

The Impact of Duolingo-assisted Learning on Chinese Vocabulary Learning Motivation and Achievement among Elementary School Students

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Abstract

With the rapid development of mobile technology, mobile-assisted language learning has become increasingly prevalent in foreign language education. Duolingo is one of the most popular language learning applications. However, there is still limited evidence about its effectiveness in improving Chinese vocabulary learning, especially among primary school students. The purpose of this study is to examine the effects of Duolingo-assisted learning on Chinese vocabulary acquisition among primary school students and to examine students' motivation toward Chinese vocabulary learning. A quantitative quasi-experimental design was adopted. Fifty primary school students participated in the study. A Chinese vocabulary pre-test and post-test were administered to measure learning achievement, while a learning motivation questionnaire was used to examine students' motivation toward Chinese vocabulary learning. The results of a one-way ANCOVA revealed that students in the experimental group achieved significantly higher post-test vocabulary scores than those in the control group after controlling for pre-test scores. Furthermore, the results of a one-way MANOVA indicated that the experimental group demonstrated significantly higher self-efficacy motivation, whereas no statistically significant differences were found in intrinsic motivation, self-determination, or grade motivation. These findings suggest that Duolingo-assisted learning can effectively enhance Chinese vocabulary achievement and strengthen students' confidence in learning Chinese vocabulary. The study provides empirical evidence supporting the integration of mobile-assisted language learning applications into primary Chinese language instruction and offers practical implications for teachers and educators.

Keywords: Duolingo, Chinese vocabulary acquisition, mobile-assisted language learning, motivation to learn, learning achievement

■ Introduction

Vocabulary acquisition is widely regarded as a fundamental aspect of second language learning because it supports the development of listening, speaking, reading, and writing skills. In Chinese language education, vocabulary learning is particularly important given the language's linguistic characteristics, including tones, characters, and the relationship between word forms and meanings. These features can

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create additional learning demands for beginner learners. Traditional vocabulary instruction in Chinese language classrooms frequently relies on memorization, repetition, and teacher-centered practice. Although memorization and repetition may support initial recall, recent evidence suggests that durable vocabulary learning depends on exposure frequency, depth of processing, and the types of repeated activities, rather than on repetition alone (Shin & Kim, 2023). Young learners, especially primary school students, generally require more interactive and motivating learning experiences to maintain attention and participation. With the rapid development of educational technology. Recent studies indicate that mobile language-learning applications can extend learning beyond classroom settings by providing flexible access and additional opportunities for language practice. However, their effectiveness depends on appropriate pedagogical design and integration into language-learning contexts (Fang et al., 2024; Lo & Chang, 2026). Studies of mobile-assisted Chinese language learning suggest that mobile technologies can extend learning beyond traditional classroom settings and provide additional opportunities for Chinese language practice. However, successful implementation requires appropriate pedagogical design and effective integration of mobile technologies into language-learning contexts (Zhou, 2020; Fang et al., 2024). Among various language-learning applications, Duolingo has attracted considerable attention because of its gamified design and adaptive learning features. Such as challenging tasks, reward incentives, systematic levels, progress indicators, and user rankings. These features organize language practice into goal-oriented activities and may encourage learners to participate continuously (Shortt et al., 2023). Recent AI-supported language-learning environments can provide personalized learning experiences and individualized corrective feedback based on learners' interactions (Kamelabad et al., 2026). Despite Duolingo's growing popularity, empirical research on its effectiveness in Chinese language education remains limited. Existing studies have primarily examined mobile learning technologies in general language-learning contexts, while fewer studies have investigated Chinese vocabulary learning among young learners. Furthermore, previous research has often focused on either learning achievement or learner motivation in isolation, leaving limited evidence on both outcomes in primary-level Chinese vocabulary learning environments.

In Thailand, Chinese has become an increasingly important foreign language in schools and private educational institutions. As educators continue to explore technology-enhanced approaches to language teaching, it is necessary to examine whether Duolingo can effectively support vocabulary acquisition and motivation to learn among young learners. Therefore, this study investigates the effects of Duolingo-assisted learning on Chinese vocabulary achievement and learning motivation among Thai primary school students. The findings are expected to contribute to the literature on mobile-assisted language learning and provide practical implications for Chinese vocabulary instruction in primary education settings.

The two research objectives are complementary in evaluating the educational effects of Duolingo-assisted learning. Vocabulary achievement represents the cognitive learning outcome of the intervention, whereas learning motivation reflects students' affective responses to the learning environment. Duolingo may support vocabulary achievement through repeated exposure, structured practice, and immediate feedback, while its gamified features and visible progress may influence learners' confidence, interest, and willingness to participate. Examining both outcomes provides a more comprehensive understanding of whether Duolingo-assisted learning supports not only students' vocabulary performance but also their motivation to learn Chinese vocabulary.

■ Research Questions

- 1) What effect does Duolingo-assisted learning have on Thai primary school students' motivation for Chinese vocabulary learning?
- 2) To what extent does Duolingo-assisted learning improve Thai primary school students' Chinese vocabulary achievement?

■ Research Objectives

- 1) To investigate the impact of Duolingo-assisted learning on students' motivation for Chinese vocabulary learning.
- 2) To examine the effectiveness of Duolingo-assisted learning in improving Chinese vocabulary achievement among Thai primary school students.

■ Literature Reviews

Learning Motivation in Technology-Enhanced Language Learning

Learning motivation influences learners' willingness to participate in language-learning activities, sustain effort, and regulate their learning behavior. Recent research on language-learning applications indicates that learners' goals, attitudes, and confidence in self-regulated learning shape how they select, use, and persist with digital learning tools (Lo & Chang, 2026). Motivation should therefore be treated as a multidimensional outcome, because app-based learning may strengthen confidence or persistence without producing equivalent changes across all motivational dimensions. Technology-enhanced learning environments may support motivation through interactive tasks, visible progress, timely feedback, and achievement-oriented activities. Nevertheless, recent reviews indicate that the motivational effects of the environment vary with activity design, learner characteristics, and learning context, and therefore should not be assumed to be uniform across all motivational outcomes (Dehghanzadeh et al., 2021; Shortt et al., 2023). Studies of mobile-assisted Chinese language learning have also reported benefits related to vocabulary acquisition, language skill development, and flexible learning beyond traditional classroom settings (Zhou, 2020; Fang et al., 2024). These studies do not establish that every dimension of motivation necessarily improves, but they provide a basis for examining how Duolingo-assisted learning may relate to intrinsic motivation, self-efficacy, self-determination, and grade motivation.

For primary school learners, maintaining motivation is particularly important, as they are often influenced by interest and enjoyment during the learning process. Interactive learning environments that incorporate game-based features may therefore provide effective support for sustaining learner engagement and encouraging continuous participation in vocabulary learning activities. Consequently, investigating the impact of Duolingo on students' motivation to learn is an important aspect of evaluating its effectiveness as a supplementary learning tool.

Technology-enhanced Language Learning Achievement

Technology-enhanced language learning can support learning achievement by expanding access to multimodal resources, providing interactive practice, recording learner performance, and enabling timely assessment and targeted instructional support. Artificial intelligence applications have increasingly been

used to support Chinese language teaching and learning, providing additional assistance in addressing linguistic and educational challenges encountered by learners of Chinese as a foreign language (Xia et al., 2024).

Recent evidence suggests that the effects of technology-enhanced language learning are generally positive but context-dependent. Mihaylova et al. (2022) reported an overall positive effect of mobile language-learning applications on second-language achievement compared with traditional learning conditions, although they also identified differences in study quality and risk of bias. Similarly, Okumuş Dağdeler (2023) found that learning achievement and learner perceptions were the most frequently investigated outcomes in mobile-assisted vocabulary-learning research, while gamification was a common technological focus. These findings indicate that technology can create additional opportunities for language practice, but improved achievement depends on instructional design, learner characteristics, and the integration of digital tools into teaching.

Mobile-Assisted Language Learning in Chinese Vocabulary Instruction

Mobile-assisted language learning has become an important component of technology-enhanced language education. Recent reviews indicate that mobile devices and applications can extend learning beyond classroom settings, support interactive language practice, and provide opportunities for self-regulated learning. In the context of Chinese language learning, mobile technologies can extend learning across different times and locations and provide additional opportunities for language practice beyond conventional classroom settings (Zhou, 2020; Fang et al., 2024; Lo & Chang, 2026). Vocabulary is one of the most frequently investigated areas in mobile-assisted language learning. Mobile applications can present lexical content through text, images, audio, and interactive exercises while providing repeated opportunities for recognition, retrieval, and practice. A recent systematic review found that vocabulary achievement and learner perceptions were among the most common research outcomes, and that gamification was frequently incorporated into mobile-assisted vocabulary-learning activities (Okumuş Dağdeler, 2023). Mobile technologies may therefore support vocabulary development by increasing learners' access to practice and presenting lexical information in multiple formats.

However, the availability of mobile technology does not automatically produce effective learning. Younger learners may require stronger teacher scaffolding and supervision than university students, while successful implementation also depends on instructional design, technical conditions, and curricular integration. Recent reviews of mobile-assisted Chinese language learning have identified methodological and research gaps and have called for further investigation into the effective integration of mobile technologies in CSL/CFL learning contexts (Fang et al., 2024). Consequently, mobile applications should be regarded as instructional resources that complement teacher-guided vocabulary learning rather than as independent substitutes for classroom teaching.

Duolingo as a Supplementary Language Learning Tool

Among commercially available language-learning applications, Duolingo has received considerable attention for its accessibility, structured progression, and gamified design. The application organizes language practice through challenging tasks, systematic levels, reward incentives, progress indicators, and user rankings (Shortt et al., 2023). These features break longer learning goals into shorter activities and allow learners to monitor their progress and task completion.

To illustrate how these features are applied to Chinese vocabulary learning, Figure 1 presents examples of activities from the Duolingo Chinese course used during the instructional intervention. The activities require learners to recognize Chinese characters and word meanings, identify vocabulary through listening, complete sentence-based exercises, and respond to immediate corrective feedback. By combining short tasks, repeated practice, and visible progression, the application provides learners with multiple opportunities to encounter and retrieve target vocabulary. These functions may support vocabulary practice while making the learning process more manageable and engaging for young learners.

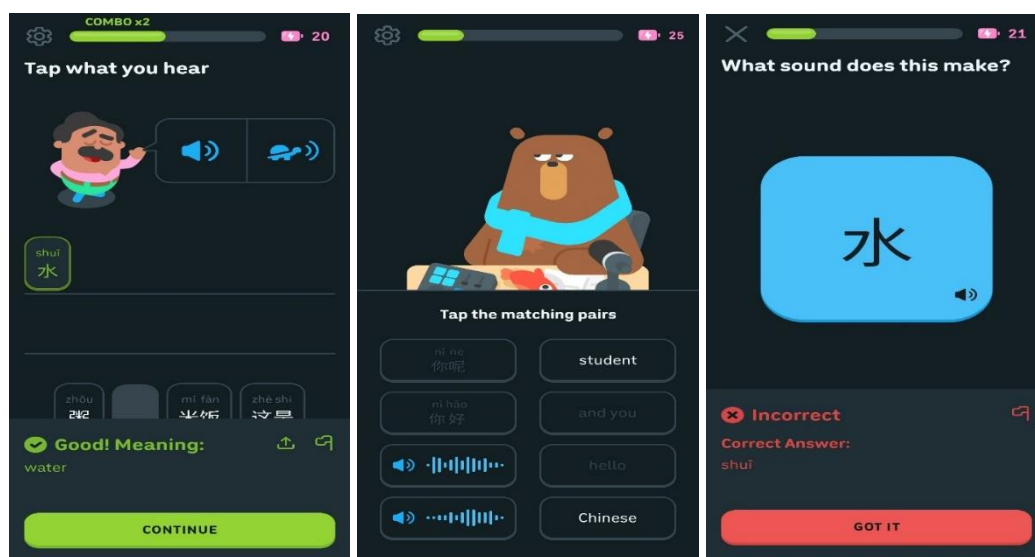


Figure 1. Examples of Chinese Vocabulary-Learning Activities in Duolingo

Recent comparative evidence has produced mixed results regarding Duolingo's effectiveness. Empirical evidence involving elementary school learners has produced mixed findings. Rachels (2016) conducted a 12-week quasi-experimental study involving third- and fourth-grade students who learned Spanish either through Duolingo or through traditional face-to-face instruction. The study examined both language achievement and academic self-efficacy and found no statistically significant differences between the two groups. This finding is particularly relevant to the present study because it demonstrates that the gamified features of Duolingo do not necessarily lead to higher achievement or self-efficacy among young learners. However, because the target language was Spanish rather than Chinese, the findings cannot be directly generalized to Chinese vocabulary learning, which additionally involves character recognition, tones, and the relationship among character forms, pronunciation, and meaning. Calheiros (2024) compared Duolingo with traditional classroom instruction among adult beginners of Mandarin Chinese. The traditional classroom group achieved higher average scores across the assessed language components, whereas the Duolingo group demonstrated greater learning efficiency per unit of time invested. These findings suggest that Duolingo may provide accessible and time-efficient practice, but it is more appropriately used as a supplementary tool than as a replacement for teacher-led instruction. Taken together, previous studies suggest that the effects of Duolingo may vary according to learner age, target language, instructional design, and learning outcomes. Rachels (2016) provided evidence from elementary school learners but focused on Spanish, whereas Calheiros (2024) examined Mandarin Chinese, involved adult beginners, and assessed a broader range of language skills. Moreover, relatively few studies have simultaneously examined vocabulary achievement and multiple dimensions of learning motivation among young Chinese-language learners. Therefore, further research is needed to investigate Duolingo-assisted Chinese vocabulary learning among

primary school students within a teacher-guided classroom environment. Evidence concerning Duolingo-assisted Chinese vocabulary learning among primary school students remains limited (Shortt et al., 2023; Calheiros, 2024). Further research is needed to examine whether its structured and gamified activities can support both vocabulary achievement and different dimensions of learning motivation among young Chinese-language learners.

To summarize the ideas from the literature reviews, Figure 2 illustrates the study's conceptual framework. Duolingo-assisted learning serves as the independent variable. The study assumes that using Duolingo may influence students' learning motivation, including intrinsic motivation, self-efficacy, self-determination, and grade motivation. In addition, Duolingo may subsequently contribute to Chinese vocabulary achievement. Therefore, the framework presents the relationship between Duolingo-assisted learning, learning motivation, and vocabulary achievement among Thai primary school students.

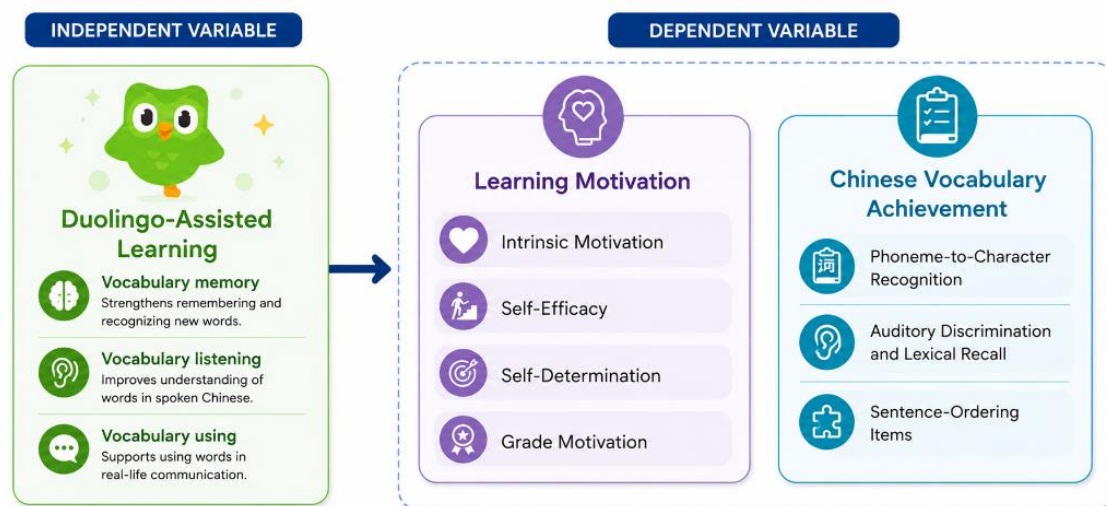


Figure 2. The conceptual framework

Research Methodology

This study adopted a quantitative quasi-experimental design. Data was collected through vocabulary tests and a learning motivation questionnaire. One-way ANCOVA and one-way MANOVA were employed to analyze vocabulary achievement and learning motivation, respectively.

Participants

A total of 50 Thai primary school students aged 7–12 years participated in this study. The participants were recruited from Panda Chinese Tutor School in Bangkok, Thailand, a private language institution that provides individual and small-group Chinese courses for children. All participants were native Thai speakers learning Chinese as a foreign language at the beginner level. Their proficiency level was determined based on their current course level, previous Chinese learning experience, and ability to participate in basic classroom activities rather than by an official HSK examination.

Purposive sampling was used to select participants who met the following criteria: they were between 7 and 12 years old, were currently studying beginning-level Chinese, were able to understand basic classroom instructions and complete simple vocabulary-learning activities, attended the instructional

sessions regularly, and had obtained consent from a parent or legal guardian. After participant selection, the 50 students were divided into an experimental group and a control group, with 25 students in each group. Because the study employed a quasi-experimental design, the participants were not randomly assigned. The group assignment was based on the researcher's regular classroom observations and the students' overall Chinese proficiency to make the two groups as comparable as possible before the intervention. The Chinese vocabulary pre-test was administered after group assignment and was therefore not used to determine group membership; instead, it was used to identify students' baseline vocabulary knowledge and was subsequently included as a covariate in the ANCOVA analysis.

The experimental group received Duolingo-assisted Chinese vocabulary instruction under teacher guidance, whereas the control group received traditional teacher-led vocabulary instruction. Both groups studied the same target vocabulary and participated in the same number of instructional sessions.

Research Instruments

This study employed two primary instruments to collect quantitative data: a Chinese vocabulary assessment and a learning motivation questionnaire. The language difficulty, content selection, and presentation format were calibrated to align with learners' cognitive and linguistic development stages.

A learning motivation questionnaire was administered to both groups after the intervention to assess the students. The questionnaire covered four dimensions: intrinsic motivation, self-efficacy, self-determination, and grade motivation. The items were adapted to the context of primary-level Chinese vocabulary learning and simplified to match the participants' age and language proficiency. Recent reliability evidence indicates that the SMQ-II and its subscales have demonstrated high internal consistency across different languages, sample types, and educational contexts (Karaca et al., 2026). The items were adapted to the context of Chinese vocabulary learning and simplified for primary school students. Responses were recorded on a five-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree (Joshi et al., 2015). The four dimensions were defined as follows:

- Intrinsic motivation is a term used to describe a student's drive to complete a task because they find it interesting or enjoyable.
- Self-efficacy motivation refers to a student's belief in his or her ability to learn or take action at a specific level.
- Self-determination motivation explains how being self-determined impacts motivation, and students feel more motivated to take action when they think it will affect the outcome.
- Grade motivation focuses on the relationship between students' motivation and their academic performance, particularly in the context of grading.

As part of the Chinese vocabulary assessment, the researchers developed a vocabulary test aligned with the curriculum content of Panda Chinese School and high-frequency lexical items featured in the AI learning application. The assessment items target vocabulary domains commonly encountered during the experimental period, including semantic fields such as colors, numerals, animals, body parts, and household objects. The vocabulary assessment comprised three item types, including multiple-choice questions requiring phoneme-to-character recognition; listening comprehension tasks assessing auditory discrimination and lexical recall; and sentence-ordering items evaluating grammatical application and vocabulary use in context. Yielding a total possible score of 20. The assessment was administered at two critical junctures: immediately preceding the intervention (pre-test) and following the completion of the experimental treatment (post-test). Post-test scores relative to pre-test baseline performance served

as the primary metric for evaluating differential vocabulary acquisition between the experimental and control groups.

Beyond the traditional pre- and post-test design, the Duolingo platform's embedded assessment module provided additional performance metrics. The application employs an adaptive algorithm to track learners' vocabulary mastery through measurable indicators, including task completion rates, error frequency, and spaced-repetition cycling. Each learner's progression was documented through quantifiable measures: accumulated experience points (XP), skill-strength indices, and checkpoint completion records. The Duolingo classroom dashboard provided instructors with aggregated performance data, including time-on-task, correct-attempt frequency, and item-specific remediation requirements. These supplementary data sources enabled a more granular assessment of vocabulary acquisition trajectories and supported targeted corrective feedback.

Analysis of Data

Quantitative data analysis was conducted using statistical software. For the learning motivation data, a one-way MANOVA was used to examine whether there were statistically significant differences between the experimental and control groups across four motivation dimensions: intrinsic motivation, self-efficacy, self-determination, and grade. The learning environment (Duolingo-assisted vs. traditional) was the independent variable, and the four motivation dimensions were the dependent variables. For the learning achievement data, a one-way ANCOVA was conducted to compare post-test scores between the two groups, controlling for pre-test scores as the covariate. This approach was adopted to account for any pre-existing differences in vocabulary knowledge between the groups and to provide a more precise estimate of the treatment effect. Prior to conducting each analysis, relevant statistical assumptions were examined, including normality, homogeneity of variances, homogeneity of variance-covariance matrices for MANOVA, and homogeneity of regression slopes for ANCOVA. Statistical significance was set at the 0.05 level.

Experimental Procedure

This study employed a quasi-experimental pre-test-post-test control-group design. The intervention was conducted over four weeks, with two instructional sessions per week, for a total of eight sessions. Each session lasted 60 minutes and included a five-minute break to help the young learners maintain attention. Both groups were taught by the same teacher, studied the same target vocabulary, and received the same overall instructional time and general learning objectives. The main difference between the two groups was the mode of vocabulary practice and reinforcement.

Before the intervention, both groups completed the same Chinese vocabulary pre-test, which took approximately 20 minutes and was used to establish baseline vocabulary knowledge.

In the experimental group, each lesson began with approximately 5–10 minutes of vocabulary review, followed by approximately 10 minutes of teacher-guided introduction of new vocabulary, including pronunciation, Chinese character forms, meanings, and basic usage. Approximately 20 minutes of each session were then devoted to Duolingo-supported practice. Students completed activities such as listening recognition, meaning matching, Chinese character recognition, translation, and simple sentence practice. During this stage, Duolingo provided immediate, automated feedback and repeated practice, while the teacher monitored students' progress, clarified vocabulary and sentence structure, and corrected pronunciation as needed. The remaining lesson time was used for classroom consolidation activities, including Chinese character games and other teacher-guided vocabulary activities.

The control group followed a comparable lesson structure and studied the same target vocabulary. Each session generally included 5–10 minutes of vocabulary review, 10 minutes of new vocabulary instruction, 20 minutes of conventional vocabulary exercises, and 15–20 minutes of Chinese character games or other classroom practice. Instead of Duolingo, students completed teacher-guided, paper-based exercises that included pronunciation practice, repetition, question-and-answer activities, sentence practice, and vocabulary review. Thus, instructional duration, target content, teacher involvement, and overall learning objectives were kept comparable, while the principal difference was that the experimental group used Duolingo during the structured practice stage.

Students in the experimental group were encouraged to continue using Duolingo outside the scheduled classroom sessions if they wished. However, out-of-class use was neither required nor systematically monitored, and it was not included as part of the formal intervention. Therefore, the intervention was primarily implemented and supervised during classroom sessions.

After the eight instructional sessions, both groups completed the same Chinese vocabulary post-test within one week. The post-test took approximately 20 minutes. Immediately afterward, students completed the learning motivation questionnaire, which took approximately 10 minutes. The overall experimental procedure is presented in Figure 3.

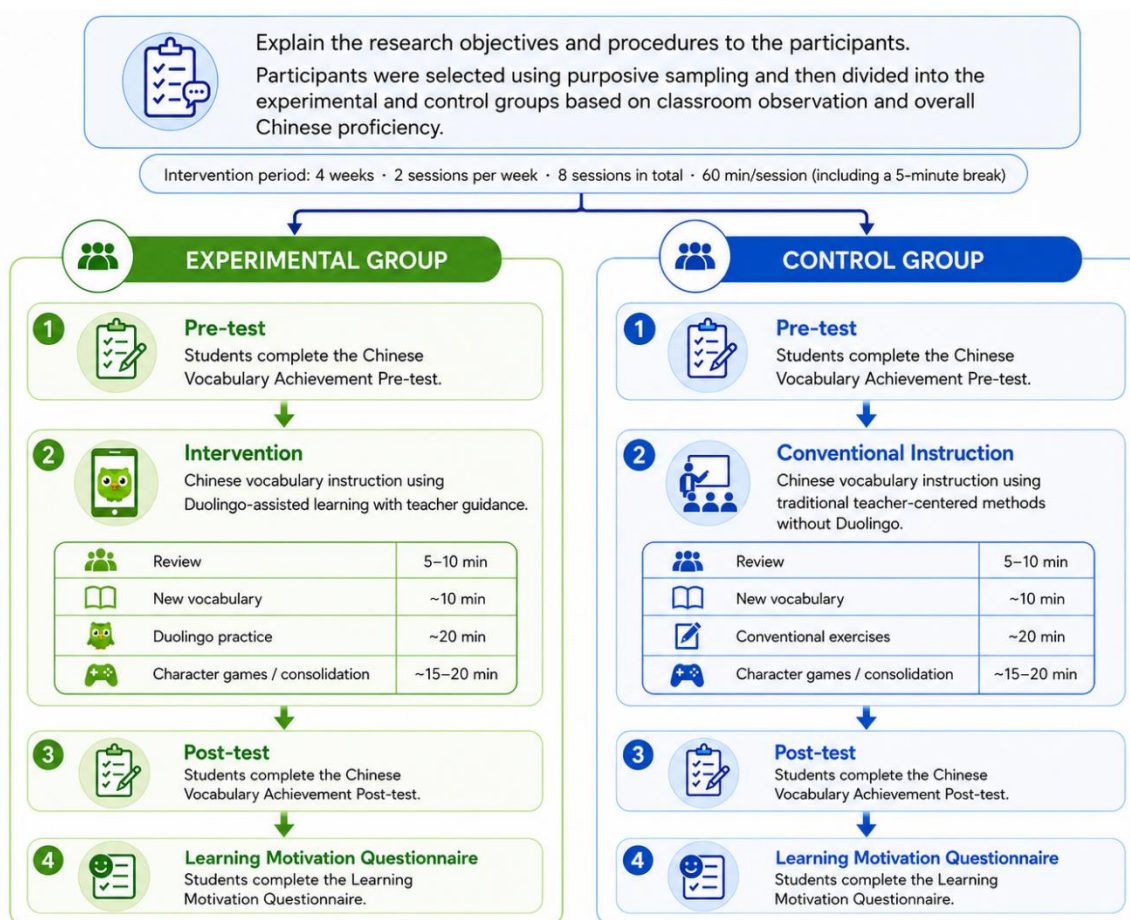


Figure 3. The research experimental procedures

Research Results

Result of Students' Learning Motivation

A one-way MANOVA was conducted to examine whether students' learning motivation differed between the Duolingo-assisted learning group and the traditional learning group. The learning environment (experimental and control groups) served as the independent variable, while the four dimensions of learning motivation (intrinsic motivation, self-efficacy, self-determination, and grade motivation) were the dependent variables.

Table 1 presents the descriptive statistics and one-way MANOVA results for the four dimensions of learning motivation. The results indicated a statistically significant difference between the experimental and control groups in self-efficacy motivation, $F_{(1, 47)} = 10.387$, $\eta^2 = 0.178$, suggesting that students who learned with Duolingo demonstrated significantly higher confidence in learning Chinese vocabulary than those who received traditional instruction. However, no statistically significant differences were found between the two groups in intrinsic motivation ($F_{(1, 47)} = 0.883$, $\eta^2 = 0.018$), self-determination ($F_{(1, 47)} = 0.145$, $\eta^2 = 0.003$), or grade motivation ($F_{(1, 47)} = 0.743$, $\eta^2 = 0.015$). These findings suggest that Duolingo-assisted learning had a significant positive effect on students' self-efficacy motivation but did not produce statistically significant improvements in the other three dimensions of learning motivation.

Table 1

One-way MANOVA results of students' Chinese vocabulary learning motivation

Motivation Dimension	Group	N	M	SD	MS	$F_{(1,47)}$	η^2
Intrinsic	Experimental	25	3.820	0.6904	0.500	0.883	0.018
	Control	25	4.020	0.8098			
Self-Efficacy	Experimental	25	4.133	0.577	3.920	10.387*	0.178
	Control	25	3.573	0.649			
Self-Determination	Experimental	25	3.900	0.604	0.045	0.145	0.003
	Control	25	3.840	0.505			
Grade	Experimental	25	4.16	0.688	0.500	0.743	0.015
	Control	25	3.96	0.935			

* $p < 0.05$

Overall, the comparison shown in Table 1 indicates that the effect of Duolingo-assisted learning on motivation was not uniform across all four dimensions. The clearest difference between the two groups was observed in self-efficacy, suggesting that Duolingo-assisted learning was particularly associated with students' confidence in their ability to learn Chinese vocabulary rather than with broad improvements across all aspects of learning motivation.

Result of Students' Chinese Vocabulary Learning Achievement

A one-way ANCOVA was conducted to examine whether there was a significant difference in Chinese vocabulary learning achievement between the experimental and control groups after controlling for students' pre-test scores. The learning environment (experimental and control groups) served as the independent variable, the pre-test score as the covariate, and the post-test score as the dependent variable.

Table 2 presents the descriptive statistics and the results of a one-way ANCOVA for students' achievement in Chinese vocabulary learning. The results indicated that the experimental group obtained a significantly higher post-test score ($M = 15.32$, $SD = 2.81$) than the control group ($M = 14.28$, $SD = 2.25$). The ANCOVA results further revealed a statistically significant difference between the two groups after controlling for pre-test scores, $F_{(1, 47)} = 4.325$, $\eta^2 = 0.061$. These findings indicate that Duolingo-assisted learning significantly improved students' achievement in Chinese vocabulary learning compared with traditional instruction.

Table 2

One-way ANCOVA results of students' Chinese vocabulary learning achievement

Group	N	M	SD	MS	$F_{(1,47)}$	η^2
Experimental	25	15.32	2.81	19.67	4.325*	0.061
Control	25	14.28	2.25			

* $p < 0.05$

Overall, the comparison in Table 2 shows that the experimental group achieved better Chinese vocabulary learning than the control group after the intervention. The significant difference persisted after controlling for students' pre-test scores, indicating that the difference in post-test performance was attributable to the different instructional conditions. In this study, Duolingo-assisted learning provided additional support for Chinese vocabulary learning compared with traditional instruction.

Discussion

This study examined the effects of Duolingo-assisted learning on Chinese vocabulary acquisition among primary school students and examined students' motivation toward Chinese vocabulary learning. According to the one-way MANOVA results on students' learning motivation, students in the experimental group reported significantly higher self-efficacy than those in the control group. However, no statistically significant differences were found in intrinsic motivation, self-determination, or grade motivation. This pattern suggests that Duolingo-assisted learning was particularly associated with learners' confidence in their ability to complete Chinese vocabulary learning tasks rather than with improvements across all aspects of motivation. Immediate feedback, structured practice, visible progress, and achievable tasks may have helped students achieve success and develop greater confidence. Recent research indicates that structured progression, goal-oriented content, and feedback can support self-regulated language learning, while repetitive activities, insufficient personalization, and limited opportunities for productive practice may reduce learners' satisfaction (Lo & Chang, 2026). The experimental group's higher self-efficacy may be associated with the application's visible progress, achievable tasks, and immediate confirmation of successful performance. However, the relatively short intervention may not have been sufficient to produce comparable changes in intrinsic motivation, self-determination, or grade motivation.

In addition, the one-way ANCOVA results revealed that students in the Duolingo-assisted group achieved significantly higher post-test scores than those in the control group, after controlling for pre-test scores. This finding suggests that Duolingo-assisted learning had a positive effect on Chinese vocabulary acquisition among primary school learners compared with traditional instruction. The result is consistent with recent systematic reviews and meta-analytic evidence indicating that mobile-assisted language learning can support second-language achievement and vocabulary development when applications provide

structured practice and are appropriately integrated into instruction (Mihaylova et al., 2022; Okumuş Dağdelen, 2023). One possible explanation is that Duolingo provides frequent, structured opportunities for learners to encounter target vocabulary through activities such as matching, translation, and listening comprehension. By requiring learners to recognize, retrieve, and use target words across matching, translation, and listening activities, these tasks may increase opportunities for vocabulary consolidation and retention (Guo et al., 2022; Okumuş Dağdelen, 2023). Immediate feedback may also help learners notice and correct errors promptly. More recent comparative evidence has produced mixed findings. Calheiros (2024) found that traditional Mandarin instruction resulted in higher average performance across the assessed language components, whereas Duolingo demonstrated greater learning efficiency per unit of study time. The difference between these findings and the present results may be related to learner age, teacher involvement, instructional design, target content, and the measures used to assess learning. Because that study involved adult learners rather than primary school students and assessed a broader range of language skills, its findings cannot be directly generalized to young Chinese learners of vocabulary. Nevertheless, the present results extend the evidence to a primary-level context of Chinese vocabulary learning and support the use of Duolingo as a supplementary instructional tool.

Overall, the findings indicate that Duolingo-assisted learning was associated with significantly higher Chinese vocabulary achievement and higher self-efficacy than traditional instruction. No significant group differences were found in the other three motivation dimensions. By considering both learning achievement and students' motivational responses, this study provides empirical support for integrating Duolingo as a supplementary tool in primary-level Chinese vocabulary instruction.

■ Conclusion

This study investigated the effects of Duolingo-assisted learning on Chinese vocabulary acquisition among primary school students and examined students' motivation for learning Chinese vocabulary. The findings revealed that students in the Duolingo-assisted group achieved significantly higher post-test scores in Chinese vocabulary than those in the traditional learning group after controlling for pre-test differences. Regarding learning motivation, the experimental group demonstrated significantly higher self-efficacy, whereas no statistically significant differences were observed in intrinsic motivation, self-determination, or grade motivation. Overall, the findings suggest that Duolingo-assisted learning can support Chinese vocabulary achievement and enhance learners' confidence in learning it. Although the application did not significantly influence all dimensions of learning motivation, it demonstrated potential as a supplementary learning tool for primary-level Chinese language instruction. These findings provide empirical support for integrating mobile-assisted language learning applications into Chinese vocabulary teaching and offer practical implications for teachers seeking to incorporate digital learning technologies into classroom instruction.

This study also contributes to the growing body of research on mobile-assisted language learning by extending previous findings to Chinese vocabulary learning among Thai primary school students. Future studies are encouraged to examine the long-term effects of Duolingo-assisted learning with larger, more diverse samples and to explore its impact on other aspects of Chinese language learning, including listening, speaking, reading, and writing.

■ Limitations and Recommendations

Despite the meaningful findings of this study, several limitations should be acknowledged. First, the sample size of this study was relatively small and limited to students from one private language school. Although statistically significant results were obtained, the findings may not be fully generalizable to learners of different age groups, proficiency levels, or learning contexts. Future studies are encouraged to include larger and more diverse samples to enhance the generalizability of the findings. Second, the duration of the Duolingo-assisted learning intervention was relatively short. Although significant improvements in Chinese vocabulary achievement were observed, the intervention period may not have been sufficient to examine the long-term effects of Duolingo-assisted learning. Future longitudinal studies are needed to investigate whether the observed learning gains can be sustained over time and whether continued use of Duolingo contributes to long-term vocabulary retention and broader language development. Third, this study focused primarily on Chinese vocabulary achievement and students' motivation to learn. Other aspects of Chinese language learning, such as listening, speaking, reading, writing, and pragmatic competence, were not examined. Future research could investigate the effects of Duolingo-assisted learning on a broader range of language skills and learning outcomes. Fourth, participants' prior experience with digital devices, mobile learning applications, and Duolingo was not systematically measured. In addition, the control group received traditional instruction rather than another form of technology-enhanced instruction. Therefore, the observed differences between the two groups should be interpreted as effects of the Duolingo-assisted instructional condition as a whole, rather than as evidence that the outcomes were caused exclusively by Duolingo-specific features. Future studies could assess learners' prior digital learning experience and include an active, technology-enhanced control group to more clearly distinguish Duolingo's effects from those of technology-supported learning more generally.

Based on these limitations, several recommendations can be made. Future studies are encouraged to adopt longitudinal research designs, include larger and more diverse samples, and combine quantitative and qualitative methods to gain a more comprehensive understanding of learners' experiences with mobile-assisted language learning. In addition, future research may explore how Duolingo can be more effectively integrated into classroom instruction and combined with teacher-guided learning activities to support different learning objectives.

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