

Effects of AI DeepSeek-Assisted Games on Chinese Vocabulary Learning Achievement and Post-Use Motivation among Lower Secondary Students

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Abstract

Chinese vocabulary learning can be challenging for beginning learners because it requires them to connect Pinyin pronunciation, vocabulary meaning, Chinese character forms, and vocabulary use in context. This study examined the effects of AI DeepSeek-assisted games on Chinese vocabulary learning achievement and post-use motivation among Thai lower secondary students. A quasi-experimental pre-test-post-test design with a nonequivalent control group was employed. The participants were 47 Mathayom 1 students in Chiang Mai Province, Thailand, comprising 20 students in the experimental group and 27 students in the control group. The experimental group used four HTML-based Chinese vocabulary games, whereas the control group participated in conventional learning activities. Both groups completed four 60-minute instructional sessions. Data were collected using a Chinese Vocabulary Achievement Test and a Post-Use Motivation Questionnaire and analyzed using descriptive statistics, paired-samples t-tests, and independent-samples t-tests. The experimental group demonstrated a significant improvement from pre-test to post-test and achieved significantly higher post-test scores than the control group. The control group also showed significant improvement after instruction. Following the intervention, the experimental group reported the highest levels of interest and enjoyment and of motivation and intention to continue learning. These findings suggest that AI DeepSeek-assisted games can be used as supplementary activities for Chinese vocabulary practice and review alongside regular classroom instruction.

Keywords: Chinese Vocabulary; Digital Game-Based Learning; Learning Achievement; Learning Motivation; Lower Secondary Students

■ Introduction

Vocabulary knowledge is a fundamental component of language learning because it supports learners' ability to understand and use language across different communicative contexts. Previous research has shown that vocabulary knowledge is closely associated with second-language reading and listening

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comprehension (Zhang & Zhang, 2022). In the context of Chinese as a second or foreign language, vocabulary learning involves more than memorizing word meanings. Learners need to establish connections among Pinyin pronunciation, vocabulary meaning, Chinese character forms, and vocabulary use in context. The characteristics of the Chinese writing system make these connections particularly important because learners must process orthographic, phonological, and semantic information simultaneously. Research on Chinese vocabulary learning has therefore emphasized the importance of connecting character forms, pronunciation, and meaning rather than learning these components in isolation (He & Loewen, 2024; Zhang & Xing, 2023). These characteristics can make vocabulary learning particularly demanding for beginning learners whose first language differs substantially from Chinese.

Although vocabulary is essential for Chinese language development, conventional vocabulary instruction and review may have certain limitations. Activities that rely mainly on memorization, copying Chinese characters, and repetitive written exercises may support initial recall; however, they may provide limited opportunities for learners to interact with vocabulary through varied forms of practice and contextual use. When vocabulary practice is highly repetitive and provides relatively few opportunities for active participation, learners may also lose interest in the learning process. This issue is particularly relevant to Chinese vocabulary learning because learners need repeated opportunities not only to remember lexical items but also to connect Pinyin pronunciation, vocabulary meaning, Chinese character forms, and vocabulary use in context.

Digital game-based learning (DGBL) offers an alternative approach to organizing vocabulary practice by integrating learning content with interactive game activities. Game-based learning environments can incorporate goals, rules, challenges, scores, progress indicators, and immediate feedback, thereby encouraging learners to participate actively in learning tasks. In vocabulary learning, game activities can require learners to retrieve, select, match, classify, or apply lexical knowledge rather than simply receive information. Previous research has generally supported the potential of digital game-based vocabulary learning. Chen et al. (2018) reported positive effects of digital game-based approaches on vocabulary learning, while Vnucko and Klimova (2023) found that most studies included in their systematic review reported favorable vocabulary-learning outcomes. Research on digital game-based second-language learning among school-age learners has also highlighted the importance of appropriately designed challenges, goal orientation, interaction, rewards, and feedback (Acquah & Katz, 2020). In addition, retrieval practice accompanied by corrective feedback has been shown to support vocabulary learning, suggesting that opportunities to retrieve knowledge and receive information about errors may contribute to effective vocabulary practice (Li et al., 2024).

Digital games may also create learning experiences associated with learners' motivation. Features such as goals, challenges, scores, feedback, and visible progress may contribute to learners' interest, enjoyment, and willingness to continue participating in learning activities. However, the relationship between digital technology, game-based learning, and motivation should be interpreted cautiously. Technology does not automatically increase language-learning motivation; rather, motivational experiences depend on the characteristics of the activity, learners' experiences, and the context in which the technology is used (Bahari, 2023). Likewise, different game elements may be associated with motivation in different ways instead of producing the same motivational effect for all learners (Krath et al., 2021; Leitão et al., 2022). Therefore, post-use motivation should be considered separately from learners' perceptions of the usefulness or appropriateness of the digital learning tool.

Despite growing interest in digital game-based language learning, further evidence is needed regarding its application to Chinese vocabulary learning in Thai lower secondary school contexts, particularly

studies that examine both vocabulary achievement and learners' motivation after game use. At the same time, recent developments in generative artificial intelligence (GenAI) have created new possibilities for teachers and researchers to develop interactive digital learning materials with less reliance on advanced programming skills. Recent research has highlighted the growing role of GenAI in language teaching and learning. Law (2024) reported that GenAI has been applied across a range of language-learning and teaching contexts, while Moorhouse (2024) identified its potential to support teachers in developing instructional materials, exercises, and assessments. Research on AI-assisted material development further suggests that GenAI can support the creation and adaptation of learning resources, but teachers remain responsible for evaluating, revising, and making final decisions about AI-generated outputs before classroom use (Xin, 2024). These findings suggest that GenAI may function as a development-support tool for language teachers rather than as a substitute for pedagogical decision-making. In the present study, AI DeepSeek was used as a support tool in the design and development of an HTML-based Chinese vocabulary learning game set. The resulting intervention consisted of four AI DeepSeek-assisted games: the Pinyin–Word Matching Game, the Word–Picture Matching Game, the Chinese Character Construction Game, and the Sentence–Arranging Game. These games provided practice across different aspects of vocabulary knowledge and incorporated game features such as scores, timing, challenges, feedback, and review of incorrect responses. Importantly, AI DeepSeek supported the development of the games, while the learning intervention experienced by the students consisted of the resulting games rather than direct interaction with DeepSeek.

Based on the background and previous studies discussed above, this study investigated the effects of AI DeepSeek-assisted games on Chinese vocabulary learning achievement and the experimental group's motivation after using the games. Specifically, the study examined changes in the experimental group's achievement from pre-test to post-test, compared post-test achievement between the experimental and control groups, and examined the level of post-use motivation among students in the experimental group. The study therefore sought to provide empirical evidence regarding the use of digital games as supplementary activities for Chinese vocabulary practice in a Thai lower secondary school context.

■ Research Questions

RQ1: Is there a significant difference between the experimental group's pre-test and post-test achievement scores?

RQ2: Is there a significant difference in post-test achievement between the experimental and control groups?

RQ3: What is the level of the experimental group's motivation after using the games?

■ Research Objectives

1) To examine the experimental group's Chinese vocabulary learning achievement before and after using the AI DeepSeek-assisted games.

2) To compare the post-test achievement scores of the experimental and control groups.

3) To examine the experimental group's motivation for learning Chinese vocabulary after using the games.

■ Literature Review

This section reviews previous studies and relevant concepts related to Chinese vocabulary learning, digital game-based learning and vocabulary achievement, language learning motivation, and the research framework of the present study.

Chinese Vocabulary Learning

Chinese vocabulary knowledge involves multiple dimensions rather than word meaning alone. Nation (2013) described vocabulary knowledge in terms of form, meaning, and use. In Chinese as a second language, learners need to connect Pinyin pronunciation, vocabulary meaning, Chinese character forms, and vocabulary use in context. He and Loewen (2024) emphasized the importance of integrating character forms, Pinyin, and meaning, while Zhang and Xing (2023) showed that Chinese character production involves interaction among orthographic, phonological, and semantic information. Therefore, Chinese vocabulary learning requires learners to build connections across these dimensions rather than memorizing them separately.

For beginning learners, these dimensions may place different but related demands on vocabulary learning. Pinyin provides information about pronunciation, whereas Chinese characters represent written forms that learners must recognize and distinguish. At the same time, learners need to associate these forms with appropriate meanings and understand how words are used in sentences and communicative contexts. Developing vocabulary knowledge therefore involves not only remembering individual word meanings but also establishing links among sound, written form, meaning, and use. These links are particularly relevant in Chinese because the relationship between pronunciation and orthographic form is less transparent than in alphabetic writing systems.

This multidimensional view of vocabulary knowledge also has implications for vocabulary instruction. Activities that focus primarily on one aspect, such as repeatedly copying characters or memorizing translations, may provide useful practice but may not fully address the different types of knowledge required for successful vocabulary use. Learners may benefit from opportunities to encounter and retrieve the same vocabulary through different representations, including Pinyin, Chinese characters, pictures, meanings, and sentence contexts. In the present study, these dimensions provided the basis for organizing the vocabulary learning activities and for designing game tasks that required learners to process vocabulary in several forms.

Digital Game-Based Learning and Vocabulary Achievement

Digital game-based learning can support vocabulary achievement by providing repeated practice, retrieval practice, and immediate feedback. Rather than only reviewing vocabulary passively, learners can respond to tasks that require them to recall, match, or apply lexical knowledge. Previous studies have reported positive effects of digital game-based approaches on vocabulary learning, while retrieval practice combined with corrective feedback has also been shown to benefit vocabulary acquisition (Chen et al., 2018; Li et al., 2024; Vnucko & Klimova, 2023).

One important characteristic of digital game-based vocabulary learning is that practice can be organized as a sequence of active responses rather than as simple exposure to vocabulary. Learners may be required to select an answer, match two representations, reconstruct a form, or arrange language elements correctly. Such activities create repeated opportunities for retrieval, while immediate feedback informs learners whether their responses are correct and

allows them to adjust subsequent attempts. Chen et al. (2018) suggested that the effectiveness of digital game-based vocabulary learning depends not merely on the presence of a game but also on how learning content and game features are integrated. Similarly, the systematic review by Vnucko and Klimova (2023) showed generally favorable outcomes for digital game-based vocabulary learning, although the design and learning context varied across studies.

Game activities can also present vocabulary through multiple forms, such as Pinyin, Chinese characters, pictures, and sentence contexts. This multimodal representation may help learners build connections among pronunciation, written forms, and meaning while receiving immediate information about whether their responses are correct.

For Chinese vocabulary learning, this flexibility is particularly useful because different game activities can target different aspects of lexical knowledge. Pinyin–word matching can draw attention to connections between pronunciation and written forms; picture-based matching can strengthen links between words and meanings; character-construction activities can direct attention to Chinese character forms and components; and sentence-arranging activities can provide practice in using vocabulary within a meaningful linguistic context. In this way, different game formats can serve different instructional purposes while remaining part of the same vocabulary-learning process.

Digital game-based learning may therefore be especially suitable as a supplementary form of vocabulary practice rather than as a replacement for classroom instruction. Acquah and Katz (2020), in their review of digital game-based second-language learning among school-age learners, highlighted the roles of appropriately designed challenges, goal orientation, interaction, rewards, and feedback. When these features are aligned with specific learning objectives, games can provide learners with additional opportunities to practice knowledge that has already been introduced through regular instruction.

Digital Games and Language Learning Motivation

Digital games can support language learning motivation by providing goals, challenges, scores, progress indicators, and immediate feedback. These features may contribute to learners' interest, enjoyment, and willingness to continue learning. However, technology does not automatically increase motivation, as its effects depend on activity design, learner experience, and the learning context (Bahari, 2023). Different game elements may also relate to motivation in different ways (Krath et al., 2021; Leitão et al., 2022). Therefore, post-use motivation should be considered separately from learners' perceptions of the usefulness or appropriateness of the games.

Motivational responses to digital games may arise from several characteristics of the learning experience. Clear goals can help learners understand what they are expected to accomplish, challenges can provide a sense of progression, and scores or progress indicators can make performance visible. Immediate feedback may also encourage learners to remain engaged by allowing them to recognize successful responses and correct errors during the activity. From this perspective, motivation is related not simply to the use of digital technology but to the way the learning task is structured and experienced by learners.

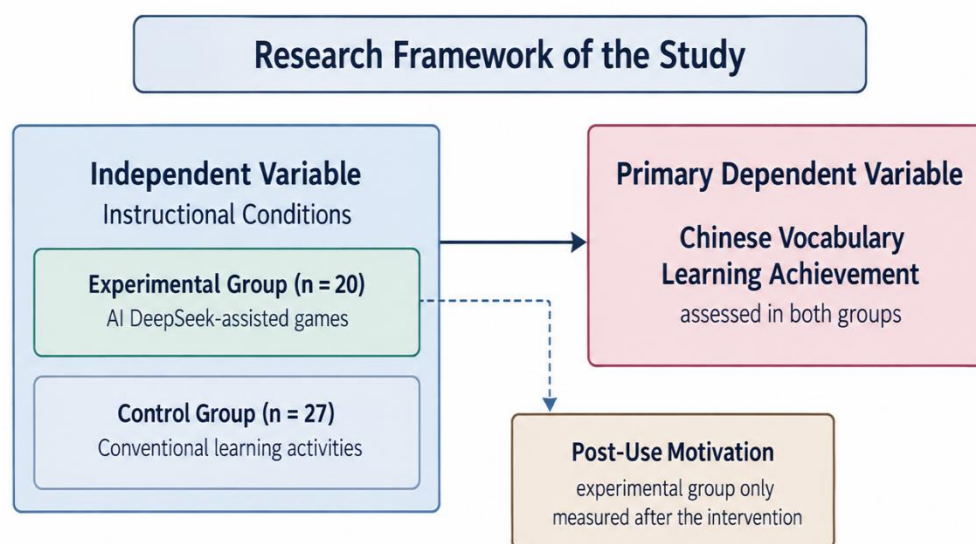
At the same time, positive reactions to a game should not automatically be interpreted as evidence that motivation has increased. A learner may consider a game useful, easy to use, or appropriate for learning without necessarily showing a measurable change in learning motivation. This distinction is particularly important when motivation is measured only after an intervention. Accordingly, the present study examined learners' interest and enjoyment and their motivation and intention to continue learning as post-use

motivational responses, while perceived usefulness and appropriateness were treated as a related but conceptually distinct dimension of the questionnaire.

Existing research provides support for the potential of digital games in language and vocabulary learning, but the available evidence spans different languages, learner populations, educational levels, and game designs. More specific evidence is therefore needed concerning Chinese vocabulary learning among lower secondary students in Thai educational contexts. In addition, generative AI creates new possibilities for developing customized digital learning materials. In the present study, DeepSeek was not used by students as a direct language-learning system; instead, it functioned as a support tool for the researcher in designing and developing HTML-based vocabulary games. This distinction allows the study to examine the learning outcomes associated with the resulting game-based activities while also illustrating one way in which generative AI can support the development of teacher-designed digital learning materials.

Research Framework

The research framework focused on the relationship between the instructional conditions and the study outcomes. The independent variable was the type of vocabulary learning activity, consisting of AI DeepSeek-assisted games for the experimental group and conventional learning activities for the control group. The primary dependent variable was Chinese vocabulary learning achievement. In addition, the experimental group's post-use motivation was examined after the intervention to evaluate learners' motivational responses to the games. The research framework of the study is presented in Figure 1.



Compensatory game access provided to the control group after data collection was not included in the analytical framework.

Figure 1. Research Framework of the Study

Figure 1 illustrates the relationship between the instructional conditions and the study outcomes. Chinese vocabulary learning achievement was examined in both groups, whereas post-use motivation was examined only in the experimental group after the intervention.

■ Methods

Research Design

This study employed a quasi-experimental pre-test–post-test design with a nonequivalent control group. Two intact classrooms were used because the students had already been assigned to their classes by the school and could not be randomly assigned. The independent variable was the type of vocabulary learning activity: AI DeepSeek-assisted games for the experimental group and conventional learning activities for the control group. The dependent variable was Chinese vocabulary learning achievement. The experimental group’s post-use motivation was also examined after the intervention.

Participants

The participants were 47 Mathayom 1 students studying basic Chinese at San Sai Witthayakhom School, Chiang Mai Province, Thailand. They were selected through purposive sampling from two intact classrooms with similar instructional contexts in terms of textbook, content level, and teacher. The experimental group consisted of 20 students, while the control group consisted of 27 students. Because the classes had been formed by the school before the study, the students were not randomly assigned to the experimental and control groups.

Intervention

The instructional content was based on Lessons 2 and 3 of *Way to Go Chinese 1*. The experimental group practiced and reviewed vocabulary through four AI DeepSeek-assisted HTML games: the Pinyin–Word Matching Game, the Word–Picture Matching Game, the Chinese Character Construction Game, and the Sentence–Arranging Game. The control group received conventional vocabulary practice through PowerPoint and classroom activities. Both groups were taught by the same teacher and followed the same target content and learning objectives across four 60-minute classroom sessions. The four classroom sessions included instruction and pre- and post-testing. After the post-test, the experimental group completed the motivation questionnaire. After all study data had been collected, the control group was offered compensatory access to the games; no data from this activity were included in the analysis.

The four games were designed as a progressive sequence to provide practice across different dimensions of Chinese vocabulary knowledge, moving from foundational vocabulary processing toward increasingly contextualized vocabulary use. Specifically, the sequence progressed from establishing connections between Pinyin pronunciation and written word forms, to understanding vocabulary meaning, recognizing Chinese character forms and structures, and finally applying vocabulary in sentence contexts. The Pinyin–Word Matching Game focused on connections between pronunciation and written forms. The Word–Picture Matching Game, which included both word–picture and sentence–picture matching tasks, emphasized vocabulary meaning and comprehension. The Chinese Character Construction Game required learners to combine character components to form target Chinese characters, thereby directing attention to character structure and supporting the recognition and retention of Chinese character forms. The Sentence–Arranging Game required learners to organize words into appropriate sentence sequences and provided practice in vocabulary use within context.

The games incorporated several interactive features, including scores, time-related elements, task challenges, immediate feedback, and opportunities to review incorrect responses. DeepSeek was used

during the design and development process to assist the researcher in organizing game requirements and generating initial HTML code. The researcher subsequently tested the generated games, examined their content and functionality, and revised elements such as screen layout, Chinese character size, visual presentation, and interaction functions when necessary. Thus, DeepSeek functioned as a development-support tool, while the final instructional decisions and suitability of the learning materials remained under the researcher's control.

In the Pinyin–Word Matching Game, students clicked a Pinyin card and the corresponding Chinese word card. Correct matches triggered audio and green visual feedback, whereas incorrect matches triggered an alert sound and red visual feedback. During gameplay, the left panel displayed elapsed time, the current score, and successfully matched items.

In the Word–Picture Matching Game, students selected the Chinese word or sentence that corresponded to a displayed picture. The game included both word–picture and sentence–picture matching tasks, allowing learners to progress from identifying vocabulary meaning at the word level to understanding vocabulary in sentence contexts. During play, the interface displayed elapsed time, score, accuracy, and task progress. The game could be used in either individual or two-player mode.

In the Chinese Character Construction Game, students used the displayed Pinyin as a cue and selected character components to construct the target Chinese character. Learners could make repeated attempts and request a hint when necessary. For the first three incorrect attempts, the system prompted learners to try again without displaying the correct answer; after a fourth incorrect attempt, a hint was automatically provided. Scores decreased according to the number of incorrect attempts and whether a hint was used. The interface also displayed task progress, correct and incorrect response counts, and successfully constructed characters.

The Sentence–Arranging Game consisted of four progressively sequenced activities: a sentence-reading warm-up, word selection for sentence blanks, simple sentence arrangement, and a more difficult sentence-arranging task containing distractors. The sequence moved learners from reading and reviewing complete sentences to retrieving appropriate vocabulary and then to arranging words into grammatically correct sentences with increasing task difficulty.

Representative screenshots of the four AI DeepSeek-assisted games are presented in Figure 2. The screenshots show the main gameplay interfaces and representative interaction features, including task presentation, scoring or timing information, progress indicators, hints, and task-control functions.

Before students used the games to practice newly introduced vocabulary, the teacher presented Chinese characters and Pinyin, explained meanings in Thai, and provided short example sentences. Students practiced pronunciation, and the teacher modeled correct pronunciation and corrected errors. For selected characters, visual materials and questions were used to draw attention to character components and their relationships with meaning. Relevant dialogues and grammatical structures were also explained before students practiced vocabulary at the sentence level.

Before each game was used, the teacher introduced its learning purpose and main game mechanics, explained the rules and functions of the main interface buttons, and demonstrated how students should operate the game and complete the learning tasks. In the experimental group, the HTML games were displayed using a computer and projector and incorporated into whole-class activities. The teacher organized participation by inviting students to take turns completing one item at a time, giving priority to students who had not yet participated. After the initial round, volunteers attempted additional challenges involving a complete set of vocabulary items or several consecutive tasks. The teacher monitored students'

responses and managed the progression of the activities, while the games provided immediate feedback through their programmed response mechanisms.

(a) Pinyin–Word Matching Game



(b) Word–Picture Matching Game



(c) Chinese Character Construction Game



(d) Sentence–Arranging Game



Figure 2. Representative Screenshots of the Four AI DeepSeek-Assisted Games

All four games included a post-activity “Knowledge Review” page. Depending on the game and mode, the review pages displayed elapsed time, scores, accuracy, error counts, and records of correct and incorrect responses. Correct and incorrect responses were distinguished using color-coded text, visual markers, or correctness symbols. After each activity, the teacher used the review pages to guide whole-class review, revisit incorrect responses, and clarify misunderstandings. The review connected the displayed response records with the relevant pronunciation, vocabulary meanings, character components, or sentence structures. Students were encouraged to ask questions, and the teacher provided further explanations as needed.

A representative Knowledge Review page from the Pinyin–Word Matching Game is shown in Figure 3. The page summarizes elapsed time, score, accuracy, and item-level response records, with correct and incorrect matches visually distinguished. It also provides options to replay the activity, practice incorrectly answered items, or return to the home page, thereby supporting targeted post-activity review.

The control group also received teacher explanations, pronunciation correction, and interactive vocabulary practice. Activities included PowerPoint-based vocabulary tables, Pinyin–word matching, flashcards, picture matching, character-related drawing activities, and sentence arrangement. Small material rewards, such as pencils, pens, or erasers, were used in both groups to acknowledge participation or successful task completion. Thus, teacher guidance, classroom interaction, and material rewards formed part of the instructional context in both conditions.

Research Instruments

The Chinese Vocabulary Achievement Test was developed by the researcher and consisted of 25 items with a total score of 100 points. The pre-test and post-test had equivalent structures, content coverage, and levels of difficulty, although some questions, options, and pictures were modified in the post-test to reduce the testing effect. The content validity of the test was evaluated by three experts using the Index of Item–Objective Congruence (IOC). The IOC values ranged from .67 to 1.00, indicating acceptable alignment between the test items and the learning objectives.



Figure 3. Representative Knowledge Review Page of the Pinyin–Word Matching Game

The achievement test included both listening and reading components. The listening section consisted of 10 items and included tasks requiring students to identify vocabulary from audio input and relate spoken vocabulary to visual information. The reading section consisted of 15 items and included sentence–picture matching, Chinese character construction from components, and word-arranging tasks. Each item was worth four points, resulting in a maximum score of 100 points. These task types were selected to assess different aspects of the target vocabulary, including pronunciation recognition, vocabulary meaning, Chinese character forms, and vocabulary use in context.

The pre-test and post-test followed the same overall structure so that achievement could be compared across the two testing occasions. However, selected item content, answer options, pictures, and ordering were adjusted in the post-test. These modifications were intended to reduce the possibility that students could answer the post-test primarily from memory of the pre-test while maintaining comparable content coverage and task requirements.

The Post-Use Motivation Questionnaire included 14 items using a five-point Likert scale. The Likert-scale items covered interest and enjoyment (3 items), motivation and intention to continue learning (5 items), and perceived usefulness and appropriateness of the games (6 items). The content validity of the questionnaire was evaluated by three experts using IOC, and all 14 Likert-scale items obtained an IOC value of 1.00. The questionnaire demonstrated high internal consistency, with a Cronbach's alpha coefficient of .965. Mean scores were interpreted as follows: 4.21–5.00 = highest, 3.41–4.20 = high, 2.61–3.40 = moderate, 1.81–2.60 = low, and 1.00–1.80 = lowest.

The questionnaire was administered to the experimental group after completion of the intervention. The three dimensions were used to distinguish students' affective responses to the learning activities from their perceptions of the learning tool. Interest and enjoyment reflected students' immediate positive

responses to participating in the game-based activities, while motivation and intention to continue learning focused on their willingness to continue engaging in Chinese vocabulary learning. Perceived usefulness and appropriateness reflected students' evaluations of the games as learning activities rather than being treated as a direct measure of motivation.

Experimental Procedure

Before the intervention, both groups completed the Chinese Vocabulary Achievement Pre-test. The experimental group then practiced Chinese vocabulary using four AI DeepSeek-assisted games, whereas the control group received conventional learning activities through PowerPoint presentations and classroom exercises. Both groups studied the same content with the same teacher and completed four 60-minute instructional sessions. After the intervention, both groups completed the achievement post-test. The experimental group subsequently completed the Post-Use Motivation Questionnaire. After all data had been collected, the control group was given an opportunity to experience the games; however, no data from this activity were included in the analysis. This procedure was aligned with the research framework presented in Figure 1: Chinese vocabulary learning achievement was examined using pre-test and post-test data from both groups, whereas post-use motivation was examined only in the experimental group after the intervention. The research procedure is presented in Figure 4.

Data Collection

Achievement data were collected from the pre- and post-tests administered to both groups. Post-use questionnaire data were collected from the experimental group after completion of the post-test. The completed tests and questionnaires were checked for completeness and organized before statistical analysis.

Data Analysis

Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarize the data. Independent-samples t-tests were used to compare achievement scores between the experimental and control groups, while paired-samples t-tests were used to compare pre-test and post-test scores within groups. Statistical significance was set at .05. Effect sizes were also calculated for the t-tests. Cohen's d was used for independent-samples comparisons, while Cohen's d_z was used for paired-samples comparisons. Questionnaire responses were analyzed using mean and standard deviation.

Ethical Considerations

Permission to conduct the study was obtained from the participating school. Before participation, the students and their parents or legal guardians were informed about the study objectives, procedures, duration, participant rights, and confidentiality. Written informed consent was obtained from the parents or legal guardians, and assent was obtained from the students. Participation was voluntary, and the students were informed that they could refuse to participate or withdraw from the study at any time without penalty. Questionnaire responses and other research data were kept confidential and used only for research purposes. The study was approved by the Chiang Mai University Research Ethics Committee (CMUREC) (Approval No. 212/68).

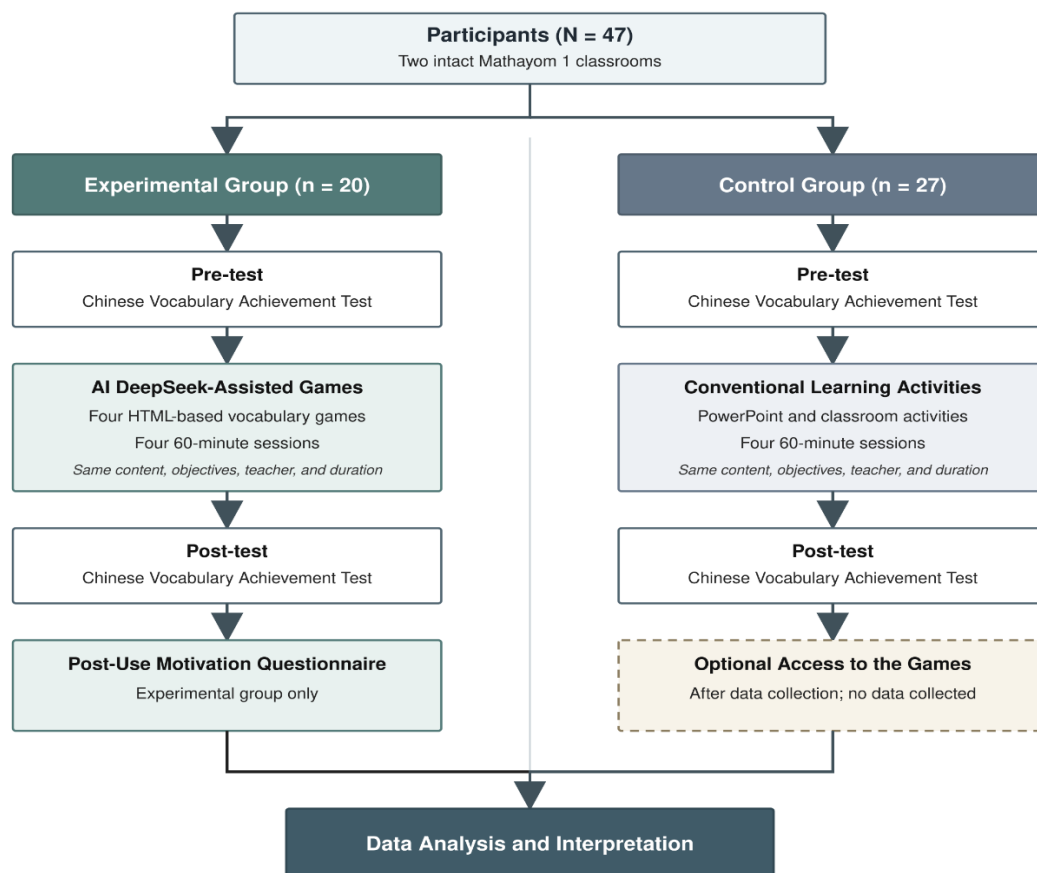


Figure 4. Research Procedure

Results and Discussion

The results are presented in accordance with the three research objectives. Objective 1 examined changes in the experimental group's Chinese vocabulary learning achievement from pre-test to post-test. Objective 2 compared post-test achievement between the experimental and control groups. Objective 3 examined the experimental group's post-use motivation after using the games. A baseline comparison between the two groups is presented first to provide context for the subsequent analyses.

Results of Baseline Comparison

Before the intervention, the experimental group had a mean pre-test score of 51.40 ($SD = 10.08$), while the control group had a mean score of 49.33 ($SD = 7.44$). An independent-samples t-test showed that there was no statistically significant difference between the two groups, $t = 0.810$, $p = .422$, Cohen's $d = 0.24$. This result indicates that the two groups had comparable levels of Chinese vocabulary knowledge before the intervention.

Table 1.

Comparison of Pre-test Scores between the Experimental and Control Groups

Group	n	Mean	SD	t	p	Cohen's d
Experimental Group	20	51.40	10.08	0.810	.422	0.24

Group	n	Mean	SD	t	p	Cohen's d
Control Group	27	49.33	7.44			

Results of Experimental Group's Pre-test and Post-test Achievement

The experimental group obtained a mean pre-test score of 51.40 ($SD = 10.08$) and a mean post-test score of 81.40 ($SD = 13.12$), representing an increase of 30.00 points. A paired-samples t-test showed a statistically significant difference between the pre-test and post-test scores, $t = 13.077$, $p < .001$, Cohen's $d_z = 2.92$. The result indicates that the experimental group achieved significantly higher Chinese vocabulary learning scores after the intervention.

Table 2.

Comparison of Pre-test and Post-test Scores of the Experimental Group

Test	n	Mean	SD	t	p	Cohen's d_z
Pre-test	20	51.40	10.08	13.077	< .001	2.92
Post-test	20	81.40	13.12			

Results of Post-test Achievement between Groups

After the intervention, the experimental group obtained a mean post-test score of 81.40 ($SD = 13.12$), whereas the control group obtained a mean score of 69.48 ($SD = 8.46$). The experimental group scored approximately 12 points higher than the control group. An independent-samples t-test showed that the difference between the two groups was statistically significant, $t = 3.782$, $p < .001$, Cohen's $d = 1.12$.

Table 3.

Comparison of Post-test Scores between the Experimental and Control Groups

Group	n	Mean	SD	t	p	Cohen's d
Experimental Group	20	81.40	13.12	3.782	< .001	1.12
Control Group	27	69.48	8.46			

For additional context, the control group also showed a statistically significant increase from a pre-test mean of 49.33 ($SD = 7.44$) to a post-test mean of 69.48 ($SD = 8.46$), $t = 12.557$, $p < .001$, Cohen's $d_z = 2.42$. Thus, both groups improved after the instructional activities, although the experimental group obtained a significantly higher post-test score than the control group.

Results of Post-Use Motivation

After using the games, the experimental group reported the highest level of interest and enjoyment ($M = 4.37$, $SD = 0.84$) and the highest level of motivation and intention to continue learning ($M = 4.29$, $SD = 0.81$). Perceived usefulness and appropriateness of the games was rated at a high level ($M = 4.20$, $SD = 0.76$). The overall post-use questionnaire evaluation was at the highest level ($M = 4.27$, $SD = 0.76$).

Table 4.

Results of the Post-Use Questionnaire for the Experimental Group

Dimension	Mean	SD	Interpretation
Interest and enjoyment	4.37	0.84	Highest

Dimension	Mean	SD	Interpretation
Motivation and intention to continue learning	4.29	0.81	Highest
Perceived usefulness and appropriateness	4.20	0.76	High
Overall questionnaire evaluation	4.27	0.76	Highest

■ Discussion

Vocabulary Learning Achievement

The findings showed that the experimental group achieved significantly higher post-test scores than their pre-test scores and also obtained significantly higher post-test scores than the control group. These results suggest that the use of the games was associated with improved vocabulary learning achievement in the context of this study. The four games provided practice across complementary dimensions of Chinese vocabulary knowledge. Specifically, the Pinyin–Word Matching Game targeted connections between pronunciation and written forms; the Word–Picture Matching Game emphasized semantic processing through word–picture and sentence–picture matching; the Chinese Character Construction Game focused on Chinese character forms and component structure; and the Sentence–Arranging Game provided practice in applying vocabulary within sentence contexts.

One possible explanation for the improvement is that the games provided learners with repeated opportunities to retrieve vocabulary knowledge and receive immediate feedback on their responses. Rather than reviewing vocabulary only through passive repetition, students were required to recall, match, construct, and apply lexical knowledge during the activities. This interpretation is consistent with Li et al. (2024), who reported that retrieval practice combined with corrective feedback can benefit vocabulary learning. It is also consistent with Chen et al. (2018), who emphasized that the effectiveness of digital game-based vocabulary learning is related to how learning activities and game features are designed rather than simply to the use of games themselves.

The use of multiple representations may also have supported vocabulary learning. The activities connected Pinyin, Chinese characters, pictures, meanings, and sentence contexts, allowing students to encounter vocabulary through several forms of practice. This is relevant to Chinese vocabulary learning because learners need to establish connections among pronunciation, written forms, and meaning. Previous research has likewise emphasized the importance of integrating these aspects in learning Chinese vocabulary (He & Loewen, 2024). More broadly, the present findings are consistent with previous research reporting generally positive outcomes of digital game-based vocabulary learning (Chen et al., 2018; Vnucko & Klimova, 2023).

The interpretation of the achievement findings should also consider the relationship between the intervention activities and the achievement assessment. Both the pre-test and post-test were designed to assess the same target vocabulary knowledge and were comparable in structure, content coverage, and level of difficulty, while the specific questions, response options, pictures, and other test materials differed between the two administrations. The intervention and assessment overlapped in several underlying dimensions of vocabulary knowledge, including pronunciation–orthography connections, semantic knowledge, character-form knowledge, and vocabulary

use in context. However, the assessment did not directly reproduce the game activities. For example, listening tasks required learners to identify written vocabulary from recorded input or determine whether recorded vocabulary corresponded to visual information, whereas the games used different forms of matching and interaction. Similarly, although character-form knowledge and sentence-level vocabulary use were practiced in the games and assessed in the tests, the assessment tasks did not include the distractors, timing, scoring, immediate feedback, or repeated-attempt mechanisms used during gameplay. Some visual and contextual representations in the assessment also differed from those encountered in the games. Thus, the intervention and assessment shared relevant vocabulary knowledge and processing demands, while successful assessment performance required learners to apply this knowledge under different task conditions and representations. Therefore, the higher post-test performance provides evidence of improvement in the dimensions of vocabulary knowledge assessed in this study, while further research is needed to determine the extent to which these gains transfer to broader aspects of Chinese vocabulary ability.

However, the control group also demonstrated a significant increase from pre-test to post-test. This finding indicates that the conventional learning activities used in the study also supported Chinese vocabulary learning. Therefore, the results should not be interpreted as showing that game-based learning replaces or makes conventional instruction ineffective. Rather, within the conditions of this study, the AI DeepSeek-assisted games appeared to provide an additional form of vocabulary practice, and the experimental group achieved significantly higher post-test performance than the control group. In addition, because the study did not separately examine individual game elements such as feedback, challenge, scores, or timing, it cannot determine which specific feature was primarily responsible for the observed achievement outcomes.

Post-Use Motivation

The findings showed that the experimental group reported a high level of post-use motivation after learning with the AI DeepSeek-assisted games. Interest and enjoyment received the highest mean score ($M = 4.37$, $SD = 0.84$), followed by motivation and intention to continue learning ($M = 4.29$, $SD = 0.81$), both of which were rated at the highest level. These results suggest that the students generally experienced the game-based vocabulary activities as interesting and enjoyable and expressed a strong willingness to continue learning Chinese vocabulary after using the games.

The motivational responses may be related to specific mechanisms built into the games. Visible scores, timing, and progress indicators made performance and task progression salient, while immediate feedback informed learners whether their responses were correct. Repeated attempts, hints, and post-activity review of incorrect responses provided opportunities to correct errors and continue engaging with the tasks. In addition, matching, character-construction, and sentence-arranging challenges required active participation rather than passive review. These features may help explain why interest and enjoyment, as well as motivation and intention to continue learning, received high post-use ratings. Previous research has suggested that motivation in game-based learning is associated not simply with the presence of games but with the characteristics of the activities and the experiences provided to learners (Krath et al., 2021). Likewise, different game elements may relate to learner motivation in different ways (Leitão et al., 2022). Therefore, the positive post-use responses observed in this study should be understood as learners' responses to the overall learning experience rather than as the effect of any single game element.

At the same time, the findings should be interpreted cautiously. The study measured motivation only after the experimental group had used the games and did not include a motivation pre-test or a

control-group motivation measure. Therefore, the results indicate the level of students' post-use motivation, but they do not demonstrate that the games increased motivation. This interpretation is consistent with Bahari (2023), who noted that technology may provide opportunities to support language-learning motivation but does not automatically increase it; outcomes also depend on activity design, learner experience, and the learning context.

In addition, perceived usefulness and appropriateness of the games was rated at a high level ($M = 4.20$, $SD = 0.76$). This dimension provides complementary information about students' perceptions of the learning tool but should not be interpreted as a direct measure of motivation. Accordingly, the overall questionnaire score of $M = 4.27$ represents the overall post-use questionnaire evaluation, rather than an overall motivation score.

The pattern across the three questionnaire dimensions also provides a more differentiated view of students' responses to the games. Interest and enjoyment received the highest mean score, suggesting that the game-based activities were generally experienced positively during use. Motivation and intention to continue learning also received a very high rating, indicating that students expressed a strong willingness to continue engaging with Chinese vocabulary after the intervention. In contrast, perceived usefulness and appropriateness received a slightly lower, although still high, rating. This difference suggests that students' affective engagement with the activities was particularly strong, while their evaluation of the games as learning tools was somewhat more moderate. Such a pattern supports the importance of examining motivational and evaluative responses separately rather than combining them into a single construct.

Educational Implications

The findings of this study suggest that AI DeepSeek-assisted Chinese vocabulary learning games can be used as supplementary activities for vocabulary practice and review in lower secondary Chinese language classrooms. Because both the experimental and control groups showed significant improvement, the games should not be viewed as a replacement for teacher-led or conventional instruction. Instead, they may be integrated with existing classroom activities to provide learners with additional opportunities to practice and review vocabulary in interactive ways.

When integrating such games into instruction, teachers should select activities according to learners' proficiency levels and the objectives of the lesson. Different game types can be used to target different aspects of Chinese vocabulary knowledge. For example, Pinyin-word matching can support connections between pronunciation and written forms, picture-matching activities can support meaning, Chinese character construction can draw attention to character components and structure, and sentence-arranging activities can provide practice in vocabulary use in context. This approach allows game activities to be aligned with specific learning objectives rather than used only for entertainment.

The study also indicates that generative AI tools such as DeepSeek may support teachers in developing customized digital learning materials. However, the teacher or researcher remains responsible for determining the learning objectives, selecting appropriate content and activity types, and evaluating whether the generated materials are suitable for learners. In this study, DeepSeek functioned as a support tool in the design and development process rather than as a substitute for instructional decision-making.

■ Conclusion

This study examined the effects of AI DeepSeek-assisted games on Chinese vocabulary learning achievement and post-use motivation among lower secondary students. The findings showed that the experimental group achieved significantly higher post-test scores than their pre-test scores. In addition, the experimental group obtained significantly higher post-test scores than the control group. However, the control group also showed significant improvement from pre-test to post-test, indicating that both forms of learning activity supported vocabulary learning within the context of the study.

Regarding post-use motivation, the experimental group reported the highest levels of interest and enjoyment and of motivation and intention to continue learning after using the games. Perceived usefulness and appropriateness was rated at a high level. Because motivation was measured only after the intervention and only in the experimental group, these findings describe students' post-use motivational responses rather than demonstrating an increase in motivation.

Overall, the findings support the use of AI DeepSeek-assisted Chinese vocabulary learning games as supplementary activities for vocabulary practice and review alongside regular classroom instruction. The results should be interpreted within the specific context and limitations of the present study rather than as evidence that game-based activities can replace conventional teaching.

■ Limitations or Recommendations from the Research

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the participants were 47 Mathayom 1 students from a single school in Chiang Mai Province, with 20 students in the experimental group and 27 students in the control group. The study used intact classrooms, and the students were not randomly assigned to the experimental and control groups. Although no statistically significant difference was found between the groups on the pre-test, the single-school setting, unequal group sizes, and lack of random assignment should be considered when interpreting the findings.

Second, the intervention was conducted over a relatively short period, consisting of four 60-minute instructional sessions. No delayed post-test was administered; therefore, the study did not examine the long-term retention of Chinese vocabulary learning after the intervention.

Third, motivation was measured only after the experimental group had used the games. There was no pre-intervention motivation measure and no corresponding motivation data from the control group. In addition, the study examined the game set as a whole and did not separately investigate the effects of individual game elements. Therefore, the findings describe the experimental group's post-use motivation and the overall effects of the game-based activities rather than changes in motivation or the effects of specific game mechanisms.

Recommendations

Future studies should include larger and more diverse samples from multiple schools and, where possible, use research designs that provide greater control over group assignment. Extending the intervention period and including a delayed post-test would also help examine whether vocabulary learning outcomes are retained over time.

Future research on motivation should consider collecting data both before and after the intervention and from both experimental and control groups. In addition, individual game elements, such

as feedback, challenge, scores, and timing, could be examined separately to determine how particular design features relate to vocabulary achievement and learner motivation.

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