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Masrai, A. (2023). Lexical knowledge and L2 general language proficiency: collocational competence and vocabulary size as determinants of lexical knowledge. *Cognitive Processing, 24*(2), 289–300.

Nation, P. (2022). *Learning vocabulary in another language* (3rd ed.). Cambridge University Press.

Ozer, O., & Kılıç, F. (2018). The effect of mobile-assisted language learning environment on EFL students' academic achievement, cognitive load and acceptance of mobile learning tools. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(7), 2915–2928. https://doi.org/10.29333/ejmste/90992

Okumuş Dağdeler, K. (2023). A systematic review of Mobile-Assisted Vocabulary Learning research. *Smart Learning Environments, 10*(1), 19. https://doi.org/10.1186/s40561-023-00235-z

Polit, D. F., & Beck, C. T. (2006). The content validity index: are you sure you know what's being reported? Critique and recommendations. *Research in Nursing & Health*, *29*(5), 489–497.

Prensky, M. R. (2010). *Teaching digital natives: Partnering for real learning*. Corwin Press.

Polakova, P., & Klimova, B. (2022). Vocabulary mobile learning application in blended English language learning. *Frontiers in Psychology*, *13*, 869055.

Saikat, S., Dhillon, J. S., Wan Ahmad, W. F., & Jamaluddin, R. A. D. (2021). A systematic review of the benefits and challenges of mobile learning during the COVID-19 pandemic. *Education Sciences*, *11*(9), 459.

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

Schmitt, N. (2010). Key issues in teaching and learning vocabulary. In R. Chacon-Beltran, C. Abello-Contesse & M. M. Torreblanca-Lopez (Eds.), *Insights into non-native vocabulary teaching and learning*, Multilingual Matters, 28–40.

Schmitt, N., & Schmitt, D. (2020). *Vocabulary in language teaching* (2nd ed.). Cambridge university press.

Sonbul, S. (2012). Approaches to second language vocabulary teaching. *The Encyclopedia of Applied Linguistics,* 1–5. https://doi.org/10.1002/9781405198431.wbeal0034

Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Sung, Y. T., Chang, K. E., & Yang, J. M. (2015). How effective are mobile devices for language learning? A meta-analysis. *Educational Research Review, 16*, 68–84.

Saldaña, J., & Omasta, M. (2016). *Qualitative research: Analyzing life*. Sage.

Stockwell, G. (2007). Vocabulary on the move: Investigating an intelligent mobile phone-based vocabulary tutor. *Computer Assisted Language Learning, 20*(4), 365–383.

Stockwell, G. (2010). Using mobile phones for vocabulary activities: Examining the effect of platform. *Language Learning & Technology, 14*(2), 95–110.

Stockwell, G., & Hubbard, P. (2013). Some emerging principles for mobile-assisted language learning. *The International Research Foundation for English Language Education*, *2013*, 1–15.

Su, Y. N., & Su, Y. P. (2015). Development and application of integrable wares of mobile learning games for college students to learn English words—Taking the game of "Happy Farm" as an example. *Technology Enhanced Foreign Language Education*, *5*, 30–35.

Sharples, M., (2006). *Big issues in mobile learning. Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative.* Learning Sciences Research Institute, University of Nottingham.

Tosun, S. (2015). The effects of blended learning on EFL students' vocabulary enhancement. *Procedia-Social and Behavioral Sciences, 199*, 641–647.

Tommerdahl, J. M., Dragonflame, C. S., & Olsen, A. A. (2024). A systematic review examining the efficacy of commercially available foreign language learning mobile apps. *Computer Assisted Language Learning*, *37*(3), 333–362.

Vygotsky, L. S., & Cole, M. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.

Wang, X. (2020). 大学生手机背英语单词APP使用情况调查研究 [Investigating Higer Education Students' Use of Mobile Apps for Memorizing English Vocabulary]. *Electronic Edition (Mid-Month)*, *8*, 241–242.

Webb, S., Sasao, Y., & Ballance, O. (2017). The updated Vocabulary Levels Test: Developing and validating two new forms of the VLT. *ITL-International Journal of Applied Linguistics*, *168*(1), 33–69. https://doi.org/10.1075/itl.168.1.02web

Wu, Q., (2015) Pulling Mobile Assisted Language Learning (MALL) into the mainstream: MALL in broad practice. *PLoS ONE*, *10*(5), e0128762. https://doi:10.1371/journal.pone.0128762

Xu, Q., & Richardson, J. C. (2024). The impact of social media and gamification of a mobile vocabulary learning app: Self-regulation and learning persistence, *Online Learning, 28*(4). https://doi.org/10.24059/olj.v28i4.4592

Zheng, Y., & Cheng, L. (2008). Test review: college English test (CET) in China. *Language Testing*, *25*(3), 408–417.

Appendix A

Semi-structured Interview Questions

1 General questions:

1.1 Did you use any other mobile vocabulary learning Apps except Shanbay? If yes, do you like them? Why or why not?

1.2 Before participating in the Shanbay activity, how did you learn English vocabulary? What kind of strategies did you use?

1.3 During the Shanbay learning activity, can you share your general satisfaction with the App? Do you like it? Why or why not?

2 Pedagogical features in SBDC that potentially support personalization, authenticity, and collaboration during the learning process:

2.1 Which feature(s) of Shanbay do you like the most? Why?

2.2 Which feature(s) of Shanbay do you like the least? Why?

2.3 What are your vocabulary learning expectations? Do you aim to recognize them during reading and listening tasks, or use them in writing and speaking? Did you find Shanbay helpful in helping you reach your expectations? How?

3 Learning perceptions related to the mobile-learning environment:

3.1 In most situations, where did you complete vocabulary learning tasks? What kind of learning environments did you choose? Why?

3.2 How do you feel about learning in a mobile environment?

3.3 Will you continue to use Shanbay in your future English vocabulary study? Why or why not?

Appendix B

Form-meaning Test Sample Questions

* 1. Choose the right answer

	加强，加固；强化	燃烧；发光；怒视；宣扬	负责的，可靠的	管理；规则	初步的；开始的	抑制，控制；约束
blaze	○	○	○	○	○	○
preliminary	○	○	○	○	○	○
regulation	○	○	○	○	○	○

* 2.

	精确的；明确的	纬度；界限	前任，前辈	经度；经线	官僚主义	初步的；开始的
bureaucracy	○	○	○	○	○	○
latitude	○	○	○	○	○	○
predecessor	○	○	○	○	○	○

* 3

	派遣，发送	压坏，压扁	人群；观众	交叉，十字	重要的；决定性的	种植；收割；修剪；剪短
dispatch	○	○	○	○	○	○
crowd	○	○	○	○	○	○
crop	○	○	○	○	○	○

Appendix C

Open-ended Survey

Open-ended survey

What time of day do you most often use the Shanbay App for your daily learning tasks, and why do you prefer this time? Please describe your typical situation or context when using the app.

Please describe the place where you usually complete your daily learning tasks with the Shanbay App. What makes this location suitable for your studies?"

Which following features of the Shanbay App have you used as part of your learning process? Please explain how you use each feature and assess its usefulness. Additionally, if there are any features you have consciously chosen not to use, please explain your reasons.

Audio pronunciation_____
Example sentences_____
Example sentences specifically from CET 6 _____
Set daily learning goal_____
Badge-sharing_____
Badge-sharing calendar_____
Unfamiliar words book_____
Notes_____
Notifications_____
Other features _____

Appendix D

Interview Participants' Demographic Information

Participant (Pseudonym)	Gender	Major	Pre-test	Post-test	Learning outcomes change (Largest decrease: -13, largest increase: +13)
Ming	Male	Civil Engineering	91.67	78.67	Large decrease (-13)
Hong	Male	Information engineering	93.75	89.33	Slight decrease (-4.41)
Qing	Female	Information engineering	93.75	90.67	Slight decrease (-3)
Rong	Male	Information Science and Technology	97.92	97.33	Slight decrease (-0.58)
Fang	Male	Biological Sciences and Medical Engineering	95.83	97.33	Slight increase (+1.5)
Lu	Male	Computer Science and Engineering	93.75	97.33	Slight increase (+3.58)
Han	Male	Computer Science and Engineering	81.25	94.67	Large increase (+13.42)
Xing	Male	Computer Science and Engineering	81.25	94.67	Large increase (+13.42)

Appendix E

Coding Scheme

Codes	Code Frequency	Categories	Themes
Audio	12	Multiple learning resources	Authenticity: Rich contents
Example sentence	7		
Learn in contexts	8		
Badge sharing	26	Social interaction	Collaboration: Collaboration supported by SBDC
Social media recognition	4		
Reminder	3		
Review learned words	3	Repetition and personalized plan	Personalization: Personalized learning within SBDC
Correct wrong memorization	1		
Save unfamiliar words	2		
Enhance memorization	4		
Guessing	1	Self-check and reflecting	
Testing	2		
Hint	1		
Daily new vocabulary task set up	1	Goal – setting	
Daily review vocabulary task set up	1		
Learning pace modification	2		
Progress checking	5	Learning progress monitoring	
Learning data	1		
Feeling of awarded	4		
Location of the learning activity (e.g. dormitory, classroom, library, bus station, canteen).	9	Learning environment and time choice	
Time management	4		
Anti-digital	1	Mobile learning acceptance	Challenges of learning in a mobile environment
Too flexible	2		
Message and notifications	2	Distraction	
Overwhelmed	1		
Technology is not function well	1	Ease of use	
Picture disadvantage	5	Content limitation	
Reading only	2		
Spelling	2		
Productive use	3		
Vocabulary learning preference	5		