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Innovating Chinese Reading Instruction through a Multimodal, Culture-Integrated Digital Platform: An Experimental Study with Thai High School Learners

Shuran Zhangwen¹, Kittawaya Thongkoo^{2*} & Kannika Daungcharone²

Faculty of Multidisciplinary and Interdisciplinary School, Chiang Mai University, Thailand¹, College of Arts, Media and Technology, Chiang Mai University, Thailand^{2*}

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Abstract

Chinese reading continues to challenge many Thai high school learners, particularly when comprehension extends beyond isolated vocabulary and sentence-level understanding. Classroom instruction often centers on lexical explanation and translation—approaches that support surface decoding but provide limited scaffolding for discourse-level meaning construction. Against this backdrop, the present study examines whether a multimodal, culture-integrated digital reading platform offers measurable advantages over traditional paper-based instruction. A quasi-experimental pre-test–post-test design was conducted with two intact classes ($N = 50$) over five weeks. One group engaged with a digital platform integrating textual input, audio support, visual representation, and culturally contextualized tasks, while the comparison group received parallel instruction through printed materials. Reading development was assessed across vocabulary recognition, sentence comprehension, and main idea extraction. Although both groups improved significantly and showed no baseline differences at pre-test ($p = .423$), students using the digital platform demonstrated significantly higher overall learning gains than those receiving traditional paper-based instruction ($p = .005$, Cohen's $d = 0.865$). The most pronounced difference appeared in main idea extraction ($p = .006$, Cohen's $d = 0.836$), whereas vocabulary recognition and sentence comprehension gains did not differ significantly. These findings suggest that multimodal, culturally embedded digital scaffolding may most strongly support discourse-level processing rather than foundational decoding skills. By differentiating effects across reading sub-skills, the study offers context-specific empirical insight into how instructional design shapes second language reading development in Thai secondary education.

Keywords: Chinese reading, multimodal learning, cultural integration, quasi-experimental study, digital learning platform

*Corresponding author

Email address: kittawaya.t@cmu.ac.th

■ Introduction

In recent years, Chinese language education has gained increasing visibility in Thailand, including at the secondary-school level, alongside broader educational, economic, and cultural exchange between Thailand and China (Xiao & Tian, 2024). Prior research has noted that Chinese teaching and learning in Thai schools takes place within culturally specific contexts and continues to face practical challenges in classroom implementation (Duangmanee & Waluyo, 2024). Thai learners also face difficulty in developing Chinese vocabulary, partly because of mother-tongue influence, the structural complexity of Chinese, and the cultural specificity of lexical meaning (Wang, 2021). In reading, these challenges may extend beyond word recognition to sentence-level understanding and passage-level meaning construction, as reading development depends on the coordination of multiple cognitive and linguistic processes rather than on vocabulary knowledge alone (Luo et al., 2022; Sabatini & Bruce, 2009). Studies on Chinese teaching in Thailand further suggest that although cultural content is present in classrooms, its connection with language-skill development is not always systematic, which may limit learners' interpretation of texts that require relevant cultural background knowledge (Chao et al., 2024). In Thai school settings, Chinese reading instruction has often been reported as relying on basic, step-by-step reading techniques and teacher-guided processing, especially for learners with limited prior Chinese knowledge (Xiu, 2020). Although such practices may help learners gain initial access to texts, they may provide less support for deeper comprehension when students need to integrate meaning across sentences and identify the main idea of a passage (Luo et al., 2022).

With the rapid development of educational technology, multimodal instruction has increasingly entered language classrooms. Multimodal learning environments present information through multiple representational channels, including written text, visual imagery, and auditory input. According to the Cognitive Theory of Multimedia Learning, learners process information through dual channels with limited cognitive capacity, and instructional designs that appropriately coordinate visual and verbal input can enhance meaningful learning (Mayer, 2024). In reading instruction, integrating textual materials with images, audio support, and structured comprehension tasks may reduce cognitive load and facilitate the construction of coherent mental representations of a text. In parallel, second language acquisition research emphasizes the importance of comprehensible input and structured processing conditions. Graded reading materials regulate vocabulary load and syntactic complexity to align with learners' proficiency levels (Luo et al., 2022). Additionally, structured reading tasks—such as identifying key information and summarizing central ideas—have been shown to support reading development and comprehension monitoring (Chen, 2023). From a pedagogical perspective, culturally responsive teaching further suggests that integrating cultural background knowledge into instruction enhances learners' interpretative abilities and meaning-making processes (Pirbhai-Illich et al., 2017). In the context of Chinese reading, cultural scaffolding may be particularly important for main idea extraction, as understanding discourse-level meaning often requires activation of culturally embedded schemas.

Although prior studies have examined multimodal learning, graded reading, and cultural integration as separate strands of research, empirical investigations that systematically integrate these elements within Thai high school Chinese reading classrooms remain limited. Moreover, few studies have adopted a quasi-experimental design to compare measurable learning gains across different instructional formats while analyzing specific reading sub-skills. To address this gap, the present study compares multimodal digital platform instruction with traditional paper-based instruction using two intact classes. Students completed pre-test and post-test assessments measuring vocabulary recognition, sentence comprehension, and main idea extraction. Learning gains were calculated as the primary indicator of instructional effectiveness to examine whether digitally scaffolded, culturally integrated reading instruction produces differential effects across levels of reading processing. Against this background, the present study extends existing work by examining Chinese reading instruction in a Thai high school context through a classroom-based quasi-experimental design. It focuses on a digital intervention that combines multimodal support with culturally contextualized reading materials and evaluates not only overall reading gains but also development across three reading sub-skills: vocabulary recognition, sentence comprehension, and main idea extraction. In this way, the study seeks to provide a more fine-grained account of how digital platform instruction may support Chinese reading development in a context-specific classroom setting.

■ Research Questions

- 1) Do both the experimental group and the control group demonstrate improvement in overall Chinese reading performance after the instructional intervention?
- 2) Compared with traditional paper-based instruction, does multimodal, culture-integrated digital platform instruction lead to higher learning gains in overall Chinese reading performance?
- 3) Are there significant differences in learning gains between the experimental group and the control group in vocabulary recognition, sentence comprehension, and main idea extraction?

■ Research Objectives

- 1) To examine whether both the experimental group and the control group demonstrate improvement in overall Chinese reading performance after the instructional intervention.
- 2) To compare learning gains in overall Chinese reading performance between students who receive multimodal, culture-integrated digital platform instruction and those who receive traditional paper-based instruction.
- 3) To analyze whether significant differences exist in learning gains between the two groups in vocabulary recognition, sentence comprehension, and main idea extraction.

■ Literature Review

Multimodal Learning and Cognitive Theory of Multimedia Learning

Amid ongoing digital transformation, Chinese language instruction has progressively extended beyond conventional classroom settings into digitally mediated environments supported by online platforms and interactive resources. This shift, however, has not been uniformly accompanied by pedagogical gains. Xu (2025) cautions that technological integration, when implemented without explicit alignment to instructional objectives, risks functioning as an adjunct rather than a catalyst for learning improvement. Similarly, Liang (2020) notes that while online resources can broaden instructional possibilities in teaching Chinese as a foreign language, their educational value must ultimately be demonstrated through measurable learning outcomes rather than assumed through technological presence alone. Taken together, these perspectives suggest that digitalization, in itself, does not ensure instructional effectiveness; its impact is contingent upon the extent to which technological affordances are pedagogically structured and cognitively grounded.

The theoretical foundation most frequently invoked to explain multimodal learning environments is the Cognitive Theory of Multimedia Learning (CTML). Mayer (2005) conceptualizes learning as a dual-channel process in which visual and auditory information are processed through separate yet capacity-limited systems. Within this framework, effective multimedia design is not defined by the volume of information presented but by how successfully it supports learners in selecting, organizing, and integrating relevant content with prior knowledge. Mayer's later work (2024) further refines this position, emphasizing that multimedia environments facilitate learning only when design features actively promote conceptual understanding rather than merely increase sensory input. From this standpoint, multimodal elements assume an instructional function as cognitive scaffolds. When carefully orchestrated, they can reduce extraneous cognitive load, direct attention toward essential information, and support generative processing that contributes to deeper comprehension.

These principles are particularly salient in reading instruction. When written texts are accompanied by visual representations, audio narration, or lexical annotations, learners are afforded multiple entry points into meaning construction. Such supports may ease lexical access and sentence-level interpretation, especially for learners navigating unfamiliar linguistic structures. More importantly, when multimodal supports are embedded within guided comprehension activities—such as inferencing prompts or meaning-construction tasks—they may extend beyond local decoding to facilitate discourse-level processing. Under these conditions, multimodal platforms operate not merely as delivery technologies but as structured instructional environments informed by cognitive theory. Their pedagogical value, therefore, must be established through empirical examination of specific reading outcomes rather than inferred from learner perception or technological novelty.

Second Language Acquisition and Graded Reading

Research in second language acquisition has long underscored the central role of comprehensible input and sustained cognitive engagement in the development of reading ability. Ellis (1994) argues that language learning is shaped not only by exposure to linguistic forms but by the depth and continuity of learners' processing over time. Building on this view, Yule (2022) conceptualizes language comprehension as operating across multiple interpretative layers, ranging from lexical decoding to sentence parsing and discourse-level integration. Such a perspective invites reading comprehension to be understood not as a singular skill but as a constellation of interdependent processes that unfold hierarchically during meaning construction. Sabatini and Bruce (2009) similarly characterize reading as an assemblage of cognitive components that must function in coordination. Within the context of Chinese reading, this layered architecture is particularly salient. Vocabulary recognition provides the initial gateway to comprehension; when lexical access is incomplete, subsequent sentence-level interpretation is inevitably constrained. Sentence comprehension, in turn, depends on the reader's ability to integrate syntactic cues with semantic interpretation, while the extraction of main ideas requires readers to move beyond isolated sentences and establish coherence across the broader discourse. From this standpoint, instructional interventions may not influence all reading dimensions uniformly, as each sub-skill engages distinct cognitive demands and processing pathways.

Graded reading approaches have been widely adopted as a means of regulating textual complexity in alignment with learners' proficiency levels. By controlling lexical density and syntactic difficulty, graded materials create conditions under which readers can engage meaningfully with texts without becoming cognitively overwhelmed. Luo et al. (2022) note that such calibrated input environments can facilitate the development of Chinese literacy by enabling sustained interaction with language forms in context. Complementing this view, Maulani et al. (2025) emphasize the importance of constructive alignment among instructional objectives, learning materials, and assessment practices. When reading instruction is designed with this alignment in mind, both teaching activities and outcome measurements can more accurately reflect the cognitive processes targeted during learning. Consequently, evaluating instructional effectiveness requires attention not only to aggregate performance scores but also to differentiated sub-skill development. Guided by these theoretical considerations, the present study examines vocabulary recognition, sentence comprehension, and main idea extraction as analytically distinct yet interrelated dimensions of Chinese reading proficiency, with learning gains serving as indicators of developmental change across the intervention period.

Cultural Integration in L2 Reading Instruction

The interdependence between language learning and cultural context has long been recognized as central to meaningful language development. Kumaravadivelu (2008) argues that language education cannot be detached from the cultural systems within which linguistic forms acquire significance, as communication is inseparable from sociocultural meaning. Building on this perspective, Pirbhai-Illich et al. (2017) describe culturally responsive pedagogy as an approach that situates comprehension within

culturally mediated processes of interpretation and meaning-making. In reading, limited cultural background knowledge may constrain learners' ability to generate inferences, interpret implicit references, and construct coherent understandings of discourse. From a cognitive standpoint, cultural knowledge functions as a schema that supports interpretative processing, enabling readers to integrate textual information with prior experiential and sociocultural frames of reference.

Within the Thai context, the role of cultural content in Chinese language classrooms has drawn increasing scholarly attention. Xiao and Tian (2024) examine Chinese language education through the lens of Chinese–Thai cultural integration, highlighting the importance of cultural literacy in facilitating language acquisition. Duangmanee and Waluyo (2024) document instructional practices in culturally localized Thai schools, observing that cultural elements are increasingly embedded in classroom instruction. Chao et al. (2024) similarly note that although cultural themes are present, their integration with language skill development often remains unsystematic and insufficiently aligned with instructional design. Research focusing on Chinese traditional festival culture provides further pedagogical insight. Festival-related texts frequently present structured narrative sequences and culturally patterned social practices (Yue, 2011; Cui, 2020; Yu, 2018; Cun, 2016; Chen, S., 2023; Chen, M. J., 2023). Through depictions of rituals, food traditions, and family interactions, such texts offer context-rich discourse that may activate learners' prior knowledge structures and support inferential reasoning.

In the present study, three festival-related texts—*The Spring Festival*, *Mother's Day*, and *What to Eat in Spring Festival*—were incorporated into reading instruction. These materials were delivered through a multimodal digital platform that combined linguistic input with culturally contextualized scaffolding. By integrating textual content with visual and contextual supports, the instructional design was intended to facilitate both schema activation and discourse-level meaning construction. Such integration provided a pedagogical context in which cultural knowledge and multimodal processing could operate jointly, thereby supporting reading comprehension across multiple cognitive dimensions.

Gaps in Current Research

Existing scholarship has examined digital learning environments, multimedia-supported instruction, second language acquisition processes, and the role of cultural knowledge in language education. Collectively, these strands of research have contributed important theoretical and pedagogical insights; however, their intersections remain underexplored in the context of Chinese reading instruction in Thai high schools. While digital platforms have become increasingly visible in Chinese language classrooms (Xu, 2025; Liang, 2020), empirical investigations that move beyond descriptive implementation toward controlled instructional comparison remain limited. In particular, quasi-experimental evidence contrasting digitally mediated reading instruction with traditional paper-based approaches in Thai secondary education settings is still relatively scarce. As a result, claims regarding the instructional value of digital platforms often rest on assumed affordances rather than systematically measured learning outcomes.

A related limitation concerns the level at which reading achievement has been examined. Some studies addressing Chinese language teaching in Thailand foreground classroom practices or the incorporation of cultural content (Duangmanee & Waluyo, 2024; Chao et al., 2024), yet fewer investigations have engaged with measurable indicators of reading development. Where learning outcomes are reported, they are frequently presented in aggregated form, offering limited insight into how specific cognitive dimensions of reading respond to instructional intervention. Such an approach constrains interpretative precision, as vocabulary recognition, sentence comprehension, and discourse-level meaning construction involve distinct processing demands and may not develop uniformly under different instructional conditions.

Against this backdrop, the present study positions digital reading instruction not as a technological substitution but as an integrated pedagogical system. By bringing together multimodal design principles, second language acquisition theory, graded input conditions, and culturally responsive pedagogy within a quasi-experimental framework, the study seeks to examine learning gains across differentiated reading sub-skills. Through this design, it aims to generate empirically grounded evidence on how a multimodal, culture-integrated digital platform may influence Chinese reading development among Thai high school learners, thereby addressing a gap at the intersection of instructional format, cognitive processing, and contextualized language education.

■ Methodology

Participants

The study was conducted in a Thai secondary school where Chinese is offered as part of the foreign language curriculum. Two intact classes were recruited, yielding a total sample of 50 students. One class served as the experimental group ($n = 23$), and the other functioned as the control group ($n = 27$). All participants were high school learners enrolled in Chinese language study at the time of data collection. Because the classes had been administratively formed prior to the study, group assignment followed existing classroom structures rather than random allocation. Participants were recruited through convenience sampling from existing classroom cohorts within the school. This configuration reflects authentic instructional conditions while allowing controlled comparison between instructional formats. A pre-test administered prior to the intervention indicated no significant difference in overall reading performance between the two groups ($p = .423$), supporting baseline equivalence.

Ethical approval for this study was granted by the Chiang Mai University Research Ethics Committee (CMUREC) (Approval No.68/367). Participation was voluntary, informed consent was obtained from both students and their guardians prior to data collection, and all data were anonymized to ensure participant confidentiality.

Research Design

The investigation adopted a quasi-experimental pre-test–post-test design to examine the instructional effects of digital platform instruction under classroom conditions. Instructional differentiation was introduced through the instructional medium. Students in the experimental group received Chinese reading instruction through the MandarinBean digital platform, while the control group received parallel traditional paper-based instruction.

To ensure a fair comparison between the two groups, the key instructional conditions were kept the same. Both groups were taught by the same teacher, studied the same reading texts, followed the same teaching time and lesson schedule, and completed the same pre-test and post-test measures. The intervention lasted for five weeks, with the pre-test administered before the instructional phase and the post-test conducted at the end of the intervention. Under these matched instructional conditions, the principal difference between the two groups was the use of the digital platform. Learning gains were calculated from the score differences between the pre-test and post-test, which allowed direct comparison of instructional outcomes across the two groups. The overall experimental procedures are illustrated in Figure 1.

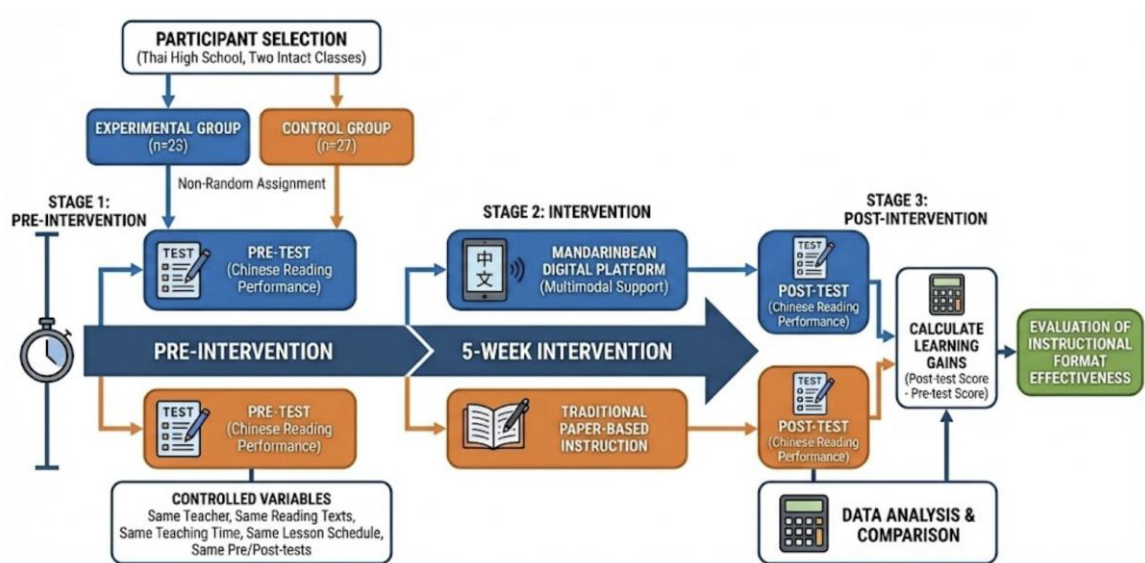


Figure 1. Experimental Procedures

Instructional Intervention

The instructional phase extended over five consecutive weeks, during which both groups engaged with identical reading content structured within the same teaching sequence. Instruction was organized around three culture-oriented texts—The Spring Festival, Mother’s Day, and What to Eat in Spring Festival, selected from the MandarinBean platform on the basis of thematic relevance and linguistic suitability for high school learners. In the experimental group, these texts were delivered through the MandarinBean digital platform, which provided embedded audio narration, vocabulary glosses with pinyin and translation, and illustrative images integrated directly into the reading interface. These multimodal elements were intended to support coordinated verbal and visual

processing during reading, thereby reducing unnecessary processing difficulty and helping students build more coherent mental representations of the texts. In addition, the cultural themes of the selected passages were used to activate relevant background knowledge and support interpretation of discourse-level meaning.

The reading activities were designed to align with second language acquisition principles by combining accessible input with structured processing tasks. Each lesson included guided vocabulary attention, sentence-level comprehension work, and meaning-focused activities requiring students to identify key information and construct the main idea of the passage. Because the support features were embedded within the same reading environment, students in the experimental group could access multimodal assistance while remaining engaged with the text. The control group studied the same texts and followed the same teaching schedule within the same five-week period; however, instruction was delivered through printed materials and teacher-guided explanation without access to the digital platform or its embedded multimodal supports. Through this design, the intervention compared two instructional formats under matched curricular conditions while making the multimodal and culture-integrated scaffolding of the digital platform the central pedagogical difference.

Research Instruments

A purpose-developed Chinese reading test was used as both the pre-test and the post-test in this study. The test was designed to assess students' Chinese reading performance under the two instructional conditions and was aligned with the instructional content of the intervention. The test lasted 45 minutes and had a total score of 100 points. It included three reading dimensions: vocabulary recognition (30 points), sentence comprehension (40 points), and main idea extraction (30 points).

For vocabulary recognition, the test included matching and fill-in-the-blank items focusing on key words and expressions from the instructional materials. For sentence comprehension, the test included true/false items and sentence translation tasks. For main idea extraction, the test included short fill-in-the-blank items based on key details and a paragraph selection task requiring students to identify the main idea of the text. The same test structure and scoring scheme were used for both the pre-test and the post-test. To reduce scoring differences, responses at both testing points were graded using the same criteria. No feedback was provided after the pre-test in order to reduce potential testing effects.

Data Analysis

All quantitative analyses were conducted using JAMOV statistical software. Descriptive statistics, including means and standard deviations, were first computed to summarize performance distributions. Baseline equivalence between groups was examined through an independent samples t-test performed on pre-test scores.

To evaluate instructional impact within groups, paired-samples t-tests were conducted comparing pre-test and post-test performance. In the paired-samples analyses, the subtraction order used in the software output was Pre-test - Post-test. Therefore, when post-test scores were higher than pre-test scores, the resulting mean differences, t values, and Cohen's d values were reported as negative. In interpreting improvement, the magnitude of Cohen's d, rather than its sign, was used as the relevant indicator of effect strength.

Learning gains were subsequently calculated by deriving score differences between the two testing points. Between-group comparisons of gain scores were then conducted to evaluate differential instructional effectiveness across conditions. Homogeneity of variance was examined using Levene's test. Where variance inequality was indicated, Welch's t-test was reported. Student's t-test was retained only when the homogeneity of variance assumption was not violated. Effect sizes were reported using Cohen's d to estimate the magnitude of observed differences, with statistical significance established at the $\alpha = .05$ level.

■ Results

Preliminary Analysis: Baseline Equivalence

An independent samples t-test was conducted to examine whether the experimental and control groups differed in total reading performance prior to the five-week instructional intervention. The results indicated no statistically significant difference between the two groups in pre-test total scores, $t(48) = 0.808$, $p = .423$, Cohen's $d = 0.229$. Levene's test for equality of variances was not significant, $F_{(1, 48)} = 3.20$, $p = .080$, indicating that the assumption of homogeneity of variance was met. Descriptive statistics showed that the experimental group ($n = 23$) obtained a pre-test mean score of 42.0 ($SD = 8.96$), whereas the control group ($n = 27$) obtained a mean score of 39.6 ($SD = 11.3$). These results suggest that the two groups were comparable at baseline prior to the intervention (see Table 1). Having established baseline equivalence, the subsequent analyses address the three research questions in sequence.

Table 1.

Independent-samples t-test for pre-test total reading score (100 points)

Group	N	Mean	SD	$t(df)$	p	Cohen's d
Experimental	23	42.0	8.96	0.808(48)	.423	0.229
Control	27	39.6	11.3			

Note. Levene's $F_{(1,48)} = 3.20$, $p = .080$.

RQ1. Within-Group Improvement in Overall Reading Performance

To address RQ1, paired-samples *t*-tests were conducted to examine whether each group demonstrated improvement in total reading scores following the five-week instructional intervention. For the experimental group ($n = 23$), post-test scores were significantly higher than pre-test scores, $t(22) = -13.0$, $p < .001$, Cohen's $d = -2.70$. Similarly, the control group ($n = 27$) also showed a statistically significant increase in post-test performance compared with pre-test scores, $t(26) = -15.3$, $p < .001$, Cohen's $d = -2.94$. The negative signs of the *t* values and Cohen's *d* reflect the subtraction order used in the paired-samples analysis (Pre-test - Post-test). In interpreting the results, the magnitude of Cohen's *d*, rather than its sign, was used to indicate the strength of improvement. Overall, these findings indicate that both instructional conditions contributed to significant improvement in students' Chinese reading performance following the intervention period (see Table 2).

Table 2.

Paired-samples t-test results for total reading scores

Group	N	<i>t</i>	df	<i>p</i>	Cohen's <i>d</i>
Experimental	23	-13.0	22	< .001	-2.70
Control	27	-15.3	26	< .001	-2.94

*Note. Negative values of *t* and Cohen's *d* reflect the subtraction order used in the paired-samples analysis (Pre-test - Post-test). Effect size interpretation was based on the magnitude of the absolute value.*

RQ2. Between-Group Comparison of Overall Reading Gains

To address RQ2, a between-group comparison of overall reading gain scores was conducted. Because Levene's test indicated unequal variances across groups, Welch's *t*-test was reported. The analysis revealed a statistically significant difference in overall gain scores, $t(37.4) = 3.00$, $p = .005$, Cohen's $d = 0.865$, indicating a substantial effect. Descriptive statistics showed that the experimental group ($n = 23$) achieved a mean gain of 8.65 ($SD = 3.20$), whereas the control group ($n = 27$) showed a mean gain of 6.30 ($SD = 2.15$). These findings indicate that students who received digital platform instruction achieved significantly greater improvement in overall Chinese reading performance than those who received traditional paper-based instruction (see Table 3). This pattern is also illustrated in Figure 2.

Table 3.

Welch's t-test results for overall reading gain scores

Group	N	Mean	SD	<i>t</i> (df)	<i>p</i>	Cohen's <i>d</i>
Experimental	23	8.65	3.20	3.00 (37.4)	.005	0.865
Control	27	6.30	2.15			

*Note. Levene's test indicated unequal variances across groups, $F(1, 48) = 4.38$, $p = .042$; therefore, Welch's *t*-test was reported for the between-group comparison of overall reading gain scores.*

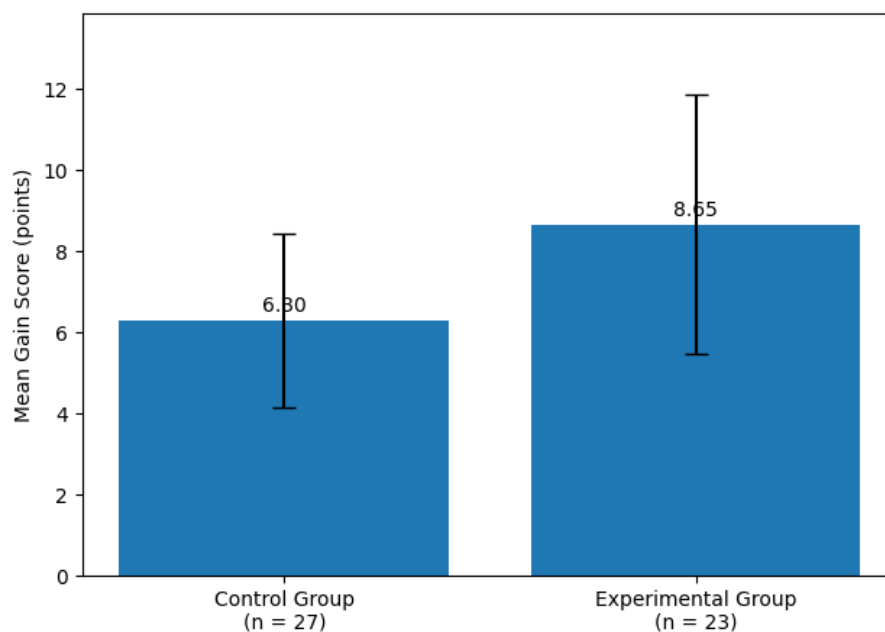


Figure 2. Comparison of Overall Reading Gain between Groups

RQ3. Between-Group Comparison of Sub-skill Gains

To address RQ3, between-group comparisons were conducted for the gain scores of vocabulary recognition, sentence comprehension, and main idea extraction. The descriptive statistics for these comparisons are presented in Table 4. For vocabulary recognition gain, Levene's test indicated unequal variances, $F_{(1, 48)} = 9.70$, $p = .003$; therefore, Welch's t-test was used. No statistically significant between-group difference was found, $t(41.8) = 1.60$, $p = .118$, Cohen's $d = 0.458$. For sentence comprehension gain, Levene's test was not significant, $F_{(1, 48)} = 1.19$, $p = .281$; an independent-samples t-test indicated no statistically significant difference between groups, $t(48) = 0.983$, $p = .330$, Cohen's $d = 0.279$. For main idea extraction gain, Levene's test again indicated unequal variances, $F_{(1, 48)} = 12.5$, $p < .001$; therefore, Welch's t-test was applied. A statistically significant between-group difference was observed, $t(41.4) = 2.92$, $p = .006$, Cohen's $d = 0.836$. The experimental group achieved a higher mean gain ($M = 1.70$, $SD = 1.52$) than the control group ($M = 0.556$, $SD = 1.19$). The comparative pattern of sub-skill gains is further illustrated in Figure 3, indicating that the digital platform offered stronger support for main idea extraction than for vocabulary recognition or sentence comprehension.

Table 4.

Between-group comparison of sub-skill gain scores

Sub-skill	Group	N	Mean	SD	Test reported	t(df)	p	Cohen's d	Levene's p
	Experimental	23	4.17	1.50	Welch's t		.118	0.458	.003

Sub-skill	Group	N	Mean	SD	Test reported	t(df)	p	Cohen's d	Levene's p
Vocabulary Recognition Gain	Control	27	3.56	1.19		1.60 (41.8)			
Sentence Comprehension Gain	Experimental	23	2.78	2.11	Student's t	0.983 (48)	.330	0.279	.281
	Control	27	2.19	2.17					
Main Idea Extraction Gain	Experimental	23	1.70	1.52	Welch's t	2.92 (41.4)	.006	0.836	< .001
	Control	27	0.556	1.19					

Note. Welch's *t*-test was reported for vocabulary recognition gain and main idea extraction gain because Levene's test indicated unequal variances. Student's *t*-test was retained for sentence comprehension gain because the homogeneity of variance assumption was not violated.

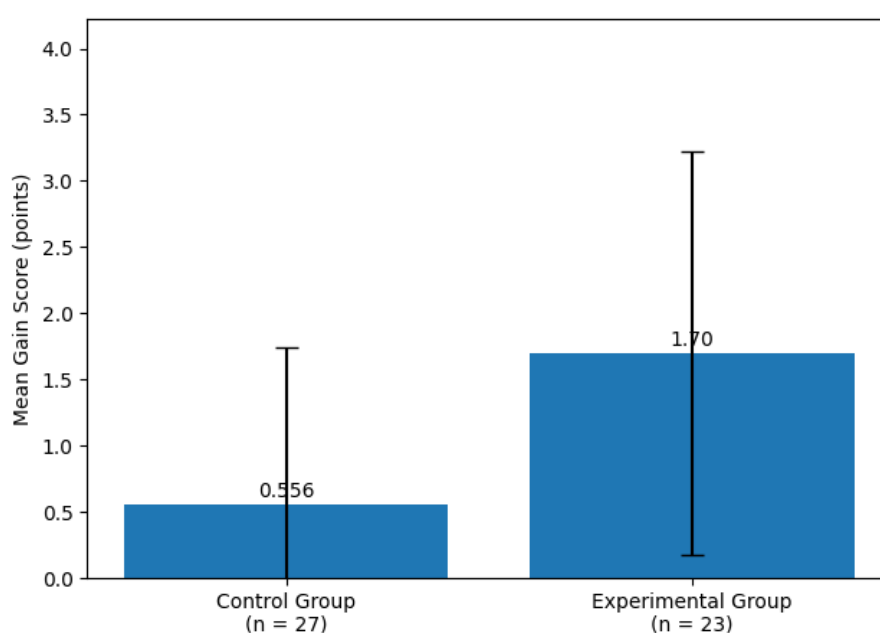


Figure 3. Comparison of Main Idea Extraction Gain Between Groups

Discussion and Conclusion

This study examined whether a multimodal, culture-integrated digital platform could support Chinese reading development among Thai high school learners. The findings showed a consistent pattern across the analyses. Both the experimental and control groups improved significantly after the five-week instructional intervention; however, the experimental group achieved greater overall learning gains. At the sub-skill level, the most notable difference appeared in main idea extraction, whereas vocabulary recognition and sentence comprehension showed no statistically significant group differences. These results suggest that while both instructional approaches supported general reading development, the digitally scaffolded environment provided additional advantages for higher-level comprehension processes. The stronger gains observed in the experimental group may be explained by the multimodal learning support

embedded in the digital platform. Students interacted with reading materials combining written text, audio narration, vocabulary glosses, and visual illustrations within a single environment. Such multimodal features may facilitate cognitive processing by helping learners organize linguistic input and construct coherent mental representations of textual meaning. This interpretation aligns with the Cognitive Theory of Multimedia Learning, which proposes that coordinated verbal and visual representations enhance comprehension through complementary cognitive channels (Mayer, 2005; Mayer, 2024). Through these integrated supports, the platform may have helped learners move from local decoding toward discourse-level processing, enabling them to synthesize information across sentences and identify the central meaning of the text. Previous research similarly indicates that multimodal digital environments can enhance reading comprehension by reducing cognitive load and supporting integration of textual information with visual and auditory cues (Xu, 2025; Liang, 2020).

Cultural contextualization of the reading materials may also explain the stronger improvement in main idea extraction. The instructional texts were organized around culturally meaningful themes that may have helped learners activate relevant background knowledge during reading. Schema-based perspectives on second language reading emphasize that comprehension improves when learners connect new textual information with existing knowledge structures (Sabatini & Bruce, 2009). Studies in Chinese language education likewise suggest that integrating cultural context into reading instruction can support deeper interpretation of texts and discourse-level comprehension (Pirbhai-Illich et al., 2017; Chao et al., 2024). In the present study, culturally contextualized materials may therefore have enabled learners to interpret relationships between textual details and identify the central message of a passage. By contrast, the absence of significant differences in vocabulary recognition and sentence comprehension suggests that these lower-level processes may develop through repeated exposure and regular classroom instruction regardless of instructional format. Because both groups were taught by the same instructor and used identical reading materials, learners likely had sufficient opportunities to practice lexical recognition and sentence-level processing. Similar patterns have been reported in second language reading research, where vocabulary development and sentence comprehension are strongly influenced by repeated exposure and guided practice rather than instructional medium alone (Ellis, 1994; Luo et al., 2022). Thus, the findings do not indicate that the digital platform was ineffective in these areas but suggest that its added value becomes more visible in higher-order comprehension processes requiring integration of meaning across a text.

Overall, the findings contribute to research on technology-enhanced language learning by providing classroom-based evidence from a Thai secondary school context. While previous studies highlight the general benefits of multimodal learning environments, the present study shows that instructional benefits may differ across reading sub-skills. Digitally scaffolded and culturally contextualized reading instruction appears particularly effective for discourse-level comprehension processes such as main idea extraction, whereas foundational reading skills may develop through conventional classroom practice. Despite these contributions, several limitations should be acknowledged. The relatively small sample and five-week intervention period may limit the stability and long-term interpretation of the findings. In addition, participants were drawn from a specific Thai high school

context in which Chinese was taught as a foreign language, and the intervention focused on a single digital platform within a defined instructional design. Consequently, the findings should not be generalized broadly to other learner populations, educational contexts, or digital learning environments without further investigation. Future research could examine longer interventions, larger and more diverse samples, and additional outcomes such as reading retention, learner motivation, and engagement in digital learning environments to better understand how digitally supported instruction influences second-language reading development.

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