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Technology-integrated Vietnamese literacy in primary education

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ABSTRACT

The rapid expansion of digital technologies has created new opportunities for improving literacy instruction in primary education. However, empirical evidence examining the impact of technology-integrated instruction on Vietnamese literacy development remains limited, particularly in tonal and diacritic-rich language contexts. This study investigates the effects of technology-integrated, learner-centered instruction on grade 4 students' reading and writing development in a Vietnamese primary school. A quasi-experimental design was employed with two intact classes (N=90). The experimental group participated in technology-integrated lessons using Google Classroom, Padlet, Wordwall, and artificial intelligence (AI)-supported reading tools, while the control group received conventional instruction. Data were collected through reading–writing pre-tests and post-tests, motivation questionnaires, and classroom observations over an eight-week intervention. The results showed that students in the experimental group achieved significantly higher gains in reading and writing performance ($p<0.001$) with a large effect size (Cohen's $d=1.20$), while the control group showed only modest improvement. Students in the technology-integrated classroom also demonstrated higher motivation, confidence, and classroom engagement. The study underscores the pedagogical potential of purposeful technology integration in primary literacy education and highlights the value of aligning digital tools with learner-centered instructional strategies. The findings provide practical guidance for teachers in designing interactive literacy lessons, support professional development initiatives, and inform curriculum implementation and digital transformation efforts in primary education in Vietnam.

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1. INTRODUCTION

The rapid expansion of digital technologies has significantly transformed literacy education, shifting instructional practices from traditional knowledge transmission toward more interactive, learner-centered, and feedback-oriented approaches [1]–[3]. In contemporary primary education, technology integration is increasingly viewed not merely as the digitization of teaching materials but as a pedagogical process that supports collaboration, multimodal learning, formative assessment, and learner engagement. Recent educational reforms and global digital transformation initiatives have further emphasized the importance of integrating educational technologies into classroom instruction to enhance students' literacy development and

learning experiences [4]–[6]. A growing body of international research has demonstrated that technology-enhanced literacy instruction can improve reading comprehension, writing quality, and learner motivation when digital tools are meaningfully aligned with pedagogical objectives. Meta-analyses and recent systematic reviews indicate that technology-supported environments yield moderate to large learning gains, particularly when they facilitate interaction, formative feedback, collaborative writing, and artificial intelligence (AI)-supported literacy development [2], [4], [5], [7]–[10]. In particular, collaborative digital platforms, gamified learning applications, and AI-supported feedback systems have been shown to facilitate active participation, formative assessment, and personalized learning experiences. These findings suggest that technology integration has considerable potential to enhance literacy development beyond traditional teacher-centered approaches. Meta-analytic evidence further suggests that literacy gains are most pronounced when digital environments combine multimodal input, opportunities for learner interaction, and timely formative feedback. These features support reading comprehension by enhancing meaning-making processes and contribute to writing development through iterative revision, peer collaboration, and immediate error correction [4], [5], [7]–[9], [11]. Nevertheless, whether these internationally reported benefits can be effectively transferred to Vietnamese primary education remains uncertain because Vietnamese literacy development involves unique tonal and diacritic-related challenges within the context of ongoing curriculum reform and educational digital transformation.

Several dominant frameworks and instructional approaches have guided previous research in this area. Learner-centered pedagogy has been widely adopted to promote interaction, collaboration, and student autonomy, while the technological pedagogical content knowledge (TPACK) framework has provided a theoretical basis for aligning technological tools with pedagogical strategies and disciplinary content [12]–[14]. Recent studies have increasingly explored the use of AI, digital feedback systems, and multimodal learning environments to support literacy instruction, particularly through immediate corrective feedback, adaptive learning opportunities, and collaborative writing activities [2], [11]. Despite these important contributions, existing studies present several limitations. First, most empirical evidence has been generated in alphabetic language contexts, with limited attention to tonal and diacritic-rich languages where literacy development involves additional phonological and orthographic challenges [15]. Second, many studies focus primarily on technological adoption, learner perceptions, or general literacy outcomes, rather than examining language-specific reading and writing skills. Third, research investigating the combined effects of technology integration, learner-centered pedagogy, and TPACK-based instructional design in primary education remains relatively limited, particularly in developing-country contexts. Consequently, there is insufficient empirical evidence regarding how technology-integrated instruction can support Vietnamese literacy development, especially in relation to tone accuracy, spelling precision, and paragraph-level writing skills.

In the Vietnamese educational context, recent curriculum reforms, particularly the 2018 general education curriculum issued by the Ministry of Education and Training (MOET), emphasize learner-centered pedagogy and the integration of digital technologies into classroom practice. Nevertheless, instructional practices in many primary classrooms remain predominantly teacher-centered, characterized by explanation-based teaching, choral reading, and mechanical writing exercises. Opportunities for interaction, peer feedback, and revision are often limited, resulting in a gap between policy expectations and classroom implementation. Existing research on information and communications technology (ICT) integration in Vietnam has largely focused on teachers' perceptions, infrastructure readiness, and policy adoption, while empirical evidence examining learning outcomes in specific subject areas remains scarce [16]. This situation indicates a gap between curriculum expectations and actual classroom implementation. This gap is particularly significant because the success of current educational reforms depends not only on the availability of digital technologies but also on evidence-based instructional models that can effectively improve student learning outcomes.

Without empirical research examining how technology-integrated instruction supports language-specific literacy development, teachers may lack pedagogical guidance for selecting and implementing digital tools in meaningful ways. Consequently, the potential benefits of technology integration may remain underutilized in classroom practice, especially in the teaching of Vietnamese, where tone accuracy, orthographic precision, and writing development present unique instructional challenges. Furthermore, the limited availability of experimental and quasi-experimental studies in Vietnamese primary education restricts understanding of whether technology-enhanced approaches can produce measurable improvements in both cognitive outcomes and learner engagement. Addressing this gap is therefore important not only for advancing the literature on technology-integrated literacy instruction but also for informing curriculum implementation, teacher professional development, and evidence-based educational practice in digitally transforming school systems. Motivated by these needs, the present study investigates the effects of technology-integrated, learner-centered instruction on grade 4 students' reading and writing development within the Vietnamese primary education context.

From a theoretical perspective, the TPACK framework provides a comprehensive lens for understanding effective technology integration in education. The framework emphasizes that meaningful instructional improvement arises from the alignment of content knowledge, pedagogical strategies, and technological tools rather than from technology use alone [13], [14]. When combined with learner-centered pedagogy, this framework supports the design of interactive and feedback-rich learning environments that may enhance literacy development in primary education. To address the identified gaps in the literature, this study aims to examine the effectiveness of technology-integrated, learner-centered instruction in improving Vietnamese primary students' literacy development. Specifically, the study investigates whether the purposeful integration of digital tools within a TPACK-informed instructional framework can enhance reading and writing achievement, increase student motivation and engagement, and support language-specific literacy skills in a tonal and diacritic-rich language context.

The study is guided by three objectives. First, it seeks to evaluate the impact of technology-integrated instruction on students' reading and writing performance. Second, it examines the influence of digital learning environments on students' motivation and classroom engagement. Third, it explores the pedagogical implications of integrating technology, learner-centered pedagogy, and TPACK-based instructional design in Vietnamese primary literacy education. By addressing these objectives, the study responds directly to the limited empirical evidence available regarding technology-supported literacy instruction in Vietnamese primary schools and contributes to a deeper understanding of effective digital pedagogies in language education. Accordingly, the present study seeks to contribute both empirical evidence and pedagogical insights regarding the role of technology-integrated instruction in Vietnamese primary literacy education. The following research questions guide the study:

- How does technology integration affect Vietnamese primary students' reading–writing achievement?
- Does the use of digital tools enhance students' motivation and engagement in Vietnamese language learning?
- What pedagogical adjustments are required for teachers to effectively implement a learner-centered, technology-integrated approach?

To address these research questions, the study employed a quasi-experimental design involving an experimental group and a control group of grade 4 students in a Vietnamese primary school. Technology-integrated, learner-centered instruction was implemented through the use of Google Classroom, Padlet, Wordwall, and AI-supported reading tools within a TPACK-informed instructional framework. Data were collected through reading–writing assessments, motivation questionnaires, and classroom observations to examine both cognitive and affective learning outcomes.

The novelty of this study lies in three key contributions to the existing literature. First, it provides empirical evidence on technology-integrated literacy instruction in a tonal and diacritic-rich language context, specifically Vietnamese, which remains underrepresented in experimental and quasi-experimental research. Second, the study employs a rigorous quasi-experimental design with effect size analysis to examine both cognitive and affective learning outcomes, contributing methodological strength to the field. Third, it demonstrates how TPACK-based instructional design can be operationalized in primary literacy classrooms through the systematic alignment of digital tools with specific reading and writing sub-skills. These contributions play an important role to extend current understanding of technology-enhanced literacy instruction beyond alphabetic language contexts and offer practical implications for instructional design in similar educational settings.

Beyond its empirical contributions, this study has both theoretical and practical significance. Theoretically, it extends the literature on technology-integrated literacy instruction by examining its application in Vietnamese, a tonal and diacritic-rich language context that remains underrepresented in international educational research. The study also contributes to the growing body of TPACK-based research by demonstrating how technological, pedagogical, and content knowledge can be systematically aligned to support specific literacy sub-skills in primary education. Practically, the findings provide evidence-based guidance for teachers seeking to integrate digital technologies into literacy instruction in pedagogically meaningful ways. The results may support teacher professional development initiatives, curriculum implementation efforts associated with the 2018 Vietnamese general education curriculum, and school-level digital transformation strategies. In addition, the findings offer useful implications for educational policymakers, curriculum developers, and researchers interested in promoting effective, sustainable, and learner-centered technology integration in primary education. The significance of this study extends beyond its immediate empirical findings. For educators, the study provides evidence-based instructional strategies for integrating digital technologies into literacy teaching in ways that enhance student engagement, reading comprehension, writing performance, and learner autonomy. For curriculum developers, the findings offer practical insights into how digital tools and learner-centered pedagogies can be systematically embedded within literacy curricula to support the objectives of the 2018 Vietnamese general education curriculum.

For policymakers, the study contributes empirical evidence that may inform decisions related to digital transformation initiatives, teacher professional development, and resource allocation for technology-supported learning in primary education. More broadly, the study demonstrates how technology integration can be implemented in pedagogically meaningful and sustainable ways, particularly in developing-country contexts undergoing educational reform and digital transformation. In summary, this study contributes to the literature by providing quasi-experimental evidence from a Vietnamese primary education context, demonstrating how TPACK-informed technology integration can enhance literacy development, learner engagement, and instructional innovation in a tonal and diacritic-rich language environment.

2. METHOD

2.1. Research design

This study employed a quantitative method [17], particularly using a quasi-experimental design to examine the effects of technology-integrated, learner-centered instruction on Vietnamese primary students' reading and writing development. A non-randomized control–experimental group design was adopted due to practical constraints within the school setting, a common approach in school-based educational research where random assignment is not feasible [18], [19]. This design enables systematic comparison between instructional conditions while maintaining ecological validity [18], [19]. Two intact grade 4 classes were assigned as: a control group that received conventional instruction and an experimental group that received learner-centered, technology-integrated instruction. Both groups followed the same curricular content prescribed by 2018 Vietnamese general education curriculum and were taught over an eight-week intervention period. The independent variable was the mode of instruction (traditional versus technology-integrated), while the dependent variables included students' reading–writing achievement and learning motivation.

2.2. Research context and setting

The study was conducted at a public primary school in southern Vietnam. The school's identity is withheld to ensure participant confidentiality. This site was selected for three primary reasons. First, the school possessed stable technological infrastructure, including internet connectivity, classroom projectors, and access to basic digital devices, which enabled the implementation of technology-integrated instruction without major technical disruption [19]. Second, the school employed experienced Vietnamese language teachers who regularly participated in professional development activities related to curriculum reform and ICT integration. Third, the school represented a high-performing public primary school in the Mekong Delta region, making it an appropriate context for examining the pedagogical potential of technology integration under realistic yet supportive conditions. Although the study was conducted at a single site, the school's characteristics allow the findings to serve as an analytic baseline for theorizing transferability to comparable primary school contexts where similar levels of teacher preparation and technological access are available [18], [19].

2.3. Participants and sampling

Participants consisted of 90 grade 4 students (aged 9–10), with 45 students in each group. Grade 4 was selected because students at this level have already acquired basic decoding skills and are transitioning toward more advanced reading comprehension and paragraph-level writing, making it a suitable stage for examining integrated reading–writing development [20]–[22]. Prior to the intervention, all participants completed a reading–writing pre-test to assess baseline literacy proficiency. Statistical analysis indicated no significant difference between the control and experimental groups at the outset of the study ($M=6.75$, $SD=0.92$, $p>0.05$), confirming initial group comparability.

Participants were selected using convenience sampling because the school administration assigned intact classes for instructional purposes. Two existing grade 4 classes with comparable academic backgrounds were included in the study. To reduce selection bias, baseline equivalence between groups was examined using pre-test scores, and no statistically significant differences were found prior to the intervention ($p>0.05$). Although random assignment was not feasible in the school setting, the use of intact classes reflects authentic classroom conditions and enhances ecological validity.

The teachers involved were qualified Vietnamese language educators with more than five years of teaching experience. Before the intervention, they participated in a two-week professional development program focusing on learner-centered pedagogy and technology integration guided by the TPACK framework [20]. This preparation aimed to minimize instructional variability and ensure consistent pedagogical implementation across lessons.

Because the study was conducted in an authentic school setting, random assignment of individual students was not feasible. Instead, two intact grade 4 classes were selected by the school administration and assigned to the control and experimental conditions. Although convenience sampling limits statistical

representativeness, the selected classes reflected typical grade 4 learners within the school context and demonstrated comparable baseline literacy achievement. Thus, the findings may be analytically transferable to similar Vietnamese primary school settings with comparable instructional and technological conditions.

2.4. Instructional conditions

As indicated in Table 1, the control group followed conventional teaching practices commonly observed in Vietnamese primary classrooms, including teacher-led reading, explanation-based instruction, choral reading, and individual writing tasks completed in notebooks [5]. In contrast, the experimental group received technology-integrated instruction designed according to learner-centered principles and the TPACK framework. Digital tools were systematically aligned with specific reading and writing sub-skills rather than used as presentation aids. Instruction emphasized interaction, formative feedback, and collaborative learning, consistent with learner-centered pedagogy [1], [23]. For example, when a student mispronounces a word, AI-supported reading tools provide immediate corrective feedback, enabling the student to recognize and correct pronunciation errors during practice [15].

The instructional intervention was designed using a structured development approach grounded in the TPACK framework. The design process emphasized the systematic alignment of technological tools, pedagogical strategies, and literacy content to ensure that technology integration served explicit instructional purposes rather than functioning as a supplementary element. Digital tools were selected based on their pedagogical affordances and mapped onto specific literacy sub-skills, including reading comprehension, vocabulary development, spelling accuracy, and paragraph writing. For example, collaborative platforms such as Padlet were used to support peer feedback and iterative writing processes, while gamified applications such as Wordwall facilitated vocabulary practice and engagement. AI-supported reading tools were employed to provide immediate corrective feedback on pronunciation and tone accuracy, addressing the specific linguistic demands of Vietnamese.

The instructional design followed three key principles: alignment between learning objectives, activities, and assessment; promotion of learner interaction and collaboration; and integration of formative feedback through both teacher guidance and digital tools. This structured design approach ensured that technology integration was pedagogically meaningful and directly targeted the development of students' reading and writing competencies. The alignment between digital tools and literacy sub-skills is summarized in Table 2. Figure 1 illustrates the conceptual pathway underlying the intervention. Digital tools were not used as isolated technological resources; rather, they supported specific pedagogical functions that facilitated the development of targeted literacy skills and ultimately contributed to improved learning outcomes.

Table 1. Research design and instructional conditions

Class	Group type	N	Instructional approach	Duration
4A	Control	45	Traditional (textbook- and board-based teaching)	8 weeks
4B	Experimental	45	Technology-integrated (Google Classroom, Padlet, Wordwall, AI-supported reading tools)	8 weeks

Table 2. TPACK-based alignment of digital tools and literacy skills

Digital tool	Target skill	Pedagogical function
Padlet	Writing	Peer feedback and collaborative writing
Wordwall	Vocabulary	Gamified practice and engagement
AI reading tool	Pronunciation	Immediate corrective feedback
Google Classroom	Reading	Resource sharing and interaction

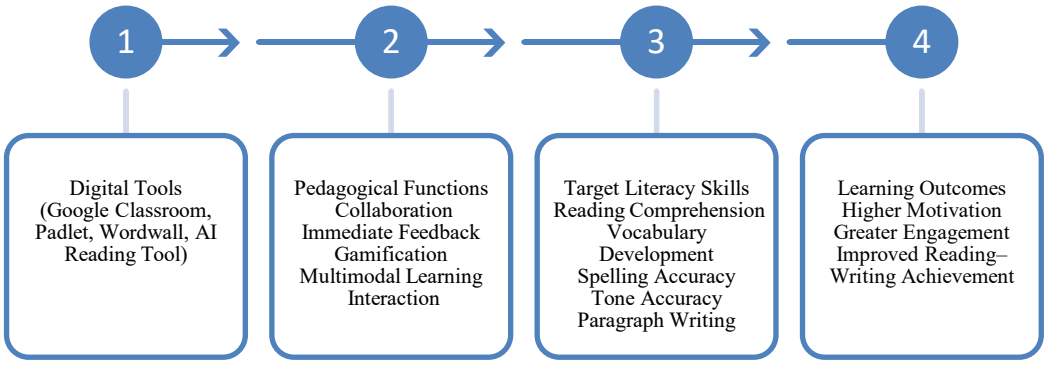


Figure 1. Conceptual framework of technology-integrated Vietnamese literacy instruction

2.5. Instruments–reliability and validity

The research instruments were developed through a multi-stage process. First, key constructs related to Vietnamese literacy achievement, learner motivation, and classroom engagement were identified based on the objectives of the 2018 Vietnamese language curriculum and previous studies on literacy education, learner-centered pedagogy, and educational technology. Second, test items, questionnaire statements, and observation indicators were drafted and aligned with the targeted constructs. Third, the instruments underwent expert review and pilot testing before final revision and implementation. Content validity was established through expert review by specialists in Vietnamese language education, consistent with recommended procedures for educational measurement. Internal consistency reliability was assessed using Cronbach's alpha, with values exceeding the acceptable threshold for educational research [19], [24].

To strengthen content validity, the instruments were reviewed by two specialists in Vietnamese language education and one expert in educational measurement and educational technology. A pilot study involving 15 grade 4 students from a comparable primary school was conducted prior to the intervention to assess item clarity, linguistic appropriateness, and administration feasibility. Minor revisions were subsequently made to improve wording precision and contextual suitability. Overall, the instrument development process combined curriculum alignment, expert validation, pilot testing, and reliability analysis to ensure the accuracy, validity, and appropriateness of the assessment tools for Vietnamese primary literacy research.

2.5.1. Reading–writing pre-test and post-test

The reading–writing tests consisted of a 20-item reading comprehension section and a short paragraph-writing task, developed in alignment with the objectives of the 2018 Vietnamese language curriculum [25]. Content validity was established through expert review by two specialists in Vietnamese language education. Internal consistency reliability was satisfactory, with Cronbach's α=0.86, indicating acceptable reliability for educational research [18].

2.5.2. Student motivation questionnaire

A 15-item Likert-scale questionnaire was administered to measure students' learning motivation and engagement in Vietnamese language learning. Items addressed interest, confidence, perceived usefulness of learning activities, and classroom participation, consistent with motivational constructs in learner-centered research [19], [24]. Reliability analysis yielded a Cronbach's α=0.88, demonstrating high internal consistency.

2.5.3. Classroom observation checklist

A structured classroom observation checklist was employed to document instructional practices, student participation, interaction patterns, and the pedagogical use of digital tools. The observation protocol consisted of predefined indicators related to student participation, peer interaction, engagement in learning activities, responsiveness to feedback, and the pedagogical use of digital tools. All indicators were operationally defined in an observation guide to support consistent data recording across observation sessions.

Classroom observations were conducted weekly throughout the eight-week intervention period by two trained observers using a standardized observation protocol. Prior to data collection, the observers participated in a calibration session to ensure consistent interpretation of observation indicators. Inter-observer agreement exceeded 85%, indicating acceptable observational reliability. Observation data were used to triangulate quantitative findings and strengthen interpretive validity [18], [19].

2.6. Procedure

The intervention was conducted over eight consecutive weeks, from March 4 to April 26, 2024. Both groups completed the pre-test in week 1 and the post-test in week 8. In the experimental group, instructional activities included interactive reading tasks supported by visual and auditory prompts, collaborative writing activities using Padlet for peer feedback and teacher guidance, vocabulary and grammar practice through Wordwall and Quizizz, and pronunciation and tone practice supported by AI-based reading tools providing immediate corrective feedback. The control group followed the same curricular content but relied on traditional instructional methods, including teacher explanation, reading aloud, and individual writing practice, without systematic use of digital tools.

Teachers implemented learner-centered pedagogy by organizing collaborative writing activities, peer feedback sessions, and guided revision cycles. During lessons, students worked in small groups to construct sentences and paragraphs, commented on peers' work through Padlet, and received immediate feedback from both teachers and digital tools. These activities were designed to promote active participation, interaction, and iterative improvement of students' writing.

2.7. Data analysis

Quantitative data were analyzed using SPSS version 26.0. Paired-sample t-tests were conducted to examine within-group differences, while independent-sample t-tests were used to compare post-test performance between groups [24]. Given the statistical equivalence of pre-test scores ($p>0.05$), independent-sample t-tests were considered appropriate for post-test comparison. Effect sizes were calculated using Cohen's d to assess the practical significance of observed differences, following established guidelines for educational research [3], [9], [24]. In addition, a post-hoc power analysis was conducted using G*Power 3.1 to examine the adequacy of the sample size. With N=90, $\alpha=0.05$, and the observed effect size (d=1.20), statistical power exceeded 0.99, indicating sufficient sensitivity to detect meaningful instructional differences.

Prior to hypothesis testing, data were screened for completeness, normality, and outliers. Descriptive statistics were calculated to summarize students' performance and motivation scores. Assumptions for parametric testing were examined and found satisfactory. Qualitative observation data were analyzed thematically to identify recurring patterns related to student engagement, participation, and classroom interaction.

2.8. Ethical considerations

This study received ethical clearance from the faculty research committee of Bac Lieu University. Written informed consent was obtained from the school administration, participating teachers, and students' parents. Participation was voluntary, and all data were anonymized to protect participants' privacy, in accordance with ethical guidelines for educational research [18].

3. RESULTS AND DISCUSSION

3.1. Quantitative findings

A comparison of pre-test and post-test scores revealed significant differences between the experimental and control groups in Vietnamese reading and writing achievement. As presented in Table 3, students in the experimental group demonstrated a substantial increase in post-test scores compared to their pre-test performance, whereas the control group showed only a modest improvement. As shown in Table 3, the experimental group achieved a statistically significant gain ($t=6.37$, $p<0.001$), with a large effect size (Cohen's d=1.20), indicating a strong instructional impact of technology-integrated teaching. In contrast, although the control group's mean score increased from pre-test to post-test, the difference was not statistically significant ($p=0.071$), and the effect size was small (d=0.26). These results indicate that integrating technology through interactive tools—Padlet, Wordwall, AI-supported reading tools—significantly enhanced students' reading comprehension, vocabulary retention, and paragraph writing fluency.

Table 3. Descriptive statistics and inferential results for reading–writing achievement

Group	N	Pre-test mean (standard deviation, SD)	Post-test mean (standard deviation, SD)	Mean gain	T (df)	P	Cohen's d
Control (4A)	45	6.80 (0.94)	7.50 (0.90)	+0.70	1.82 (44)	0.071	0.26
Experimental (4B)	45	6.70 (0.90)	9.10 (0.85)	+2.40	6.37 (44)	<0.001	1.20

3.2. Visual comparison

Figure 2 visually illustrates the magnitude of improvement achieved by the experimental group relative to the control group following the eight-week intervention. The wider separation between post-test scores highlights the stronger learning gains associated with technology-integrated instruction. The graphical pattern supports the statistical findings reported in Table 3 and provides a visual representation of the instructional effect.

Specifically, the mean score of the experimental group increased from 6.7 to 9.1, representing a mean gain of 2.4 points, whereas the control group's score rose modestly from 6.8 to 7.5 (+0.7 points). The difference in post-test means (9.1 vs. 7.5) indicates a strong positive effect of technology-integrated instruction on students' Vietnamese reading and writing skills. Statistical analysis confirmed this improvement as significant ($t=6.37$, $p<.001$, Cohen's d=1.20), reflecting a large effect size.

3.3. Additional findings by group

In addition to the overall statistical comparison, the analysis revealed distinct group-specific patterns of learning outcomes. For the experimental group, students demonstrated improvements across multiple dimensions of Vietnamese literacy beyond overall test scores. Analysis of students' written products indicated clearer sentence structures, increased lexical variety, and improved paragraph coherence. Notably,

students showed greater accuracy in spelling and tone–diacritic usage, which are critical features of Vietnamese orthography. Survey responses and classroom observations further indicated heightened learning motivation, increased confidence in reading aloud, and more active participation in writing activities. Students frequently engaged in peer interaction and feedback during collaborative writing tasks, suggesting higher levels of learner autonomy.

In contrast, the control group exhibited limited and uneven progress. Improvements were primarily observed in basic comprehension and mechanical writing accuracy, such as copying and sentence completion. There was little evidence of development in higher-level writing features, including lexical diversity or text organization. Classroom observations showed that instruction in this group remained largely teacher-centered, with minimal peer interaction or opportunities for revision. Students' motivation and engagement levels remained relatively unchanged throughout the intervention period. Overall, these findings indicate that while traditional instruction may support incremental gains in Vietnamese reading and writing, technology-integrated instruction produces broader and more consistent improvements across both linguistic performance and learner engagement.

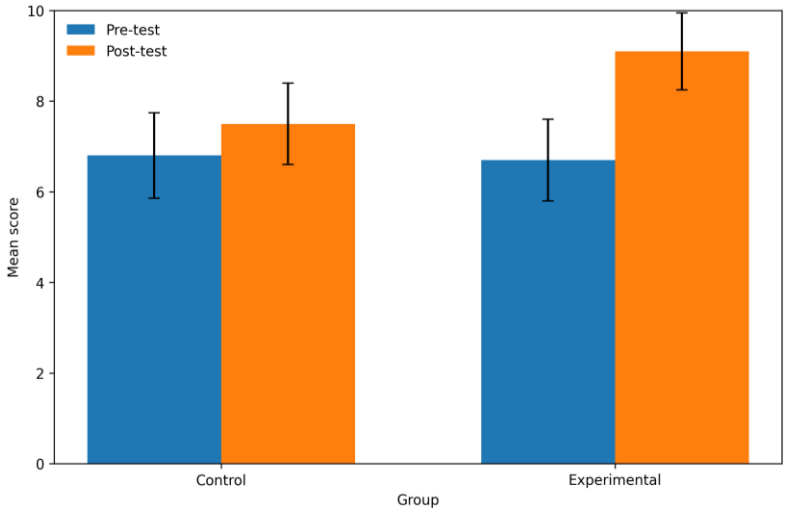


Figure 2. Comparison of reading–writing achievement scores before and after the intervention in the control and experimental groups. Note: error bars represent ±1 SD; n=45 per group

3.4. Qualitative findings

Qualitative insights were obtained from systematic classroom observations conducted throughout the eight-week intervention period. These data were analyzed thematically to identify recurring patterns related to students' motivation, engagement, and classroom interaction. The findings are presented separately for the experimental and control groups to highlight group-specific characteristics. Names of these participants were pseudonyms.

3.4.1. Experimental group

Analysis of qualitative data revealed three prominent themes, namely increased learning motivation, enhanced learner confidence, and active participation through interaction and feedback. First, a strong theme of increased motivation toward learning Vietnamese emerged from open-ended survey responses. A large majority of students reported that they enjoyed learning Vietnamese through digital tools and perceived lessons as more engaging due to the use of images, sounds, and interactive activities. Many students indicated that technology-based tasks made learning feel more enjoyable and less monotonous than traditional lessons. One student stated:

> "*I like learning Vietnamese more because the lessons have pictures and sounds, so it is easier to understand the text." Another student noted, "Using digital activities makes the class more interesting, and I want to participate more.*" (Nam)

Second, qualitative evidence pointed to greater learner confidence, particularly in reading aloud and writing paragraphs. Students expressed that practicing with digital tools and receiving immediate feedback helped them feel more secure when using Vietnamese, especially when dealing with spelling and tone

accuracy. Several students noted that they were less afraid of making mistakes because they could revise their work after receiving feedback. For example, one student explained:

> "*Before, I was afraid of reading because I might pronounce the tone wrong, but now I can practice many times and correct myself." Another student shared, "I feel more confident when writing because I can revise my sentences after receiving feedback.*" (Quyen)

Third, classroom observation data highlighted increased levels of interaction and participation. Students in the experimental group frequently engaged in peer discussion during collaborative writing tasks, exchanged comments on shared texts, and actively responded to teacher prompts. The classroom atmosphere was characterized by frequent learner–learner and learner–teacher interaction, with students taking greater responsibility for their learning activities. As one student remarked:

> "*I like working with my friends because we can help each other fix mistakes and improve our writing.*" (Hong)

These patterns suggest higher levels of learner autonomy and collaborative engagement in the technology-integrated classroom.

3.4.2. Control group

In contrast, qualitative findings from the control group revealed more limited changes over the intervention period. Two main themes were identified: stable learning motivation and restricted classroom interaction. Students' responses to open-ended questionnaire items suggested that motivation toward learning Vietnamese in the control group remained largely unchanged over the intervention period. While some students expressed general interest in the subject, few reported increased enjoyment or engagement compared to the beginning of the study. Learning activities were often described as familiar and routine. For example, one student stated:

> "*We learn Vietnamese in the same way as before, reading the text and writing in the notebook.*" (Han)

Another student commented:

> "*The lessons are normal and not very different from previous classes.*"

Similarly, a student noted:

> "*I do the exercises the teacher gives, but there are not many new activities.*" (Ngan)

These responses indicate that instructional practices in the control group did not substantially alter students' learning experiences or motivation levels during the study. Classroom observations further indicated restricted levels of interaction. Instruction in the control group remained predominantly teacher-centered, with most classroom time devoted to teacher explanations, choral reading, and individual writing tasks. Opportunities for peer discussion, feedback, or collaborative revision were minimal. Student participation was largely reactive rather than self-initiated, and instances of peer-supported learning were rarely observed.

3.4.3. Summary of qualitative patterns

Overall, the qualitative findings reveal clear contrasts between the two groups. The experimental group demonstrated heightened motivation, confidence, and interactive engagement, whereas the control group showed limited qualitative change in learning behaviors and classroom participation. These patterns complement the quantitative results and provide additional insight into how technology-integrated instruction influenced students' learning experiences during Vietnamese reading and writing lessons.

3.5. Interpretation of key findings

The findings demonstrate that students who participated in technology-integrated instruction achieved significantly greater improvements in reading and writing performance than those receiving conventional instruction, with a large effect size. In contrast, the control group exhibited only modest and statistically non-significant gains. These results suggest that traditional, teacher-centered approaches alone may be insufficient to meet the cognitive and instructional demands of contemporary primary literacy education. The substantial

effect size observed in this study aligns with international meta-analytic evidence indicating that well-designed technology-enhanced literacy instruction can generate moderate to large improvements in reading comprehension, writing performance, learner engagement, and collaborative learning outcomes when digital tools are purposefully aligned with pedagogical objectives [2], [4], [5], [7], [9]–[11]. These findings are also consistent with studies on technology-supported personalized literacy learning environments [26].

3.6. Learner-centered pedagogy and TPACK alignment

From a learner-centered perspective, the intervention reshaped classroom practices by increasing opportunities for interaction, collaboration, and formative feedback, reflecting broader shifts in teachers' pedagogical practices when integrating technology in classroom instruction [23], [27]. Students in the experimental group engaged actively in collaborative writing, peer feedback, and iterative revision, reflecting enhanced learner agency and shared responsibility for learning. These instructional features contrast with the predominantly passive learning behaviors observed in the control group.

The TPACK framework provides a coherent explanatory lens for these outcomes, emphasizing that meaningful instructional improvement emerges from the purposeful integration of TPACK, rather than from technological novelty alone [12], [13]. This finding reinforces the central premise of TPACK that instructional effectiveness emerges from the integration of content, pedagogy, and technology, rather than from technological use alone. As illustrated in Figure 1, the intervention was designed around the systematic alignment of digital tools, pedagogical functions, and literacy sub-skills, consistent with the core principles of the TPACK framework. A possible explanation for these outcomes is that each digital tool addressed a specific instructional need within the literacy learning process. Padlet supported collaborative drafting and peer feedback, enabling students to revise their writing iteratively. Wordwall increased engagement through gamified practice and repeated exposure to vocabulary items. AI-supported reading tools provided immediate corrective feedback on pronunciation and tone usage, which is particularly important in Vietnamese because tonal inaccuracies may alter meaning. The combination of these complementary functions may explain the substantial gains observed in both literacy performance and learner engagement.

3.7. Language-specific implications for Vietnamese literacy

A distinctive contribution of this study lies in its focus on Vietnamese as a tonal, diacritic-rich language. Improvements in spelling accuracy, tone usage, and paragraph coherence observed among students in the experimental group suggest that multimodal input, AI-supported instruction, and instant feedback are particularly effective in supporting phonological–orthographic mapping in linguistically complex contexts [1], [2], [10], [15]. Given that minor inaccuracies in tone or diacritic placement can substantially alter meaning in Vietnamese, the availability of immediate feedback and opportunities for self-correction appears especially beneficial for developing orthographic accuracy and writing fluency. These findings extend existing literacy research, which has largely concentrated on alphabetic, non-tonal languages, by demonstrating that technology-integrated instruction can address language-specific cognitive demands in mother-tongue literacy learning. Moreover, findings from this research also support teacher education and professional development programs, the preparation of primary teachers to use digital tools for literacy instruction in pedagogically meaningful ways, and policy efforts aimed at promoting sustainable and context-sensitive technology integration in schools.

Digital tools support Vietnamese literacy learning by providing multimodal representations of language, including visual cues, audio pronunciation, and instant corrective feedback [2], [3], [11]. These features are particularly beneficial for Vietnamese learners because tone and diacritic distinctions require precise phonological–orthographic mapping, which can be reinforced through repeated practice and immediate feedback. This mechanism may be particularly important in Vietnamese because tone markers and diacritical signs carry lexical and semantic distinctions. Errors in tone placement can alter word meaning, while inaccuracies in orthographic representation may affect reading comprehension and written communication. AI-supported reading tools provided immediate audio and visual feedback that enabled students to identify pronunciation and tone-related errors, self-correct their responses, and reinforce phonological–orthographic connections through repeated practice [10]. Similarly, digital writing environments facilitated iterative revision and peer feedback, helping students monitor spelling accuracy, diacritic use, and sentence construction more effectively than traditional paper-based activities.

Unlike many previous studies conducted in alphabetic language settings, this study demonstrates how technology-integrated instruction can address language-specific challenges associated with tonal and diacritic-rich literacy systems. This contribution is particularly important because Vietnamese literacy development requires accurate tone representation and orthographic precision, dimensions that have received limited attention in the international technology-enhanced literacy literature. The scarcity of experimental and quasi-experimental studies in tonal and diacritic-rich languages further underscores the significance of the present findings, which contribute rare empirical evidence from a linguistically complex literacy context.

3.8. Motivation, engagement, and learning processes

Qualitative findings further illuminate the mechanisms underlying the observed achievement gains. Students in the experimental group reported increased motivation, confidence, and willingness to participate in reading and writing activities. Classroom observations documented higher levels of peer interaction, self-initiated learning, and sustained engagement during technology-supported tasks. In contrast, instructional practices and learner behaviors in the control group remained largely unchanged over the intervention period. These patterns suggest that motivation and engagement functioned as mediating factors linking instructional design and learning outcomes [10], [11], [26], [28], [29]. Technology-integrated activities that encouraged interaction and feedback not only supported cognitive development but also fostered positive affective responses, which are critical for sustained literacy learning.

The findings also carry important policy implications. As Vietnam continues implementing the 2018 general education curriculum and national digital transformation initiatives, educational authorities may consider strengthening teacher professional development programs that focus on pedagogically meaningful technology integration rather than technical skills alone. In addition, sustained investment in digital infrastructure, access to educational technologies, and school-based instructional support may facilitate the effective implementation of learner-centered literacy instruction across diverse educational contexts.

3.9. Limitations and transferability

Despite the positive outcomes, the findings should be interpreted within contextual boundaries. Effective implementation depended on teacher preparation, pedagogical design, and access to stable technological infrastructure. Replication in under-resourced or rural contexts may require adaptation, targeted professional development, and the use of low-cost or offline digital solutions.

Nevertheless, the study provides transferable insights for comparable primary school settings where basic technological access and teacher support are available. Future research should examine the sustainability of learning gains through longitudinal designs and explore the potential of adaptive, AI-supported reading tools for personalized Vietnamese literacy instruction. Future studies should also investigate which specific digital tools contribute most strongly to different literacy sub-skills, including reading comprehension, spelling accuracy, vocabulary development, and paragraph writing [30]. Comparative studies across urban and rural schools may further clarify contextual factors influencing the effectiveness of technology-integrated literacy instruction. In addition, future research could explore how generative AI tools may support personalized literacy learning while maintaining pedagogical and ethical standards in primary education. This study contributes to literacy research by extending TPACK-based instructional design into tonal and diacritic-rich language contexts, an area underexplored in experimental research. The present findings contribute to emerging discussions on digital equity and sustainable educational innovation in developing country contexts undergoing digital transformation. These findings are also consistent with recent OECD and UNESCO reports emphasizing the importance of sustainable and pedagogically meaningful digital transformation in education systems worldwide [3], [31].

The intervention in Vietnamese primary school is considered sustainable, because it can be adopted in similar context. The intervention, used in this research, was implemented using relatively accessible and widely available tools, including Google Classroom, Padlet, Wordwall, and AI-supported reading tools, within an authentic school setting over an eight-week period. We also clarify that the sustainability of such an approach depends on several practical factors, including basic technological infrastructure, teacher preparation, and pedagogically appropriate lesson design.

Several limitations should be acknowledged when interpreting the findings of this study. First, the research was conducted in a single primary school with a relatively small sample of grade 4 students. Although the participants represented a typical Vietnamese primary school context, the findings may not be fully generalizable to schools with different demographic, socioeconomic, or technological conditions. Second, the intervention lasted only eight weeks, which limits conclusions regarding the long-term sustainability and retention of literacy gains. Future longitudinal studies are needed to determine whether the observed improvements can be maintained over extended periods. Third, the study employed a quasi-experimental design using intact classes rather than random assignment of individual students. Although baseline equivalence between groups was established through pre-test analysis, the possibility of uncontrolled contextual influences cannot be completely excluded. Fourth, the study was implemented in a school with relatively supportive technological infrastructure and teachers who received prior professional development in technology integration. Therefore, similar outcomes may not be immediately achievable in less-resourced schools where access to digital tools, internet connectivity, or teacher training is more limited. Finally, the study focused on the overall effectiveness of technology-integrated instruction and did not isolate the individual contributions of specific digital tools. Consequently, it remains unclear which technologies

contributed most strongly to improvements in particular literacy sub-skills. These limitations provide important directions for future multi-site, longitudinal, and comparative research.

Overall, the findings provide clear responses to the three research questions. Technology-integrated instruction significantly improved students' reading and writing achievement, enhanced motivation and classroom engagement, and demonstrated the pedagogical value of combining learner-centered practices with TPACK-informed technology integration. These results collectively support the effectiveness of technology-enhanced literacy instruction in Vietnamese primary education. These contributions extend recent findings reported in technology-enhanced literacy research as noted earlier in the introduction [2], [3], [10], [31].

4. CONCLUSION

This study provides empirical evidence that technology-integrated, learner-centered instruction can significantly enhance Vietnamese primary students' reading and writing development. Compared with conventional instruction, the technology-supported approach resulted in substantially greater gains in literacy achievement, accompanied by higher levels of student motivation, confidence, and classroom engagement. These findings demonstrate that the purposeful alignment of digital tools, pedagogical strategies, and literacy content can support both cognitive and affective dimensions of learning. The study makes several important contributions to the literature. First, it extends research on technology-enhanced literacy instruction to Vietnamese, a tonal and diacritic-rich language context that has received limited attention in international educational research. Second, it provides quasi-experimental evidence demonstrating that technology integration can improve both literacy achievement and learner engagement in primary education. Third, it illustrates how the TPACK framework can be operationalized through the systematic alignment of digital tools with specific literacy sub-skills, including tone accuracy, spelling precision, reading fluency, and paragraph writing. These contributions advance current understanding of technology-integrated literacy instruction beyond predominantly alphabetic language contexts.

The findings also carry practical implications for teachers, schools, and policymakers. The results support the integration of learner-centered digital pedagogies into literacy instruction and provide evidence that may inform teacher professional development, curriculum implementation, and educational digital transformation initiatives. For curriculum developers, the findings suggest the value of embedding technology-supported literacy activities and formative digital assessment practices within curriculum frameworks. In the longer term, the instructional model examined in this study may serve as a foundation for developing curriculum-aligned guidelines that integrate digital literacy activities, collaborative writing practices, and formative feedback mechanisms into Vietnamese language standards. Such efforts could support the systematic operationalization of technology-integrated literacy instruction within future curriculum revisions and teacher education programs. For policymakers, the results highlight the importance of sustained investment in teacher capacity building, digital infrastructure, and evidence-based technology integration policies that support equitable and effective literacy learning. In particular, the study highlights the importance of selecting digital tools based on pedagogical purposes rather than technological novelty alone.

Despite these contributions, several issues remain unresolved. The extent to which technology-integrated literacy instruction produces long-term learning gains beyond the intervention period remains unclear. In addition, further investigation is needed to determine how similar approaches can be adapted for schools with limited technological resources and diverse student populations. Questions also remain regarding the differential effectiveness of specific digital tools and AI-supported applications across various literacy domains. Future research should therefore employ longitudinal designs, larger and more diverse samples, and multi-site studies to examine the sustainability and generalizability of the findings. Further studies may also investigate adaptive and AI-supported literacy learning environments, compare the effectiveness of different digital tools, and explore how technology-integrated instructional models can be embedded into curriculum standards and teacher education programs. Such research would contribute to the development of more effective, equitable, and sustainable approaches to literacy education in the digital era.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all participating students and their parents prior to data collection.

ETHICAL APPROVAL

The research involving human participants complied with all relevant national regulations and institutional policies and was conducted in accordance with ethical principles for educational research. Ethical clearance was granted by the Faculty Research Committee of Bac Lieu University. Written informed consent was obtained from the school administration, participating teachers, and students' parents prior to data collection. Participation was voluntary, and all data were anonymized to protect participants' privacy.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to ethical restrictions involving primary school students, the data are not publicly available.

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