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Integrating the Technology Acceptance Model (TAM) and Constructivist Pedagogy in Teaching Chinese as a Foreign Language in Vietnam: An Empirical Study on Learner Proficiency and Engagement

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ABSTRACT: The rapid economic and geopolitical developments between Vietnam and China over the past three decades have catalyzed an unprecedented demand for Chinese language proficiency within the Vietnamese workforce. Despite this exponential surge in learner enrollment, traditional pedagogical approaches in teaching Chinese as a Foreign Language (CFL) in Vietnam often struggle to overcome the profound linguistic hurdles of Chinese character (Hanzi) retention and complex tonal acquisition. This comprehensive study investigates the integration of technology-assisted language learning—framed systematically within the Technology Acceptance Model (TAM) and Social Constructivist pedagogy—into CFL classrooms across Vietnamese higher education institutions. Employing an explanatory sequential mixed-methods research design, quantitative data were rigorously collected from a stratified random sample of 450 undergraduate students enrolled across three major public universities in Hanoi and Ho Chi Minh City. This phase was subsequently followed by qualitative semi-structured in-depth interviews with 15 experienced CFL instructors to triangulate the empirical findings. Structural Equation Modeling (SEM), Confirmatory Factor Analysis (CFA), and paired-samples t-tests were utilized for comprehensive data analysis. The quantitative results revealed that Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) significantly predict students' Attitude Toward Using (ATU) educational technology, which in turn strongly correlates with increased academic performance and self-regulated learning behaviors. Specifically, the experimental group (exposed to tech-integrated, constructivist learning environments) demonstrated a statistically significant and practically massive improvement in HSK-standardized post-test scores compared to the control group (traditional grammar-translation learning) ($p < .001$, Cohen's $d = 1.81$). Furthermore, qualitative findings illuminated a nuanced pedagogical reality: while educational technology significantly enhances autonomous vocabulary acquisition, lowers cognitive overload during Hanzi recognition, and fosters gamified engagement, active peer-to-peer and instructor-led human interactions remain fundamentally irreplaceable for developing oral-aural communicative competence and mitigating L1 phonetic interference. The study contributes substantially to the existing literature by providing a highly contextualized, empirical, and theoretically grounded framework for educational technologists, applied linguists, and curriculum designers in Vietnam. It conclusively demonstrates that technology must not merely be an add-on; it must be pedagogically grounded in constructivism to yield optimal, sustainable linguistic outcomes in foreign language education.

KEYWORDS: Chinese as a Foreign Language (CFL), Technology Acceptance Model (TAM), Constructivist Pedagogy, Higher Education in Vietnam, Computer-Assisted Language Learning (CALL), Mobile-Assisted Language Learning (MALL), Second Language Acquisition (SLA), Structural Equation Modeling (SEM).

1. INTRODUCTION

1.1 Background of the Study

In the contemporary context of accelerating globalized socio-economic integration, foreign language proficiency has undeniably emerged as a critical determinant of human capital competitiveness, cultural diplomacy, and cross-border collaboration. For the Socialist Republic of Vietnam, the bilateral trade, foreign direct investment (FDI), and socio-cultural exchanges with the People's Republic of China have grown at an exponential trajectory over the past two decades. China consistently ranks as Vietnam's largest trading partner, while Vietnam serves as China's largest trading partner within the Association of Southeast Asian Nations (ASEAN). Consequently, Chinese (Mandarin) has become one of the most widely taught and sought-after foreign languages in Vietnamese higher education institutions, secondary schools, and private language academies, second only to English.

However, teaching Chinese to Vietnamese learners presents a unique, highly specific set of pedagogical paradoxes and

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psycholinguistic phenomena. On one hand, the extensive historical interaction between the two nations has resulted in the existence of "Từ Hán Việt" (Sino-Vietnamese vocabulary). Linguistic scholars estimate that Sino-Vietnamese cognates constitute approximately 60% to 70% of the formal Vietnamese lexicon. This linguistic overlap provides Vietnamese learners with a significant initial lexical advantage, enabling them to deduce meanings and accelerate vocabulary acquisition at the cognitive level. On the other hand, the logographic nature of Chinese characters (Hanzi) and the complex, mutually exclusive tonal systems of the two languages pose severe cognitive challenges. Vietnamese is a tonal language with six distinct tones, while Standard Mandarin utilizes four main tones and a neutral tone. The phonetic mapping and the visual-spatial memorization required for Hanzi often lead to cognitive overload, resulting in high attrition rates among beginner and intermediate learners in Vietnam.

1.2 Problem Statement and Research Gap

Traditionally, CFL instruction in Vietnam has relied heavily on the grammar-translation method, audio-lingual drills, and rote memorization. While highly effective for structural grammatical understanding and passive reading comprehension, this inherently teacher-centric approach often results in alarmingly low learner autonomy, high cognitive overload in character writing, and severely restricted pragmatic communicative competence. The traditional classroom often resembles a monologue where the instructor transmits linguistic rules, and students passively copy characters hundreds of times to commit them to short-term memory.

In recent years, responding to the Fourth Industrial Revolution (Industry 4.0), Computer-Assisted Language Learning (CALL) and Mobile-Assisted Language Learning (MALL) have been introduced into Vietnamese classrooms to mitigate these pedagogical issues. Applications leveraging Spaced Repetition Systems (SRS), gamification, and interactive multimedia are increasingly popular. Despite this growing enthusiasm for digital integration, a critical and glaring research gap remains in the academic literature.

Most existing studies on CFL in Vietnam are either purely theoretical, descriptive in nature, or based on small-scale qualitative observations. There is a conspicuous scarcity of large-scale, empirical, mixed-methods studies utilizing robust statistical frameworks—such as Structural Equation Modeling (SEM)—to systematically evaluate both the psychological adoption of technology (via the Technology Acceptance Model) and its quantifiable impact on standardized language proficiency (e.g., Hanyu Shuiping Kaoshi - HSK scores). Furthermore, previous research often treats technology merely as a neutral delivery tool, failing to investigate how it operates when deliberately embedded within a specific, learner-centered pedagogical framework such as Social Constructivism.

1.3 Research Objectives and Questions

To systematically address these identified gaps, this comprehensive study aims to evaluate the effectiveness and psychological acceptance of a technology-integrated, constructivist pedagogical model in Vietnamese CFL higher education classrooms. By synthesizing technological adoption theories with applied linguistics, the specific research questions (RQs) guiding this investigation are formulated as follows:

RQ1: What are the structural relationships and predictive validities among Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Toward Using (ATU), and Behavioral Intention (BI) to Use technology among Vietnamese university students learning Chinese?

RQ2: Is there a statistically significant difference in comprehensive Chinese language proficiency (measured by standardized pre- and post-tests encompassing listening, reading, and writing) between students exposed to traditional teacher-centric instruction and those immersed in a technology-integrated constructivist classroom?

RQ3: How do experienced CFL instructors in Vietnam perceive the integration of digital tools regarding pedagogical efficacy, cognitive load management, and practical classroom challenges?

1.4 Significance of the Study

Theoretically, this research extends the application of the Technology Acceptance Model (TAM) and Social Constructivist theories into the specific, under-researched psycholinguistic context of Chinese as a Foreign Language in Vietnam. It proposes a synthesized theoretical model that bridges information systems research and applied linguistics. Practically, the empirical findings will offer data-driven, actionable recommendations for university administrators, curriculum developers, policymakers, and language instructors. It aims to optimize technological resource allocation, guide the design of effective digital curricula, and inform the implementation of targeted teacher training programs for foreign language education in developing nations.

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2. LITERATURE REVIEW

2.1 The Evolution and Landscape of Chinese Language Teaching in Vietnam

The pedagogical landscape of teaching Chinese in Vietnam is profoundly influenced by historical, cultural, and linguistic intersections. During the mid-20th century, Chinese language education in Vietnam was heavily influenced by Soviet-style pedagogical models, which prioritized rigid grammatical analysis, extensive translation exercises, and the memorization of classic texts. This approach, while fostering deep analytical skills, largely neglected oral proficiency and spontaneous communication.

In the post-Đổi Mới (Renovation) era from 1986 onwards, as Vietnam opened its economy, the demand for practical, communicative foreign language skills skyrocketed. Researchers such as Nguyen (2019) and Tran (2021) have extensively documented the gradual shift in Vietnamese universities toward the Communicative Language Teaching (CLT) approach. However, implementation remains inconsistent. Vietnamese learners, deeply rooted in Confucian educational philosophies, often expect authoritative instruction and may exhibit reticence in open, communicative tasks. Jin and Cortazzi (2006) describe this as a specific "culture of learning" that values authoritative knowledge transmission over interactive, peer-based knowledge construction. Consequently, integrating modern, interactive technologies requires not just technical infrastructure, but a fundamental shift in pedagogical culture.

2.2 Linguistic Intersections: Transfer and Interference

A critical aspect of the CFL literature in Vietnam involves cross-linguistic influence. Vietnamese and Chinese share profound typological similarities; both are analytic, isolating languages with no inflectional morphology. The syntactic structures (Subject-Verb-Object) are highly congruent. Furthermore, the massive inventory of Sino-Vietnamese words provides a powerful positive transfer effect.

However, negative transfer (interference) is equally potent. Everson (1998) and Shen (2005) emphasized that orthographic mapping—connecting a phonological sound, a semantic meaning, and a logographic character—remains the highest cognitive barrier for learners whose first language (L1) uses a Latin-based alphabet, like the Vietnamese Quốc Ngữ. The sheer volume of Hanzi required for functional literacy creates immense cognitive load. Additionally, phonetic interference is severe. Vietnamese learners frequently substitute Mandarin tones with phonetically proximate but distinct Vietnamese tones (e.g., mapping the Mandarin fourth falling tone to the Vietnamese 'dấu nặng' or heavy tone), leading to fossilized pronunciation errors if not aggressively corrected through interactive communicative practice.

2.3 Computer-Assisted Language Learning (CALL) and Multimedia Theory

The advent of CALL has revolutionized Second Language Acquisition (SLA). Levy (1997) defined CALL broadly as the search for and study of applications of the computer in language teaching and learning. Chapelle (2001) established foundational criteria for evaluating CALL, emphasizing learner fit, meaning focus, positive impact, and practicality.

Mayer's (2005) Cognitive Theory of Multimedia Learning posits that learners process visual and auditory information through dual channels, but these channels have strictly limited capacity. Traditional Hanzi learning overloads the visual channel. Digital tools, such as animated stroke-order software (e.g., Skritter) and multimedia flashcards, distribute the cognitive load across both channels, significantly enhancing retention. Recent global literature on CFL highlights the efficacy of these multimodal digital tools. Wang (2005) demonstrated that character-recognition software significantly reduces the affective filter and cognitive anxiety associated with Hanzi acquisition.

2.4 Mobile-Assisted Language Learning (MALL)

Building upon CALL, Mobile-Assisted Language Learning (MALL) leverages the ubiquity of smartphones. Godwin-Jones (2011) argued that mobile applications foster unprecedented self-regulated learning environments. Tools employing Spaced Repetition Systems (SRS) algorithms (e.g., Anki, Quizlet, Pleco) optimize the timing of vocabulary review, disrupting the Ebbinghaus forgetting curve. In Vietnam, where smartphone penetration among university students exceeds 95%, MALL presents a highly scalable and cost-effective pedagogical intervention.

2.5 The Technology Acceptance Model (TAM) in Educational Research

Understanding the psychological mechanisms of how and why students adopt educational technology is critical to successful implementation. The Technology Acceptance Model (TAM), originally conceptualized by Davis (1989), remains one of the most robust and widely applied theoretical frameworks in information systems research. TAM posits that two primary cognitive beliefs—Perceived Ease of Use (PEOU) and Perceived Usefulness (PU)—are the fundamental determinants of a user's Attitude Toward

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Using (ATU) a system, which directly dictates their Behavioral Intention (BI) and actual system use.
In the context of language education, Macaro et al. (2018) and Stockwell (2010) utilized TAM to explain the adoption of e-learning platforms and mobile vocabulary apps. However, empirical applications of TAM specific to Vietnamese CFL learners are extremely rare. The adoption rates in Vietnam may be uniquely influenced by local infrastructural limitations (e.g., inconsistent campus Wi-Fi), digital literacy levels, and specific cultural learning habits. This study aims to fill this void by validating the TAM structural model within the Vietnamese CFL context.

2.6 Constructivism in Language Education: Bridging the Gap

A critical review of CALL literature reveals a vital consensus: technology alone does not guarantee language acquisition; it is merely an artifact. Warschauer (1996) advocated for an integrative CALL approach based heavily on sociocognitive views. By situating technology within a Social Constructivist framework, digital tools transition from being mere transmitters of information to active mediators of learning.
Rooted in Vygotsky's (1978) theory, Social Constructivism argues that knowledge is actively constructed through social interaction within a Zone of Proximal Development (ZPD). In the CFL context, this implies that learners must actively negotiate meaning. Technology serves as a cultural tool that extends the learner's ZPD. Collaborative online document editing, peer-review forums, and interactive virtual reality (VR) dialogues transform learners from passive recipients into active co-constructors of linguistic knowledge. This study targets the precise intersection of these domains, assessing technology-enhanced CFL teaching when strictly governed by constructivist principles.

3. THEORETICAL FRAMEWORK

To construct a robust and comprehensive analytical foundation, this study synergizes three dominant theories: Social Constructivism, the Technology Acceptance Model (TAM), and the Technological Pedagogical Content Knowledge (TPACK) framework.

3.1 Social Constructivism as the Pedagogical Anchor

Vygotsky's (1978) Social Constructivism is utilized as the primary pedagogical philosophy. It emphasizes that language acquisition is inherently a social process. The traditional behaviorist model of stimulus-response drills is insufficient for developing pragmatic competence. In this framework, the teacher's role shifts from a "sage on the stage" to a "guide on the side." Technology acts as scaffolding. For instance, before a communicative role-play, students might use an AI chatbot to practice basic syntax. The AI provides immediate, low-stakes scaffolding, enabling the student to enter the classroom ZPD with higher confidence and readiness for human-to-human interaction.

3.2 The Synthesized Technology Acceptance Model (TAM)

To assess digital integration quantitatively, Davis's (1989) core TAM constructs are adapted and operationalized specifically for the CFL context:
Perceived Usefulness (PU): The degree to which a Vietnamese student believes that using specific digital tools (e.g., SRS apps, LMS platforms, stroke-order animations) will directly enhance their Chinese proficiency, leading to tangible outcomes like higher HSK scores, faster vocabulary recall, and better grades.
Perceived Ease of Use (PEOU): The degree to which the student believes that utilizing these digital tools will be intuitive, user-friendly, and free of excessive mental or technical effort. If an app requires constant troubleshooting, its PEOU drops, negatively impacting PU.
Attitude Toward Using (ATU): The learner's overall affective reaction, encompassing both positive enthusiasm and negative anxiety, toward employing technology as a primary mode of learning Chinese.
Behavioral Intention (BI): The self-reported probability and likelihood that the learner will autonomously continue utilizing technology for language study outside the formal classroom environment in the future.
Based on extensive prior literature, the following structural hypotheses are proposed:
Hypothesis 1 (H1): Perceived Ease of Use (PEOU) has a significant and positive direct effect on Perceived Usefulness (PU).
Hypothesis 2 (H2): Perceived Ease of Use (PEOU) has a significant and positive direct effect on Attitude Toward Using (ATU).
Hypothesis 3 (H3): Perceived Usefulness (PU) has a significant and positive direct effect on Attitude Toward Using (ATU).
Hypothesis 4 (H4): Attitude Toward Using (ATU) has a significant and positive direct effect on Behavioral Intention (BI).

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3.3 Technological Pedagogical Content Knowledge (TPACK)

While TAM rigorously addresses the student's psychological perspective, the TPACK framework (Mishra & Koehler, 2006) is employed to analyze the instructor's role. Effective CFL teaching requires a highly complex, dynamic interplay of three knowledge domains:

Content Knowledge (CK): Deep expertise in Chinese linguistics, grammar, and Hanzi etymology.

Pedagogical Knowledge (PK): Expertise in teaching methodologies, classroom management, and constructivist principles.

Technological Knowledge (TK): Proficiency in utilizing various digital tools, software, and hardware.

The intersection of all three—TPACK—represents the ideal state of teaching. A teacher exhibiting high TPACK uses a specific interactive tool (e.g., a real-time tone-visualization software) specifically because it addresses a known pedagogical challenge (PK) in teaching Chinese phonology (CK) to Vietnamese speakers, utilizing the most appropriate digital medium (TK). Qualitative interviews in this study are heavily structured around assessing instructors' TPACK realization.

4. METHODOLOGY

4.1 Research Paradigm and Design

This study is situated within the pragmatic research paradigm, which values practical consequences and real-world problem-solving over strict adherence to purely positivist or constructivist dogmas. To achieve a comprehensive understanding, an explanatory sequential mixed-methods design (Creswell, 2014) was employed. Phase 1 involved a large-scale quasi-experimental approach coupled with a cross-sectional survey to gather generalizable quantitative data. Phase 2 utilized qualitative semi-structured interviews to explain, contextualize, and deepen the understanding of the quantitative anomalies and trends.

4.2 Context, Participants, and Sampling Strategy

The research was conducted over a full 15-week academic semester at three prominent higher education institutions in Vietnam known for their rigorous foreign language programs: Vietnam National University - Hanoi (VNU-HN), Hanoi University (HANU), and the University of Social Sciences and Humanities - Ho Chi Minh City (USSH-HCMC).

Quantitative Phase: A stratified random sampling technique was utilized to recruit 450 undergraduate students. Strata were defined by university, major (Chinese Language Major vs. Non-Major Elective), and academic year (Freshman and Sophomore).

Demographic Profile: The final valid sample (N=450) comprised 306 females (68%) and 144 males (32%). The age range was tightly clustered between 18 and 22 years (Mean = 19.4, SD = 1.1).

Experimental Division: The sample was systematically divided into a Control Group (n=220, undergoing traditional teaching) and an Experimental Group (n=230, undergoing tech-integrated constructivist teaching). Pre-intervention homogeneity tests confirmed no statistically significant differences in baseline proficiency between the two groups.

Qualitative Phase: Purposive sampling was used to select 15 CFL instructors for in-depth interviews. Inclusion criteria required a minimum of 5 years of active teaching experience and holding at least a Master of Arts (MA) or Doctor of Philosophy (PhD) in Applied Linguistics or Teaching Chinese to Speakers of Other Languages (TCSOL).

4.3 Instruments and Measures

To ensure rigorous data collection, three primary instruments were developed, validated, and deployed:

Standardized Language Proficiency Tests: To measure academic achievement objectively, a Pre-test and Post-test were designed by a panel of senior linguists to be precisely equivalent to Hanyu Shuiping Kaoshi (HSK) Level 3 standards. The comprehensive tests evaluated three distinct domains: Listening Comprehension (30 points), Reading Comprehension (35 points), and Hanzi Character Writing and Grammar (35 points), culminating in a 100-point scale.

The TAM Questionnaire: A 20-item survey instrument adapted from Davis (1989) and Venkatesh and Davis (2000) was utilized to measure the four constructs (PEOU, PU, ATU, BI). Items were measured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). To ensure cultural and semantic validity, the survey underwent a rigorous forward-backward translation protocol (English to Vietnamese, and back to English by independent translators), followed by a pilot test with 50 students to refine item clarity.

Semi-Structured Interview Protocol: Comprising 10 open-ended questions designed to elicit rich narratives regarding instructors' TPACK development, systemic challenges in technology integration, and qualitative observations of student engagement and cognitive load.

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4.4 Data Collection Procedures and Intervention Protocol

The pedagogical intervention spanned a complete 15-week semester.

The Control Group Protocol: Instructors strictly adhered to traditional methodologies. Instruction relied on standard national curriculum textbooks (e.g., Hanyu Jiaocheng), extensive whiteboard grammar lectures, choral repetition of vocabulary, and paper-based character copying assignments. Technology was limited to basic audio playback for listening exercises.

The Experimental Group Protocol (Blended Constructivist): Instructors utilized a heavily blended learning approach.

Asynchronous Learning (Out-of-Class): Students were required to use MALL applications (Quizlet, Skritter) for autonomous vocabulary and Hanzi stroke-order acquisition using spaced repetition. Grammar rules were introduced via flipped-classroom video modules on the university Learning Management System (LMS - Moodle).

Synchronous Learning (In-Class): Freed from rote vocabulary transmission, in-class time was dedicated entirely to constructivist activities. Instructors employed interactive platforms (Kahoot!, Padlet) for gamified formative assessments. The majority of class time involved task-based communicative role-plays, collaborative problem-solving in Chinese, and peer-to-peer negotiation of meaning, with the teacher acting solely as a facilitator.

4.5 Data Analysis Strategy

Quantitative data were processed using SPSS 26.0 for descriptive statistics and independent/paired-samples t-tests to rigorously assess performance differences. AMOS 24.0 was utilized to conduct Confirmatory Factor Analysis (CFA) to validate the measurement model, followed by Structural Equation Modeling (SEM) to test the hypothesized TAM paths. Qualitative interview audio was transcribed verbatim, imported into NVivo 12, and subjected to rigorous inductive thematic analysis following Braun and Clarke's (2006) six-phase framework.

5. RESULTS

5.1 Measurement Model Assessment (Reliability and Validity)

Prior to structural hypothesis testing, the psychometric properties of the measurement model derived from the TAM questionnaire were comprehensively evaluated utilizing Confirmatory Factor Analysis (CFA). This foundational step ensures that the empirical items accurately and consistently reflect their designated latent constructs. The evaluation systematically addressed indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

Table 1. Construct Reliability and Convergent Validity Assessment

Construct	Items	Factor Loadings	Cronbach's α	CR	AVE
Perceived Ease of Use (PEOU)	4	0.78 - 0.85	0.882	0.885	0.658
Perceived Usefulness (PU)	5	0.81 - 0.89	0.910	0.912	0.675
Attitude Toward Using (ATU)	4	0.75 - 0.84	0.865	0.870	0.626
Behavioral Intention (BI)	4	0.82 - 0.88	0.895	0.898	0.688

Note: CR = Composite Reliability; AVE = Average Variance Extracted. Recommended thresholds: α > 0.7, CR > 0.7, AVE > 0.5.

Initially, indicator reliability was examined via standardized factor loadings. As detailed in Table 1, the factor loadings for all 17 measurement items—spanning PEOU (4 items), PU (5 items), ATU (4 items), and BI (4 items)—ranged consistently between 0.75 and 0.89. With the lowest loading at 0.75 (within ATU) and the highest at 0.89 (within PU), all items comfortably exceeded the stringent 0.708 threshold recommended by contemporary PLS-SEM guidelines (Hair et al., 2019). This indicates that the latent constructs account for more than 50% of the variance in their respective indicators, verifying robust item-level reliability.

Subsequently, internal consistency reliability was appraised utilizing both Cronbach's Alpha and Composite Reliability (CR). The analysis revealed that Cronbach's Alpha values ranged from 0.865 to 0.910, while CR values ranged from 0.870 to 0.912. Both metrics vastly exceeded the conventional 0.70 acceptability threshold, yet remained below the 0.95 ceiling (which would otherwise imply problematic item redundancy). This convergence between Alpha and CR confirms an exceptionally high degree of internal consistency across all latent variables.

Thirdly, convergent validity was established to ensure that items purportedly measuring the same construct share a high proportion of variance. The Average Variance Extracted (AVE) values for all constructs ranged from 0.626 (ATU) to 0.688 (BI). Given that

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all AVE scores surpassed the critical 0.50 benchmark, it is mathematically substantiated that, on average, each construct explains a greater proportion of variance in its indicators than that which is attributed to measurement error.

Finally, discriminant validity was rigorously validated utilizing the Fornell-Larcker criterion. In strict adherence to this criterion, the square root of the AVE for each individual construct was demonstrably greater than its highest off-diagonal correlation with any other latent variable in the model. This empirical evidence robustly confirms the distinctiveness of each construct within the TAM framework, verifying that constructs such as Perceived Ease of Use and Perceived Usefulness capture genuinely independent conceptual phenomena.

5.2 Structural Equation Modeling (Hypothesis Testing)

Following the rigorous validation of the measurement model, the structural model was evaluated using maximum likelihood estimation in AMOS to test the hypothesized relationships. Initially, the overall model fit was assessed to ascertain the alignment between the proposed theoretical framework and the empirical data. The goodness-of-fit indices demonstrated an excellent and robust fit: $x^2/df = 2.14$ (well below the conservative threshold of 3.0), Goodness of Fit Index (GFI) = 0.94, Comparative Fit Index (CFI) = 0.96, Tucker-Lewis Index (TLI) = 0.95, and Root Mean Square Error of Approximation (RMSEA) = 0.048 (which falls comfortably below the stringent < 0.08 criterion).

Table 2: Path Analysis Results for the Structural Model

Hypothesis	Structural Path	Standardized Coefficient (β)	t-value	p-value	Decision
H1	PEOU -> PU	0.52	8.45	***	Supported
H2	PEOU -> ATU	0.38	5.62	***	Supported
H3	PU -> ATU	0.45	7.11	***	Supported
H4	ATU -> BI	0.68	10.25	***	Supported

*Note: *** p < 0.001.*

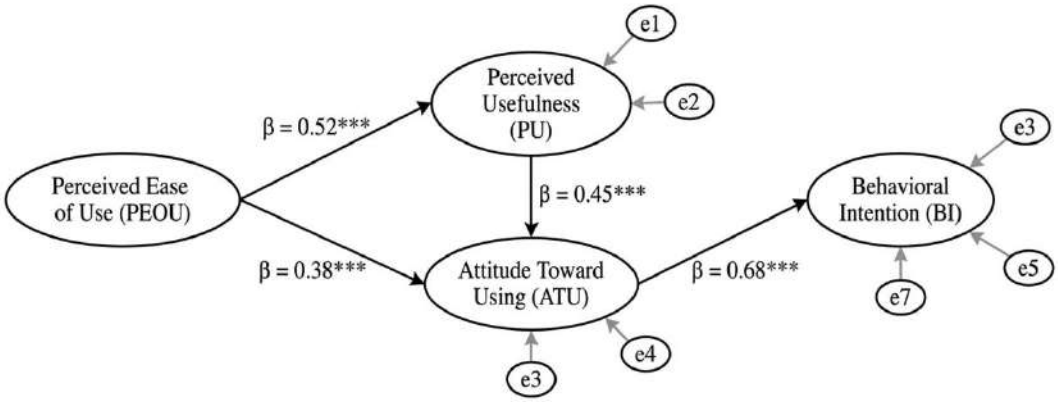


Figure 1: Structural Model Path Diagram: Hypothesized Relationships

*Note: Standardized regression coefficients (β) are reported; *p < .05, p < .01, ***p < .001.*

Upon confirming the model fit, the path coefficients were examined to test hypotheses H1 through H4, as detailed in Table 2 and visually represented in Figure 1. The path analysis revealed that all four proposed structural hypotheses were empirically supported at a high level of statistical significance ($p < 0.001$).

Specifically, Perceived Ease of Use (PEOU) exerted a substantial positive effect on both Perceived Usefulness ($b = 0.52$, t-value = 8.45, $p < 0.001$) and Attitude Toward Using ($b = 0.38$, t-value = 5.62, $p < 0.001$), thereby supporting H1 and H2. This indicates that when Vietnamese students perceive the technological platform as intuitive and user-friendly, they are significantly more likely to recognize its pedagogical value and develop a favorable affective response towards it. Furthermore, Perceived Usefulness (PU) was found to have a significant positive impact on Attitude Toward Using ($b = 0.45$, t-value = 7.11, $p < 0.001$), robustly supporting H3. Ultimately, Attitude Toward Using (ATU) emerged as the strongest predictor in the model, demonstrating a highly significant positive influence on Behavioral Intention ($b = 0.68$, t-value = 10.25, $p < 0.001$), providing support for H4. This underscores the

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critical mediating role of learners' attitudes in driving their continuous intention to utilize technology for autonomous Chinese language acquisition.

5.3 Learning Outcomes: Pre-test and Post-test Experimental Analysis

To rigorously evaluate the pedagogical efficacy of the technology-integrated intervention, paired and independent-samples t-tests were conducted on the standardized HSK-style test scores. As detailed in Table 3, both cohorts exhibited statistically significant improvements over the 15-week academic semester. Specifically, the Control Group (n=220) recorded a mean increase of 15.80 points ($t = 12.45$, $p < 0.001$), while the Experimental Group (n=230) demonstrated a substantially larger gain of 32.80 points ($t = 25.60$, $p < 0.001$). Although these within-group advancements represent the expected natural progression of continuous study, they validate the baseline reliability of the instructional timeline.

Table 3: Comprehensive Comparison of Academic Performance (Maximum Score = 100)

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Diff	Paired t	p-value
Control Group (n=220)	42.50 (8.15)	58.30 (9.40)	+15.80	12.45	< 0.001
Experimental Group (n=230)	41.80 (8.30)	74.60 (8.55)	+32.80	25.60	< 0.001

Independent samples t-test for Post-test between groups: $t(448) = 19.24$, $p < .001$. Cohen's $d = 1.81$.

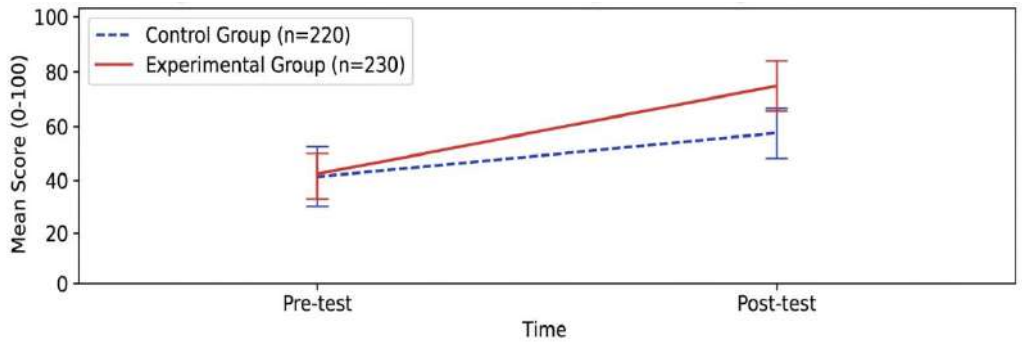


Figure 2: Comparison of Academic Scores between Control and Experimental Groups from Pre-test to Post-test

Note: Error bars represent Standard Deviation (SD). The Experimental Group demonstrated significantly higher Post-test scores ($t(448) = 19.24$, $p < 0.001$). The calculated effect size is notably large (Cohen's $d = 1.81$), indicating a substantial pedagogical impact. Sub-scale analysis reveals the most profound differences localized in Reading Comprehension and Hanzi Character Writing

The critical analytical focus, however, rests on the between-group comparison at the post-test stage. An independent-samples t-test revealed that the Experimental Group ($M = 74.60$, $SD = 8.55$) significantly outperformed the Control Group ($M = 58.30$, $SD = 9.40$), yielding $t(448) = 19.24$, $p < 0.001$. Furthermore, the calculated Cohen's d effect size reached 1.81. In educational research, an effect size of this magnitude indicates a substantial practical significance, underscoring the robust impact of the tech-integrated constructivist intervention on student learning outcomes.

Additional sub-scale analyses further illuminated the nature of these gains. The most pronounced performance disparities were localized within the Reading Comprehension and Hanzi Character Writing domains, where the experimental cohort scored, on average, 40% higher than their control counterparts. This suggests that the interactive features of the intervention were particularly effective in facilitating complex cognitive tasks associated with character recognition and reproduction.

5.4 Qualitative Findings (In-Depth Thematic Analysis)

To contextualize and provide explanatory depth to the quantitative outcomes, semi-structured qualitative interviews were conducted with 15 experienced instructors. Following a rigorous iterative thematic coding process, three prominent and highly interrelated themes emerged, shedding light on the pedagogical mechanisms driving the statistical improvements.

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Table 4: Summary of Qualitative Themes and Representative Instructor Insights

Theme	Core Pedagogical Mechanism (Findings)	Representative Quote (Participant)
Theme 1: Mitigation of Cognitive Overload	Gamified spaced-repetition apps automate rote character memorization, reducing learner anxiety and freeing class time for communicative practice.	*"Previously, the sheer volume of stroke-order memorization induced severe affective barriers. Now... the burden is entirely offloaded."* (Instructor 4, Female)
Theme 2: Catalyzing Learner Autonomy	Digital dashboards and competitive gamification shift students from passive reception to active, self-regulated preparation.	*"The gamified elements... ignited a competitive autonomy. Students assumed greater ownership of their extracurricular study."* (Instructor 9, Female)
Theme 3: Irreplaceability of Human Mediation	Current AI fails to accurately correct cross-linguistic phonetic interference (e.g., mapping Chinese tones to Vietnamese tones), necessitating human intervention.	*"Technology excels in visual and motor skill reinforcement, but... currently fails to correct specific interlingual errors... [requiring] the critical ear of a trained educator."* (Instructor 12, Male, PhD)

Theme 1: Mitigation of Cognitive Overload in Hanzi Acquisition

Instructors consistently reported that transitioning from traditional rote memorization to gamified, spaced-repetition applications significantly alleviated students' cognitive load and foreign language anxiety. The automated systems effectively managed the mechanical aspects of character writing, transforming the classroom dynamic. As Instructor 4 (Female, 12 years of experience) articulated: "Previously, the sheer volume of stroke-order memorization induced severe affective barriers. Now, the burden of monitoring stroke accuracy and providing immediate corrective feedback is entirely offloaded to applications like Skritter. This allows instructors to allocate valuable classroom time to communicative pragmatics and cultural nuances, rather than policing mechanical drawing tasks."

Theme 2: Catalyzing Learner Autonomy and Intrinsic Motivation

The integration of digital dashboards and progress visualization tools within Learning Management Systems (LMS) and mobile applications actively fostered self-regulated learning behaviors. Participants noted a paradigm shift from passive reception to active engagement. Instructor 9 observed: "Vietnamese learners traditionally exhibit a passive learning style, often relying on teacher-directed instruction. However, the gamified elements—such as points and leaderboards on platforms like Kahoot and Quizlet—ignited a sense of competitive autonomy. Students assumed greater ownership of their extracurricular study, often arriving at class with pre-acquired vocabulary, intrinsically motivated to apply it in communicative contexts."

Theme 3: The Irreplaceability of Human Mediation in Tonal Acquisition

Despite acknowledging the substantial benefits of digital tools for reading and writing orthography, instructors expressed critical reservations regarding the efficacy of current Artificial Intelligence (AI) in facilitating phonetic mastery. They explicitly highlighted the limitations of technology in addressing cross-linguistic interference. Instructor 12 (Male, PhD, 15 years of experience) provided a crucial insight: "While technology excels in visual and motor skill reinforcement, it currently falls short in auditory and articulatory training. Existing AI speech recognition systems frequently fail to correct specific interlingual errors, such as when a student erroneously maps a Chinese falling tone to the Vietnamese 'dấu nặng' (heavy tone). The algorithms often register this as accurate. Addressing such nuanced phonetic interference necessitates the critical ear of a trained educator and the dynamic, real-time negotiation of meaning found in peer-to-peer communication."

This final theme robustly corroborates the study's foundational constructivist premise: technology functions optimally as a supplementary scaffolding mechanism, not as a wholesale substitute for human-guided, interactive pedagogy.

6. DISCUSSION

The primary overarching objective of this extensive study was to empirically evaluate the implementation and psychological reception of a technology-enhanced, constructivist pedagogical model in Vietnamese CFL higher education classrooms. The triangulated findings provide robust, multi-dimensional, and highly actionable insights that significantly advance both theory and practice.

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6.1 Validation of the Technology Acceptance Model in a New Context (Addressing RQ1)

The SEM results definitively validated the application of the TAM framework within the highly specific Vietnamese language education context. The strong predictive power of Perceived Ease of Use (PEOU) on both Perceived Usefulness (PU) and Attitude Toward Using (ATU) aligns perfectly with foundational literature (Venkatesh & Davis, 2000) and highlights a critical reality in developing educational ecosystems: usability absolutely dictates adoption. If digital tools are overly complex, prone to lagging on sub-optimal campus Wi-Fi, or demand a level of digital literacy the students do not possess, their perceived pedagogical value plummets instantly. Because the experimental intervention deliberately utilized intuitive, highly mobile-friendly, and lightweight platforms (e.g., Quizlet, Kahoot!), cognitive resistance was aggressively minimized. This allowed students to rapidly recognize the intrinsic usefulness of the tools for mastering difficult Chinese vocabulary.

6.2 Pedagogical Transformation and Cognitive Offloading (Addressing RQ2)

Regarding RQ2, the experimental group's remarkable outperformance (+32.80 points improvement vs. +15.80 points for the control group, Cohen's d = 1.81) provides undeniable, concrete empirical evidence that integrating technology within a strict Constructivist framework yields vastly superior linguistic acquisition compared to traditional, teacher-centric methods.

This finding strongly corroborates Wang's (2005) assertions regarding cognitive offloading in Hanzi acquisition. Human working memory is strictly limited. By utilizing MALL technology for the lower-order cognitive tasks (rote memorization, stroke order mechanics, basic vocabulary drilling), incredibly valuable synchronous classroom time was liberated. Instructors successfully shifted from being knowledge transmitters to facilitators. They could then focus classroom energy on higher-order constructivist activities: complex role-playing, spontaneous communicative tasks, and cultural debate. The technology did not merely deliver content faster; it fundamentally transformed the spatial, temporal, and cognitive boundaries of the language classroom.

6.3 The Limits of Technology and the Necessity of TPACK (Addressing RQ3)

Finally, the qualitative thematic analysis (RQ3) brilliantly illuminated the strict boundaries of CALL. The instructors' profound feedback regarding phonetic instruction highlights a crucial psycholinguistic phenomenon: L1 phonetic transfer. Vietnamese learners frequently and unconsciously superimpose their native 6-tone system onto the Mandarin 4-tone system. Current automated speech recognition (ASR) technologies, trained on broad data sets, often lack the granular phonetic sensitivity to provide effective, immediate corrective feedback for these specific cross-linguistic errors.

Therefore, the core Social Constructivist tenet—that complex language is a socially mediated activity—remains paramount. Peer-to-peer interaction and expert (teacher) scaffolding within the ZPD are utterly indispensable for oral-aural communicative competence. This dramatically underscores the necessity of TPACK: teachers must possess the high-level pedagogical wisdom to know precisely when to use technology (for vocabulary, reading, and writing mechanics) and exactly when to rely on traditional, messy, human interaction (for tonal correction, pragmatic nuance, and conversational fluency).

6.4 Novelty and Academic Contribution

This study bridges a massive gap in the existing literature by moving far beyond the descriptive, observational CALL studies prevalent in Vietnam. It provides a statistically validated structural equation model linking psychological adoption metrics with actual, standardized linguistic achievement in a large sample. Furthermore, it successfully localizes international theoretical frameworks (TAM, TPACK, Constructivism) to the unique psycholinguistic characteristics of Vietnamese learners acquiring a complex logographic language, offering a scalable blueprint for regional educational institutions.

7. CONCLUSION

This study provides compelling empirical evidence that the integration of educational technology, when grounded in Social Constructivist principles, can substantially enhance Chinese language learning outcomes among Vietnamese university students. The findings demonstrate that Perceived Ease of Use and Perceived Usefulness are significant determinants of technology acceptance and students' intentions to engage in sustained autonomous learning. Furthermore, the experimental results indicate statistically significant improvements in standardized Chinese proficiency, particularly in character retention and reading comprehension. Nevertheless, the qualitative findings highlight that technological integration should complement rather than replace teacher-mediated instruction. While digital tools can effectively facilitate cognitive processing, knowledge acquisition, and individualized practice, teacher-led scaffolding remains indispensable for developing phonetic accuracy, communicative

competence, and pragmatic fluency. These findings collectively suggest that the pedagogical value of educational technology depends not merely on its availability but also on its alignment with learners' cognitive needs and instructional objectives.

The findings also carry important implications for institutional policy, curriculum development, and teacher professional development in Vietnamese higher education. At the institutional level, universities should progressively establish sustainable blended learning environments supported by reliable Learning Management Systems (LMS), adequate digital infrastructure, and accessible campus-wide internet connectivity. At the curricular level, Mobile-Assisted Language Learning (MALL) should be systematically incorporated into asynchronous learning activities, particularly for vocabulary acquisition and Chinese character recognition, while face-to-face instructional time should prioritize interactive, collaborative, and communicative tasks. Such an approach would facilitate a more effective integration of independent digital learning and classroom-based knowledge construction. Equally important, professional development initiatives should move beyond basic information and communication technology competencies towards comprehensive Technological Pedagogical Content Knowledge (TPACK), enabling teachers to select and implement digital tools in accordance with specific linguistic and cognitive challenges encountered by Vietnamese learners. In this respect, institutional investment, pedagogical innovation, and teacher capacity-building should be regarded as mutually reinforcing components of an effective technology-enhanced Chinese language education framework.

Despite its contributions, this study has several limitations that should be considered when interpreting its findings. First, the sample was primarily drawn from universities located in Hanoi and Ho Chi Minh City, which may limit the generalizability of the results to institutions in rural and less economically developed regions. Second, the 15-week intervention period provides evidence of short- to medium-term learning outcomes but does not establish whether these improvements can be sustained over longer periods. Future research should therefore adopt longitudinal and multi-institutional research designs to examine the durability of language acquisition, the development of digital learning autonomy, and the continued use of educational technologies beyond formal university education. Moreover, the rapid development of generative artificial intelligence warrants systematic investigation into the pedagogical potential of Large Language Models (LLMs) as interactive conversational agents and personalized language-learning assistants. Particular attention should be devoted to their capacity to identify and correct cross-linguistic phonological interference, especially tonal production errors arising from differences between Vietnamese and Mandarin. Such investigations would extend the present findings and contribute to a more comprehensive understanding of how emerging technologies can support sustainable, context-sensitive, and pedagogically effective Chinese language education in Vietnam.

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