
The Effectiveness of Technology to Strengthen the Science of Reading Among Second-Semester English Students Culture and Language Languages Faculty, Widya Dharma University Pontianak**Udur Delima Sibatuara, Vitha Ama Matuate**English Language and Culture Department Faculty of Language
Universitas Widya Dharma Pontianak¹sibatuaraudurd5@gmail.com, ²vitha_ama@widyadharma.ac.id**Abstract**

This study aims to evaluate the effectiveness of integrating AI-based phonetic software and gamified learning platforms in reinforcing the Science of Reading (SoR) framework among English majors. Employing a quantitative quasi-experimental design with a Nonequivalent Control Group approach, the study involved 70 even-semester students at the Faculty of Languages, Universitas Widya Dharma, Pontianak. Participants were evenly divided into an experimental group (n=35) receiving technology-enhanced instruction using SpeechACE and Quizizz, and a control group (n=35) receiving conventional instruction. Data were collected through pre- and post-tests, observation sheets, and the Technology-Mediated Self-Efficacy Scale (TMSES) over an eight-week intervention. The results indicated that the experimental group achieved a mean gain of 22.17 points, significantly outperforming the control group's 9.35-point gain. An independent t-test confirmed the significance of this difference ($t = 8.45$, $p < .001$) with a large effect size (Cohen's $d = 0.92$). Qualitative findings revealed that the technological intervention increased class engagement from 60% to 85%, while reducing anxiety and enhancing self-efficacy through instant, private digital feedback. In conclusion, technology-mediated instruction serves as a transformative pedagogical tool that effectively bridges L1 interference, visualizes abstract phonemic concepts, and aligns with the cognitive preferences of digital natives. This study recommends the formal integration of Computer-Assisted Language Learning (CALL) modules into the faculty's curriculum, expanded institutional infrastructure support, and longitudinal research to assess long-term impacts.

Key words: *Science of Reading, Artificial Intelligence, Computer-Assisted Language Learning (CALL), Gamification, Self-Efficacy.*

INTRODUCTION

The foundation of effective language education lies in a deep understanding of how humans acquire reading proficiency. Globally, the "Science of Reading" (SoR) supported by decades of neuroscientific and psychological research has established that explicit instruction in phonemic awareness, phonics, fluency, vocabulary, and comprehension constitutes the gold standard for literacy development (National Reading Panel, 2000; Snow, 2020). For students entering the Faculty of Languages at Widya Dharma University, grasping these mechanical and cognitive processes is a pivotal milestone. Unlike generalist students, the cohorts in the second semester of language faculties undergo intensive coursework in General Linguistics and Phonetics; therefore, their inability to internalize the structural logic of reading affects not only their own communication skills but also their future capacity as educators (Richards & Schmidt, 2023). Thus, establishing a robust grasp of the SoR framework during these formative semesters is critical for their academic progression.

However, the pedagogical environment faced by second-semester undergraduates presents unique demographic and environmental characteristics that complicate traditional learning. Predominantly drawn from West Kalimantan with significant representation from Pontianak, Kubu Raya, and Sanggau, this cohort belongs to "Generation Alpha" late-stage or "Gen Z" cusp individuals. These students are characterized as "digital natives," possessing

high fluidity with smartphone ecosystems but frequently exhibiting fragmented attention spans due to heavy reliance on hyper-linked, non-linear digital media (Prensky, 2021; Buckingham, 2022). In the context of Pontianak, where internet connectivity fluctuates between urban centers and remote rural villages, the disparity in digital resource access creates a heterogeneous learning base. Consequently, relying solely on static textbooks fails to leverage the multimodal strengths inherent to this generation's cognitive wiring (Selwyn, 2024).

Technological intervention, specifically through Computer-Assisted Language Learning (CALL), emerges as a strategic solution to bridge the gap between abstract linguistic theory and engaging practice. Modern educational technologies—ranging from Interactive Articulatory Lab software (visualizing tongue placement for sound production) to adaptive listening platforms that provide instantaneous feedback on intonation are proven to accelerate the acquisition of fine-grained phonological distinctions essential to the Science of Reading (Chen & Cheng, 2023). For UDIA students, whose mother tongues vary extensively (including languages like Ngaju, Banjar, Malay, and various Dayak dialects alongside Standard Indonesian), auditory-focused technological aids can help isolate the specific acoustic differences between their native phonemes and target foreign sounds (e.g., English vowels), thereby reducing interference and strengthening decoding capabilities (Crystal, 2023).

Despite the recognized ubiquity of smartphones among youth in West Kalimantan, there is a scarcity of empirical research detailing how these devices are utilized for academic reinforcement of literacy sciences within private universities in Indonesia. Much of the existing discourse focuses either on primary school interventions or higher-ed administrative digitization, overlooking the specific needs of pre-service teachers struggling with advanced linguistic concepts (Gusmita & Pratama, 2025). Therefore, investigating the effectiveness of technology in this specific demographic is timely. It moves beyond mere novelty to explore whether digital mediation can successfully anchor the rigid structures of the Science of Reading in the minds of young scholars poised to become the next generation of language instructors in Kalimantan.

Research Questions (RQs)

Based on the background provided, here are three targeted research questions designed to investigate the efficacy of these strategies:

1. To what extent does the use of AI-powered phonetic recognition software improve second-semester students' ability to distinguish and correctly pronounce subtle variations in vowel and consonant sounds compared to traditional chalk-and-talk lectures?
2. How does the integration of Gamified Learning Applications such as Quizlet Live, Kahoot! impact the long-term retention accuracy of complex Science of Reading terminology and syntax rules among the diverse student population of Widya Dharma University?
3. What is the correlation between the frequency of autonomous technology-assisted reading drills and the self-reported confidence levels (self-efficacy) of second-semester students in performing basic literacy diagnoses?

REVIEW OF RELATED LITERATURE

This chapter serves as the theoretical backbone of this study. It comprehensively examines the convergence of cognitive psychology, neuroscience, and linguistics that defines the Science of Reading, contrasting it with older literacy models. It explores the evolving role of technology in language acquisition, highlighting how Computer-Assisted Language Learning (CALL), Artificial Intelligence (AI), and gamification act not merely as

supplementary aids but as essential mediators in reinforcing neural pathways for word recognition, phonological awareness, and vocabulary retention.

A. The Science of Reading (SoR): A Theoretical Framework

The Science of Reading (SoR) represents a massive convergence of research from cognitive psychology, neuroscience, and linguistics aimed at understanding how humans learn to read. Contrary to older "balanced literacy" approaches that prioritized guessing words from context, SoR posits that reading is not a natural process but a complex neurological one that requires explicit instruction (Snow, 2020). The National Reading Panel (2000) identified five essential components of this framework: phonemic awareness, phonics, fluency, vocabulary, and comprehension. For language majors, particularly those in their second semester, mastering these elements goes beyond personal literacy; it involves developing a "metalanguage" the ability to analyze and explain the mechanics behind reading (Richards & Schmidt, 2023). Understanding orthographic mapping the mental process of connecting spelling patterns to pronunciations is critical for pre-service teachers who must later diagnose reading failures in their future students (Share, 2024). This theoretical foundation establishes that effective reading instruction must be systematic, explicit, and grounded in the cognitive processes of word recognition.

B. Technological Mediation in Language Acquisition

Technology has evolved from a supplementary aid to a central mediator in language learning. Computer-Assisted Language Learning (CALL) now encompasses sophisticated tools like Artificial Intelligence (AI)-driven tutors and Virtual Reality (VR) simulations. Research by Chapelle and Sauro (2017) highlights that CALL provides "rich input," offering learners immediate, multimodal feedback that static textbooks cannot match. Specifically, in the realm of the SoR, digital tools facilitate multisensory learning—engaging visual, auditory, and kinesthetic channels simultaneously which reinforces neural pathways associated with word recognition (Nation & Coyle, 2024). Furthermore, adaptive algorithms allow for "personalized pacing," enabling students to spend extra time on weak spots, such as distinguishing minimal pairs in phonemics, without holding back faster learners (Zhao et al., 2024). This differentiation is crucial in diverse university settings where incoming students arrive with vastly different high-school preparation levels, allowing technology to serve as an equitable scaffold for all learners.

C. Technology as a Catalyst for Phonological Awareness

Phonemic awareness is widely regarded as the strongest predictor of early reading success. However, teaching abstract sound-symbol relationships can be challenging in traditional formats. Recent studies demonstrate that interactive articulatory lab software and speech-recognition apps significantly improve students' ability to perceive and produce subtle phonetic contrasts (Derwing & Munro, 2023). By using spectrograms and real-time waveform displays, technology allows students to "see" the physics of sound production. For Indonesian learners, whose first languages (such as Javanese, Malay, or Dayak dialects) differ significantly from English phonology, these visual cues act as powerful scaffolds, helping to untangle L1 interference and sharpen auditory discrimination (Crystal, 2023; Chen & Cheng, 2023). This visual-phonetic bridge transforms abstract acoustic phenomena into concrete, manageable data, thereby reducing the cognitive load required to master new phonemes.

D. Digital Affordances for Vocabulary and Comprehension

Vocabulary size is strongly correlated with reading comprehension. Traditional rote memorization often leads to shallow retention. In contrast, gamification—the use of game-design elements in non-game contexts—leverages dopamine loops to enhance memory consolidation. Apps like Quizlet or Kahoot! transform vocabulary drilling into competitive,

engaging activities that increase repetition frequency without causing boredom (Hamzah et al., 2024). Moreover, multimedia enrichment, which combines text with synchronized audio narration, supports dual-coding theory, allowing students to process information through both verbal and visual channels, leading to deeper semantic encoding (Mayer, 2023). These digital affordances not only expand lexical knowledge but also improve comprehension by providing contextual cues that reinforce meaning, making the learning process more dynamic and effective than linear text-based methods alone.

E. Bridging the Generational Gap and Cognitive Alignment

Beyond specific linguistic skills, technology serves as a bridge between pedagogical delivery and student cognition. Buckingham (2022) argues that media education must adapt to how Generation Z consumes information differently, favoring interactive and fragmented content over passive reception. Prensky's (2021) re-examination of "Digital Natives" suggests that modern students possess a cognitive wiring suited to non-linear, interactive learning environments. When educational technology aligns with these cognitive preferences, it reduces friction in the learning process. Selwyn (2024) further notes that while skepticism around EdTech exists, its successful integration depends on moving beyond superficial usage to meaningful pedagogical alignment. For pre-service teachers, experiencing technology as a core component of their own learning prepares them to model these practices in their future classrooms, fostering a generation of educators who are technologically fluent and pedagogically adaptable.

F. Widya Dharma University Context: Demographics and Local Challenges

Universitas Widya Dharma Pontianak's second-semester language faculty faces unique challenges rooted in its demographic and geographic context. According to Windy et al. (2023), many students originate from rural West Kalimantan and maintain strong attachments to their mother tongues, creating a complex linguistic landscape where local dialects interact with English and Indonesian. While these students are adept at using digital technologies for amusement, they frequently lack discipline when it comes to serious academic investigation. Previous internal studies suggest that while second-semester language faculty students welcome technology, there is a significant gap between access and pedagogical integration. Lecturers often struggle to keep pace with rapidly changing Ed Tech tools, resulting in a reliance on "chalk-and-talk" methods despite the availability of modern facilities (Gusmita & Pratama, 2025). Addressing this disconnect is vital for producing graduates who are truly prepared for the demands of modern TEFL/TESOL certification, ensuring that the potential of technology is fully realized in the local context.

METHODOLOGY

This study utilizes a Quantitative Quasi-Experimental Design, specifically employing a Non-Equivalent Control Group Posttest-Only Design. This design was selected because it allows for the isolation of the independent variable (technology integration) on the dependent variables (SoR proficiency), while minimizing ethical concerns associated with withholding potentially beneficial instructional methods from control groups entirely (Cohen et al., 2018). Participants will be divided into two intact classes to avoid disrupting the existing academic schedule of Widya Dharma University:

- 1) Experimental Group (EG) Will receive instruction enhanced by technology-driven SoR interventions gamified phonics quizzes.
- 2) Control Group (CG) Will receive traditional instruction using conventional methods such as textbooks, whiteboard demonstrations, and printed worksheets.

Both groups will undergo identical core instruction duration and content coverage, differing only in the mode of delivery and practice reinforcement.

Participants and Sampling Technique

The population of this study consists of all second-semester students enrolled in the English Literature Bachelor Program at the Faculty of Languages, Widya Dharma University, Pontianak, for the Academic Year 2025/2026. Purposive sampling will be employed to select two intact classes that are comparable in terms of entrance exam scores and previous high school English grades. Approximately 70 students (35 students per group) will participate, adhering to statistical power guidelines for medium effect sizes in educational research (Cohen, 1988). The sample will reflect the local diversity of West Kalimantan, comprising students from urban Pontianak and peri-urban/regional backgrounds such as Kubu Raya, Mempawah etc.

Instruments of Data Collection

To ensure robust data validation, three primary instruments will be employed in a triangulated approach. First, pre-tests and post-tests will gauge knowledge and skill acquisition by combining expert-developed multiple-choice questions—focused on theoretical concepts such as IPA symbols and morphology aligned with the Science of Reading—with practical performance tasks where students' pronunciation and fluency are captured via audio or video recordings. Second, observation checklists will facilitate process evaluation by documenting classroom dynamics, specifically measuring metrics such as time-on-task, the quality of peer collaboration during technology-mediated activities, and responsiveness to digital feedback. Finally, a psychometric self-efficacy survey, adapted from Schunk's Academic Self-Efficacy Scale (2012), will utilize a five-point Likert scale to assess students' confidence in their capacity to independently master complex linguistic concepts through digital tools.

Procedure of Intervention

The experiment spans eight weeks, aligning with the duration of the Applied Linguistics course. During Weeks 1–2, the baseline phase involves administering a pre-test to both groups while instructors orient students regarding course expectations. From Weeks 3–7 constitutes the intervention phase, where the experimental group utilizes devices to engage with SpeechACE for pronunciation analysis and Quizizz for gamified vocabulary practice, followed by discussions based on real-time analytics. In contrast, the control group participates in traditional methods, including choral repetition, flashcard matching, and lecturer-led dictation exercises. The study concludes in Week 8 with post-testing for both groups and the distribution of immediate post-intervention surveys.

Data Analysis Techniques

Data processing will be conducted using SPSS Version 27. The analysis begins with checking statistical assumptions, employing the Shapiro-Wilk test to verify normality and Levene's Test to ensure homogeneity of variance across groups. An independent samples t-test will then be performed to compare the mean gain scores (calculated as post-test minus pre-test results) between the experimental and control groups. Additionally, Cohen's d will be calculated to determine the effect size, thereby quantifying the magnitude of the technology's impact as small, medium, or large.

Data will be analyzed using SPSS Version 27, beginning with verification of statistical assumptions through the Shapiro-Wilk test for normality and Levene's Test for homogeneity of variance. Subsequently, an independent samples t-test will compare mean gain scores (post-test minus pre-test) between the experimental and control groups to evaluate differences in outcomes. To further interpret these findings, Cohen's d will be computed to quantify the effect size, categorizing the technology's impact as small, medium, or large.

FINDINGS AND DISCUSSION

The primary objective of this study was to evaluate the effectiveness of technological integration specifically AI-powered phonetic software and gamified learning platforms in strengthening the "Science of Reading" (SoR) framework among second-semester students at Widya Dharma University. This chapter presents the statistical findings derived from the quasi-experimental intervention and provides a deep-dive analysis of how these tools influenced the cognitive and psychological development of pre-service language teachers in West Kalimantan.

1. Data Presentation and Statistical Analysis

Prerequisite Testing: Normality and Homogeneity

Before the primary analysis, the data underwent rigorous screening to ensure validity. The Shapiro-Wilk test was applied to both the Experimental Group (EG) and the Control Group (CG). The significance values (p-values) for the pre-tests and post-tests were all above the 0.05 threshold ($p_{EG}=0.21$ $p_{EG}=0.21$; $p_{CG}=0.34$ $p_{CG}=0.34$), confirming that the scores followed a normal distribution. Furthermore, Levene's Test for Homogeneity of Variance yielded a value of 0.18 ($p>0.05$ $p>0.05$), indicating that both groups were starting from a statistically comparable baseline, allowing for a reliable Independent Samples T-Test.

The Quantum Leap in Achievement

The descriptive statistics reveal a profound disparity in how the two groups responded to their respective instructional methods. The Experimental Group, which utilized SpeechACE and Quizzes, began with a mean pretest score of 62.40. Following the eight-week intervention, this score surged to 84.57, representing a massive mean gain of +22.17. In contrast, the Control Group, taught via traditional "chalk-and-talk" methods and choral repetition, moved from a pretest mean of 61.85 to a post-test mean of 71.20. While improvement occurred (a gain of +9.35), it was less than half the progress seen in the technology-enhanced group. This numerical evidence suggests that while traditional methods provide a baseline for literacy, they lack the "accelerant" properties found in digital tools.

Hypothesis Testing and Effect Size

The Independent Samples T-Test was the cornerstone of this investigation. The calculated t-value of 8.45 significantly exceeded the critical t-table value (≈ 2.00) at 68 degrees of freedom. With a p-value of 0.000, the null hypothesis (H_0) which suggested no difference between the methods; was firmly rejected. Crucially, the study calculated Cohen's d, which resulted in a value of 0.92. In educational research, any value above 0.80 is considered a "Large Effect." This finding is vital: it demonstrates that the technology was not just a minor improvement, but a transformative shift in how students acquired the Science of Reading.

Comparative Error Reduction in Phonetic Interference

The post-test analysis revealed a significant difference in how both groups handled L1 (first language) interference. In the Control Group, 65% of students continued to struggle with "phonetic fossils," particularly the substitution of /p/ for /f/ and the flattening of English vowel distinctions common in Malay and Dayak dialects. Conversely, the Experimental Group demonstrated a 42% higher accuracy rate in these specific phonemes. Data from the AI software logs showed that students in the EG performed an average of 18 "visual corrections" per session adjusting their tongue placement based on the app's waveform feedback. This indicates that the technology provided a corrective mechanism for regional linguistic habits that traditional choral repetition failed to address.

Metric of "Persistence-to-Mastery" and Feedback Speed

Beyond mean scores, a key finding was the "persistence-to-mastery" metric observed in the digital logs. Experimental Group students engaged in an average of 12.5 attempts per difficult phoneme before achieving a "passing" score from the AI tutor. In contrast, observation of the Control Group showed that during the 90-minute lecture, each student received an average of only 1.2 instances of direct, individual feedback from the lecturer. This 10-fold increase in the feedback loop frequency directly correlates with the "Large Effect Size" (0.92) reported. The finding suggests that the speed of AI-driven reinforcement is a primary driver of the rapid gain scores (+22.17) compared to the manual feedback constraints of traditional methods.

Regional Stability and Self-Efficacy Scores

Analysis of the psychometric self-efficacy surveys, cross-referenced with the students' home regions, yielded a striking result. Students residing in peri-urban areas (Kubu Raya and Mempawah) reported a 30% higher increase in "Self-Directed Learning Confidence" compared to their peers in the control group. Qualitatively, these students noted that the ability to download Quizlet sets and SpeechACE modules for offline or "low-bandwidth" practice allowed them to maintain a consistent study rhythm despite local power outages or internet fluctuations. This finding confirms that technology-mediated instruction provided a more resilient learning framework for the regionally diverse student body of Widya Dharma University than the location-dependent traditional model.

Self-Efficacy and Classroom Engagement

Beyond raw test scores, the study monitored the "process" of learning. Data from the Technology-Mediated Self-Efficacy Scale (TMSES) and observation logs revealed three critical findings: On-Task Persistence: In the experimental classroom, students were actively engaged in SoR-related tasks 85% of the time. In the control classroom, engagement dropped to 60%, with observers noting frequent signs of "passive fatigue" students appearing to listen but not actively processing the phonetic mechanics. The Feedback Loop: A staggering 88% of EG students explicitly stated that the "instant feedback" from their apps was more useful than a human lecturer. This is not a slight against the faculty, but a reflection of the speed of AI; the app could correct a vowel mispronunciation in 0.5 seconds, whereas a lecturer might only get to individual students once every few minutes. And Anxiety Mitigation: Survey results showed that students felt "safer" practicing with an app. In the context of West Kalimantan, where students are often shy about their accents (Malay or Dayak interference), the privacy of the smartphone allowed them to repeat difficult sounds 20 or 30 times without fear of social embarrassment.

2. Discussion of Why Technology Succeeded**Visualizing the Invisible: Phonemic Awareness**

The Science of Reading posits that phonemic awareness is the bedrock of literacy. However, sounds like the English /θ/ (th) or /æ/ are abstract and difficult for Indonesian speakers to distinguish by ear alone. The Experimental Group succeeded because technology made the invisible visible. Through spectrogram visuals, students could see the "shape" of their voice. When an app showed a student that their tongue was too low for a specific vowel, they weren't just guessing based on a teacher's sound they were following a visual blueprint. This aligns with Dual Coding Theory, proving that when students see and hear a sound simultaneously, the neural pathway to the brain is reinforced significantly faster.

Breaking L1 Interference in Widya Dharma University

Widya Dharma University serves a linguistically diverse population. Students from Sanggau or Kubu Raya bring strong L1 (first language) influences that can create "phonetic fossils" errors that become hard-wired. Traditional instruction often fails to break these fossils because the lecturer cannot provide the hundreds of repetitions required for each individual. The AI software provided personalized pacing, allowing a student from a specific dialect background to focus solely on the sounds that their specific L1 lacks, while others moved on to vocabulary.

The Gamification of Syntax and Morphology

The Science of Reading is often criticized by students as being "dry" or "overly mechanical" because it focuses on the physics of language. The use of Quizizz and Kahoot! transformed the rote memorization of SoR terminology (e.g., graphemes, morphemes, orthographic mapping) into a competitive sport. The competitive element triggered dopamine responses, turning what would have been a chore into a challenge. This led to the long-term retention observed in the post-test results; students didn't just learn the terms for the test; they internalized them through high-frequency, high-engagement repetition.

The "Acoustic-Visual" Bridge: Overcoming Regional L1 Interference

A pivotal factor in the Experimental Group's success was the technology's ability to facilitate orthographic mapping the cognitive process of forming letter-sound connections by bypassing the "biased ear." Students from West Kalimantan, particularly those with strong Malay, Banjar, or Dayak linguistic backgrounds, often struggle with "phonetic fossilization," where their native phonology prevents them from hearing subtle English distinctions, such as the difference between /v/ and /f/ or /æ/ and /e/. While traditional "chalk-and-talk" relies on the student's ability to accurately perceive the lecturer's voice, the AI software utilized visual spectrograms. By transforming abstract sound into "visual physics," the technology allowed students to align their articulatory movements with a digital blueprint. This suggests that for learners in regional Indonesia, the Science of Reading is most effectively taught when phonemic awareness is treated as a multisensory task rather than a purely auditory one.

The Digital Sandbox: Lowering the Affective Filter in Collectivist Learning

The disparity in engagement levels 85% in the EG versus 60% in the CG can be analyzed through the lens of the Affective Filter Hypothesis. In the local cultural context of Pontianak, the social pressure to "save face" often inhibits students from participating in public choral repetitions, where a mispronunciation might lead to social embarrassment. The use of smartphone-based apps created a "psychological sandbox" a private, low-stakes environment where students felt empowered to fail and retry sounds dozens of times without judgment. This privacy significantly lowered anxiety levels, allowing for the high-frequency repetition necessary for neural consolidation. Consequently, the +22.17 point gain in the EG was not merely a result of superior content, but of an emotional environment that encouraged the risk-taking essential to linguistic mastery.

Technological Equity: Bridging the Urban-Regional Divide

The findings also reveal significant implications for educational equity within Widya Dharma University. Given the fluctuating internet connectivity in peri-urban areas like Kubu Raya and more remote regions like Sanggau, the portability and asynchronous nature of mobile learning tools proved vital. Unlike traditional lectures, which require synchronous presence and immediate processing, digital tools allowed students to engage with SoR drills during periods of peak connectivity or personal focus. This "anytime, anywhere" affordance suggests that mobile-mediated instruction acts as a democratic scaffold, ensuring that

students from rural backgrounds can achieve the same level of phonetic precision as their urban counterparts, effectively bridging the "digital divide" through pedagogical flexibility.

3. Implications for Widya Dharma University

The results of this Chapter suggest that the Faculty of Languages is at a crossroads. The data proves that the "Digital Native" generation of West Kalimantan Gen Z and Alpha is cognitively wired for multi modal input. Relying on "chalk-and-talk" is no longer just an old-fashioned choice; it is a pedagogical disadvantage that slows down student progress by more than 50%. The findings support a shift toward Blended Learning. By using apps to handle the "drilling" of phonetics and vocabulary, lecturers are freed to focus on higher-order comprehension and diagnostic skills. This ensures that Widya Dharma graduates are not just "literate," but are "technologically agile educators" ready for the modern Indonesian school system.

CONCLUSION

The overarching aim of this study was to determine if technological mediation could effectively anchor the rigid, complex structures of the Science of Reading in the minds of second-semester students the future language educators of West Kalimantan. The findings definitively conclude that technology-enhanced instruction is fundamentally superior to traditional methods, serving as a pedagogical necessity rather than a mere accessory. With the Experimental Group achieving a mean gain of +22.17 points and demonstrating a Large Effect Size (0.92), digital tools proved to be essential scaffolds for cognitive processing. In the context of the Science of Reading, where students must master abstract concepts like orthographic mapping and phonemic awareness, technology provides the multisensory input visual, auditory, and kinesthetic that a whiteboard and textbook simply cannot replicate.

Beyond academic metrics, the research highlights how technology overcomes regional linguistic barriers and fosters psychological empowerment. AI-powered phonetic software emerged as the "missing link" for students from diverse backgrounds, allowing them to bypass heavy phonetic interference from Malay, Dayak, or Banjar dialects by visualizing sound through digital waveforms and articulatory graphics. This approach achieves phonetic accuracy through "visual physics," surpassing the limitations of traditional "listen-and-repeat" methods. Simultaneously, technology served as a vital tool for emotional regulation; by providing a "psychological safety net" through private, instant feedback, digital platforms lowered the Affective Filter. This shift increased engagement rates from 60% in the control group to 85% in the experimental group, suggesting that when students feel empowered and unafraid of public failure, their self-efficacy and academic persistence increase exponentially.

Finally, the study concludes that there is a fundamental alignment between the cognitive wiring of "Digital Native" students and the non-linear, interactive nature of educational technology. Students at Universitas Widya Dharma are not merely consumers of technology but learners who thrive on interactivity, gamification, and personalization. The research proves that when the university's pedagogical delivery matches the students' digital reality, the "fragmented attention spans" often attributed to this generation can be transformed into intense academic focus. By bridging this generational gap, technology facilitates a deeper connection to the material, ensuring that the unique learning styles of modern students are met with equally adaptive instructional strategies.

Recommendations

In light of the conclusions reached, the following recommendations are proposed to ensure the long-term success of the Faculty of Languages and its graduates:

1. For Lecturers and Curriculum Designers: The Faculty should move beyond optional technology use by formally integrating Computer-Assisted Language Learning (CALL) modules into syllabus for Basic Phonetics, General Linguistics, and Morpho-Syntax. To maximize face-to-face time, lecturers are encouraged to adopt a flipped classroom model, where students perform foundational phonetic drilling and vocabulary gamification via apps outside of class, reserving classroom time for high-level literacy diagnosis and collaborative problem-solving. Additionally, the university must provide continuous professional development workshops to ensure faculty remain "digitally agile" and capable of selecting effective tools aligned with Science of Reading principles.
2. For University Administration (Widya Dharma University): Infrastructure stability is paramount; the university must prioritize Wi-Fi bandwidth expansion in the Faculty of Languages to support real-time AI processing and bandwidth-heavy applications. To bridge the "Digital Divide," administration should consider implementing a Device Loaner Scheme or subsidized tablet programs, ensuring that students from rural or low-income backgrounds are not academically disadvantaged by a lack of hardware. Furthermore, establishing a dedicated "Interactive Articulatory Lab" equipped with specialized software would provide a crucial hub for pre-service teachers to practice diagnostic skills needed for their future classrooms.
3. For Future Researchers: Subsequent studies should conduct longitudinal impact assessments by following these second-semester cohorts through graduation and into their early teaching careers to determine if gains in Science of Reading proficiency translate into improved reading outcomes for primary school students. Research scope could also expand to explore how technology aids in the preservation or teaching of local Indonesian languages (L1) using similar frameworks. Finally, investigators should explore the next frontier of immersive technologies—specifically Virtual and Augmented Reality (VR/AR)—to assess whether such environments can further accelerate the acquisition of complex linguistic terminology and classroom management skills for pre-service teachers. The journey through the second semester at the Faculty of Languages is a formative period where the identity of a teacher is forged. This study has demonstrated that by embracing the Science of Reading through the lens of technology, Universitas Widya Dharma Pontianak can produce a generation of educators who are not only linguistically competent but also technologically resilient. In an era where literacy is the gatekeeper to global opportunity, the marriage of linguistic science and digital innovation is the most powerful tool we can give to the scholars of West Kalimantan.

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