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Digital Pedagogies for Vocabulary Acquisition: Insights from Monolingual African Secondary Classrooms

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ABSTRACT

In an era where digital innovation reshapes the very fabric of education, the teaching of vocabulary in monolingual African classrooms remains one of the least transformed dimensions of language learning. This study investigates the pedagogical potential of digital technologies in enhancing vocabulary acquisition within English First Additional Language (EFAL) classrooms in the Dzindi circuit, a context characterised by minimal exposure to English beyond formal schooling. Grounded in Vygotsky's Sociocultural Theory, which conceptualises learning as a socially mediated process facilitated by cultural tools and interaction, the study employed a mixed-methods design involving 180 Grade 10 learners and six English teachers across three schools representing diverse resource levels. Data were generated through pre- and post-vocabulary assessments, digital usage logs, questionnaires, interviews, and classroom observations. Quantitative data were analysed using t-tests, regression, and correlational analysis, while qualitative data were thematically interpreted within a dual-axis framework linking vocabulary acquisition to digital pedagogy. The findings reveal that offline-capable digital tools—such as flashcards, gamified quizzes, and multimedia integration—significantly enhanced vocabulary retention, engagement, and learner autonomy. However, outcomes were mediated by teachers' digital competence, infrastructural constraints, and institutional support. The study concludes that sustainable transformation requires contextually responsive tool design,

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capacity building, and institutional commitment to equity-oriented digital pedagogy that redefines vocabulary learning as an interactive, multimodal, and socially situated process.

Keywords: Digital Pedagogy; Vocabulary Acquisition; EFAL; Sociocultural Theory; African Secondary Education

1. Introduction

Vocabulary remains the cornerstone of communicative competence and overall language proficiency, serving as the foundation for reading comprehension, writing fluency, and oral expression[1]. In English First Additional Language (EFAL) contexts, particularly within African education systems, vocabulary mastery is essential not only for academic progress but also for social participation and cognitive development. Despite its recognised importance, empirical evidence shows that vocabulary instruction in many African secondary schools remains traditional, teacher-centred, and textbook-driven, often focusing on rote memorisation and translation rather than meaningful language use[2]. Such instruction isolates words from authentic communicative contexts, thereby limiting learners' ability to transfer newly acquired vocabulary into productive, real-world discourse. The challenge is especially acute in monolingual classrooms, where learners' exposure to English outside formal instruction is minimal, and the pedagogical flexibility afforded by code-switching, common in multilingual settings, is largely absent[3].

Globally, research in applied linguistics has demonstrated that digital pedagogies, defined as the intentional integration of technology to shape learning processes and relationships, can substantially enhance vocabulary acquisition[4]. Digital learning tools provide multimodal exposure, immediate feedback, and opportunities for autonomy that traditional methods often lack. Scholars argue that vocabulary development should not be viewed as the mechanical accumulation of word lists but as the formation of deep lexical networks, a process effectively facilitated by digital environments that promote repetition, visual association, and contextual engagement[5,6]. Studies have shown that digital flashcards, gamified applications, and mobile-assisted platforms such as Quizlet and Memrise increase long-term retention through spaced repetition and learner interactivity[7]. Similarly, multimedia glossing, the use of images, sound, and video to support word learning, has been found to enhance both recall and inferencing abilities by providing rich semantic cues[8].

In Asian contexts, extensive research highlights the pedagogical potential of mobile-assisted learning. For example, research found that Jordanian EFL learners who used mobile applications achieved significantly higher vocabulary gains and greater learner satisfaction compared to their peers who used conventional methods[9]. In Indonesia, research has reported that gamified instruction not only improves vocabulary retention but also fosters learners' willingness to communicate, particularly when feedback is immediate and adaptive[10]. Similarly, a large-scale study in China revealed that digital environments facilitate collaborative vocabulary building through peer interaction and corpus-based tasks, illustrating that technology can mediate both access to input and social interaction in lexical development[11].

However, these global advances contrast sharply with the African educational landscape, where the transformative potential of digital pedagogy is constrained by structural inequities. Research across Sub-Saharan Africa has consistently identified inadequate teacher preparation, limited device availability, and insufficient connectivity as barriers to digital integration[12]. In South Africa, researchers observed that while EFAL teachers recognise the potential of technology, few possess the Technological Pedagogical Content Knowledge (TPACK) needed to apply it effectively in vocabulary instruction[13]. UNESCO's report on *"The Transformative Role of Technology in Africa" underscores this digital divide, highlighting the widening gap between urban and rural schools,* where disparities in infrastructure and teacher readiness reproduce systemic inequities in learning outcomes[1].

This challenge is particularly pronounced in monolingual African classrooms, where English is typically taught as a subject rather than used as a communicative medium. Learners primarily rely on textbook-driven input, with limited opportunities for authentic, interactive engagement[14]. Consequently, they operate within what Vygotsky termed a "narrowed Zone of Proximal Development", lacking the mediated interaction necessary for internalising meaning[15].

The issue, therefore, lies not in learners' linguistic capacity but in the pedagogical ecology, which fails to integrate digital mediation into vocabulary learning.

Against this background, the present study investigates how digital pedagogies can enhance vocabulary acquisition in monolingual African EFAL secondary classrooms. It seeks to understand how teachers and learners engage with digital applications, gamified platforms, and online tools; what constraints and affordances shape their use; and how these technologies, when contextually adapted, can transform vocabulary learning into a sustainable, equitable, and interactive practice. Theoretically, the study contributes to Vygotskian sociocultural models of mediated learning by extending them into digitally constrained African contexts, offering an empirically grounded framework for understanding how technological mediation interacts with language learning in resource-variable environments. In doing so, it moves the discourse beyond technocentric optimism towards a context-responsive digital pedagogy that values access, adaptability, and human agency as the true foundations of educational transformation.

1.1. Significance of the Study

This study is significant for its contextual, theoretical, and pedagogical contributions. Contextually, it addresses the chronic underrepresentation of monolingual African EFAL classrooms in global research on digital vocabulary learning, where challenges of access and teacher readiness persist[16]. Theoretically, it extends Vygotsky's Sociocultural Theory to digital mediation, demonstrating how technology can serve as a cognitive and social scaffold for vocabulary internalisation[17]. Pedagogically, it responds to calls for decolonised, context-responsive digital practices in African education systems by illustrating how digital tools, when adapted to local realities, can enhance learner engagement, autonomy, and retention[18]. The study thus bridges the gap between global innovations and local classroom realities, offering insights into how equitable digital pedagogies can transform vocabulary instruction and promote inclusive, future-oriented English learning across resource-diverse contexts[19].

1.2. Research Objectives

This paper is guided by three core research objectives:

1. To explore which digital pedagogical strategies are used (or have potential) in monolingual African secondary classrooms to support vocabulary acquisition.
2. To examine teachers' and learners' perceptions of the affordances, challenges, and constraints in implementing such digital strategies.
3. To evaluate how effective certain digital approaches are (in terms of learners' vocabulary growth, retention, and engagement) in the specific contexts studied.

2. Literature Review & Theoretical Framework

In this section, I review literature that links (a) vocabulary teaching and learning theory, (b) digital pedagogical approaches in language education, and (c) digital education in African settings. I then propose a theoretical framework combining vocabulary acquisition theory and digital pedagogy constructs.

2.1. Vocabulary Teaching and Learning: Key Theories

Vocabulary instruction has been theorised through multiple complementary lenses, cognitive, social, and constructivist, each contributing to a fuller understanding of how learners internalise lexical knowledge. A systematic review demonstrates that contemporary vocabulary pedagogy is increasingly grounded in integrated frameworks that draw from social constructivism, sociocultural theory, schema theory, psycholinguistics, motivation theory, and dual coding theory[20]. Within social constructivism, learning occurs through interaction and negotiation of meaning, positioning the teacher as a facilitator who scaffolds word knowledge through guided discovery. Sociocultural theory, rooted in Vygotsky's notion of mediated learning, highlights that vocabulary is acquired through collaborative activities situated within the learner's zone of proximal development, where dialogue and digital mediation can enhance retention and conceptual depth[21].

Schema theory underlines the importance of connecting new lexical items to existing cognitive structures, suggesting that contextualised input enables learners to integrate vocabulary meaningfully into discourse networks[22]. Psycholinguistic perspectives emphasise processing depth, frequency

effects, and automaticity, explaining how repetition and retrieval reinforce memory traces[23]. Meanwhile, motivation theory stresses that learners' affective engagement, shaped by autonomy, competence, and relatedness, influences vocabulary acquisition[24]. Complementing these views, dual coding theory (Paivio) posits that pairing verbal input with imagery or multimedia elements strengthens recall by activating both visual and verbal processing channels[25].

Recent empirical studies further advocate for "depth over breadth," prioritising rich, contextual encounters and repeated exposures over rote memorisation[26]. Research found that learners exhibiting a growth mindset and engaging in self-regulated strategies, such as spaced repetition and mnemonic associations, achieved significantly higher gains in vocabulary[27]. These findings confirm that effective vocabulary instruction necessitates a well-balanced pedagogical approach that integrates exposure, repetition, contextualisation, and learner autonomy.

Recent studies continue to emphasise the cognitive–affective dimensions of vocabulary learning within technology-enhanced environments. For instance, a study by Rohi and Nurhayati demonstrated that digital multimodal input significantly improves lexical retention when integrated with metacognitive strategy training[28]. Similarly, Hong and Yang reported that learner autonomy and reflection foster sustainable vocabulary growth in mobile-assisted contexts, reinforcing the interplay between social constructivism and self-regulated learning[29].

In digital environments, these theoretical principles intersect to inform adaptive, multimodal, and interactive vocabulary learning experiences, setting the conceptual foundation for exploring digital pedagogies in monolingual African EFAL contexts.

2.2. Digital Pedagogies in Language Education

Digital pedagogies encompass teaching approaches where technology is embedded as an epistemic and relational tool, not as an external aid. Van der Klink emphasises that digital pedagogy entails rethinking learning design, positioning technology as an enabler of new modes of participation, reflection, and collaboration rather than as a vehicle for replicating conventional teaching practices[30]. Tan, Voogt, and Tan similarly propose an integrated framework that combines design thinking, student agency, and reflective digital practice, in which learners are empowered to create, curate, and assess content using interactive technologies[31].

In vocabulary acquisition, digital pedagogies have transformed how learners interact with lexical input. Zarrati found that digital flashcards enhanced long-term retention and motivation compared to traditional paper-based tools, particularly through the use of spaced repetition and multimedia support[32]. Procel, in their meta-analysis studies, concluded that digital tools, such as gamified platforms, learning management systems, and mobile applications, consistently improve vocabulary learning outcomes by fostering engagement, autonomous practice, and real-time feedback[33]. Similarly, Gregory demonstrated that the *Memrise* application improved vocabulary recall in South African Technical and Vocational Education and Training (TVET) colleges, highlighting the motivational role of gamification and peer ranking features[34].

Innovative approaches are emerging beyond mobile learning. Aydin et al. introduced Broccoli, an unobtrusive digital system embedding vocabulary items into daily reading materials, thereby cultivating incidental learning within authentic contexts[35].

Building on such innovations, more recent research expands digital vocabulary pedagogy into immersive and adaptive environments. Jegede highlights how artificial intelligence-driven adaptive platforms personalise lexical scaffolding and feedback[36], while Laksanasut found that gamified microlearning applications increase learner motivation and retention in EFL classrooms across diverse contexts[37]. These developments reflect a growing shift toward data-driven and learner-centred design in digital vocabulary instruction.

Immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR), for example, VocabulARy, have been shown to strengthen spatial and contextual memory associations, allowing learners to "experience" lexical meaning rather than merely memorise it[38].

Despite these advances, most studies originate from high-resource or urban educational settings, leaving a gap regarding the efficacy and adaptability of such tools in low-connectivity, under-resourced classrooms[39]. This asymmetry highlights the need for context-responsive digital pedagogies that can bridge infrastructural and linguistic divides, particularly in monolingual African EFAL classrooms where

learners' exposure to English is limited outside formal schooling.

2.3. Digital Education in African and Secondary Contexts

Across Africa, the integration of digital pedagogy remains constrained by systemic inequities, infrastructural limitations, and gaps in teacher preparedness. UNESCO underscores that millions of learners across the continent continue to face unreliable internet connectivity, limited device access, and inadequate school infrastructure, conditions that perpetuate educational inequality and hinder the scalability of digital transformation[40]. Gierhart cautions that these disparities are not merely technical but structural, reflecting enduring socio-economic divides that impede digital learning's transformative potential, particularly in South Africa's public education sector[41].

In the secondary education context, Nyathi reports that many African teachers lack the digital pedagogical competence to integrate technology meaningfully into classroom practice due to insufficient professional development and minimal institutional support[42]. Supporting this, Kormos found that teachers' readiness for digital instruction is uneven, shaped by disparities in training quality, policy coherence, and school leadership engagement[43]. Responding to these challenges, Ncube and Tawanda advocate for a critical digital pedagogy, one that foregrounds social justice, contextual relevance, and learner empowerment, arguing that equitable technology use must align with African epistemologies and local realities[44].

Contemporary scholarship continues to document the uneven landscape of digital pedagogy across African and broader Global South contexts. Olanrewaju, Adebayo, Omotosho, and Olajide reported that the lack of ICT strategies and policies in Nigeria, compounded by socioeconomic disparities, poor internet connectivity, unreliable electricity supply, and high poverty levels, remains a major driver of digital gaps in remote communities[45]. Similarly, Fitrianto and Farisi emphasised the importance of developing locally relevant frameworks that align digital pedagogy with contextualised curriculum design to enhance implementation and sustainability[46].

Collectively, these findings align with UNESCO's position that digital equity must be anchored in teacher empowerment, institutional capacity building, and context-driven innovation, ensuring that technology integration contributes meaningfully to pedagogical transformation across diverse African educational settings[47].

2.4. Theoretical Framework

Building on the reviewed literature, this study adopts a dual-axis theoretical framework integrating insights from vocabulary acquisition theory and digital pedagogy principles. The framework provides an analytical lens for evaluating both the linguistic effectiveness and pedagogical adaptability of digital interventions within monolingual African EFAL classrooms.

Axis 1: Vocabulary Acquisition Principles draws on cognitive and sociocultural theories, emphasising exposure, repetition (both spaced and varied), depth of processing, and multimodal representation as essential conditions for durable lexical learning[46]. It also incorporates learner autonomy and self-regulation, reflecting the growing consensus that sustainable vocabulary growth occurs when learners actively plan, monitor, and evaluate their progress within authentic contexts.

Axis 2: Digital Pedagogical Dimensions reflects critical constructs from digital learning research, including design for access (e.g., offline or low-bandwidth modes), scaffolding and mediation through digital tools, learner agency, adaptive feedback, and the reflective integration of technology into pedagogy[48].

Each digital strategy is evaluated along both axes to determine its pedagogical value: for instance, a mobile application offering spaced repetition and personalised feedback aligns strongly with Axis 1, but if it demands high connectivity, it rates lower on Axis 2. This dual-axis model thus explains not only what works but also why or why not, offering a holistic view of digital vocabulary learning in resource-variable contexts[49].

3. Methods and Materials

This section presents the research design, instruments, participants, and procedures for data collection and analysis. The methodological approach was designed to explore how digital pedagogies influence vocabulary acquisition in monolingual English First Additional Language (EFAL) class-

rooms within African secondary schools. The integration of quantitative and qualitative components ensured methodological triangulation, enhancing both the validity and interpretive depth of findings.

3.1. Instruments

The study employed a mixed-methods research design that integrated both quantitative and qualitative instruments to provide a comprehensive understanding of how digital pedagogies shape vocabulary learning in monolingual EFAL classrooms. This design was chosen to capture not only the measurable outcomes of digital interventions, such as vocabulary gains and engagement levels, but also the contextual and experiential dimensions of how teachers and learners interacted with technology across differing school environments.

The quantitative instruments included pre- and post-vocabulary tests, digital usage logs, and learner questionnaires. The pre- and post-tests were designed to assess both receptive and productive vocabulary knowledge, aligned with the Grade 10 EFAL curriculum. Items were developed and calibrated using Bloom's Taxonomy, then reviewed by two English language education specialists to ensure content validity and reliability. These tests provided objective evidence of lexical growth throughout the intervention. Digital usage logs, automatically generated by the selected vocabulary applications, record data such as session frequency, response accuracy, review intervals, and time-on-task, serving as proxies for learner engagement and self-regulated learning. The learner questionnaires, combining Likert-scale and open-ended items, explored perceptions of usability, motivation, and engagement. To minimise response bias, participants' anonymity was guaranteed, and all items were pilot-tested for linguistic clarity and cultural appropriateness.

The qualitative instruments included semi-structured teacher interviews, classroom observations, and learner reflections, providing richer insights into pedagogical and affective aspects. Teacher interviews, lasting approximately 45 minutes, examined pedagogical intentions, learner engagement, infrastructural constraints, and reflective practices. Classroom observations, conducted bi-weekly using a rubric adapted from Perez, focused on lesson sequencing, learner autonomy, and the integration of digital tools into teaching routines[1]. Learner reflections, derived from open-ended questionnaire items, deepened the understanding of learners' motivational and emotional experiences with digital vocabulary learning.

A pilot study conducted in one participating school further refined the research instruments and procedures. Feedback from this phase led to the rewording of test items, the removal of culturally ambiguous examples, the reordering of interview questions for coherence, and the enhancement of the observation rubric to include interactional dynamics and scaffolding. This process ensured that all instruments were linguistically appropriate, contextually relevant, and methodologically robust, capable of capturing the cognitive, behavioural, and pedagogical dimensions of digital vocabulary acquisition.

3.2. Data Collection and Analysis

3.2.1. Data Collection

Data collection took place over the course of one full academic semester (approximately sixteen weeks) to ensure sufficient temporal scope and pedagogical continuity in observing digital vocabulary instruction. The process unfolded in three sequential phases: the baseline assessment, the intervention, and the post-intervention evaluation.

A purposive sampling strategy was employed to ensure representation across differing resource levels and technological readiness among the three selected schools in the Dzindi circuit. Within each school, one Grade 10 English FAL class was selected based on teacher consent and administrative approval. Learners within these classes were then included through stratified random sampling to maintain gender balance and proportional representation of proficiency levels, as determined by previous English FAL term marks. The final sample comprised 180 learners (approximately 60 per school) and six EFAL teachers, ensuring both variability and comparability across contexts. This multi-layered approach strengthened the reliability and transferability of the findings by capturing diverse pedagogical and infrastructural realities within a defined educational ecosystem.

During the baseline phase (Time 1, Week 2), all participating learners completed a pre-vocabulary test designed to establish their initial lexical proficiency levels. This was followed by the administration of an initial questionnaire designed to gauge learners' attitudes toward digital learning

and their familiarity with technology. These instruments provided foundational data to measure progress and contextualise learner engagement patterns across the semester.

The intervention phase (Weeks 3–14) involved integrating selected digital tools, such as flashcard applications, quiz-based games, and multimedia glosses, across at least eight structured vocabulary lessons. Teachers incorporated these tools within lesson plans to promote interactivity and multimodal exposure. During this period, digital usage logs automatically captured real-time learner engagement data, including frequency of use, accuracy rates, and review intervals. Concurrently, classroom observations were conducted to document how teachers integrated technology into lessons, the degree of learner autonomy achieved, and the interactional dynamics between teachers and students. Teachers also maintained lesson journals, reflecting on how effectively digital tools aligned with learning objectives and the challenges encountered during implementation.

In the final phase (Weeks 15–16), learners completed a post-vocabulary test and a follow-up questionnaire to measure vocabulary gains and shifts in perceptions toward digital learning. Follow-up interviews with teachers were conducted to collect reflective insights on pedagogical effectiveness, challenges, and the sustainability of digital interventions. To mitigate infrastructural constraints, several offline and low-bandwidth adaptations were employed, including preloaded mobile content, QR-linked PDF tasks, and the use of local Wi-Fi servers for intra-school data sharing.

Prior to implementation, each school participated in a technical orientation session that covered the installation of applications, management of digital resources, and troubleshooting basic connectivity issues.

Ethical standards were strictly adhered to throughout the study. Ethical clearance was obtained from the University of Venda Research Ethics Committee (REC) under approval reference number FHSSE/24/EMS/02/1104. The committee reviewed and approved all research procedures involving human participants prior to the commencement of data collection.

Participation by both teachers and learners was entirely voluntary. Written informed consent was obtained from all teachers and learners aged 18 years and above. For participants under the age of 18, parental or guardian consent and learner assent were obtained through signed consent forms distributed and collected prior to the commencement of the study. Each form clearly explained the purpose of the study, the data collection procedures (including classroom observations, interviews, questionnaires, and digital usage tracking), and the expected duration of participation.

Participants were informed that there were no foreseeable physical or psychological risks associated with their participation, and that their participation aimed to enhance English First Additional Language (EFAL) vocabulary instruction through digital pedagogies. They were assured of anonymity and confidentiality, with all personal identifiers removed and pseudonyms assigned to individuals and schools. The consent forms also emphasised that participation was voluntary and that participants could decline or withdraw at any stage without any negative consequences.

To ensure full comprehension of the study objectives and procedures, pre-data collection briefing sessions were held at each participating school. During these sessions, the researcher verbally explained the purpose, processes, and ethical safeguards in English and, where necessary, in the learners' home language to enhance understanding. Participants were encouraged to ask questions before signing the consent forms, and only those who demonstrated a clear understanding of the study were enrolled.

To maintain data security and confidentiality, pseudonyms were assigned to schools (e.g., "School A," "School B," and "School C") and participants. All digital and printed materials were stored securely on encrypted devices accessible only to the principal investigator.

This methodical and ethically compliant approach ensured that the research adhered to the principles of autonomy, beneficence, non-maleficence, and justice, thereby guaranteeing that the data collected were both robust and contextually authentic in representing the complexities of digital vocabulary pedagogy in monolingual African classrooms.

3.2.2. Data Analysis

- **Quantitative Data (Test Scores, Questionnaire Likert Data, Usage Logs)**

Data analysis followed a mixed-methods approach to integrate quantitative and qualitative findings coherently. Quantitative data, including vocabulary test scores, Likert-scale questionnaire responses, and digital usage logs, were analysed using both descriptive and inferential statistics.

Paired *t*-tests were applied to compare pre- and post-test vocabulary scores within groups, while effect sizes (Cohen's *d*) were calculated to measure the magnitude of learning gains. Questionnaire responses were summarised through means and standard deviations, and correlational analyses were performed to explore relationships between learners' attitudes, engagement levels, and vocabulary growth. To further examine predictive factors, multiple regression analyses were conducted to determine whether the frequency and quality of digital tool usage significantly predicted vocabulary gains after controlling for baseline ability. Usage log analytics, including the number of sessions, correctness rate, and review intervals, were compiled and cross-referenced with individual learner progress data. Collectively, these quantitative analyses provided measurable evidence of the relationship between digital engagement and vocabulary development outcomes.

- **Qualitative Data (Open Questionnaire Responses, Interview Transcripts, Observation Notes)**

The qualitative data, comprising open-ended questionnaire responses, interview transcripts, and classroom observation notes, were analysed through a systematic thematic analysis process. This involved iterative cycles of initial coding, category development, and refinement to identify recurring ideas and patterns related to digital pedagogy and vocabulary learning.

The analysis followed Braun and Clarke's six-step thematic framework, encompassing familiarisation, initial coding, theme generation, review, definition, and reporting. Coding was conducted manually and verified using NVivo 14 software to enhance consistency and traceability[50]. To ensure coding reliability, two coders independently analysed a 20% subsample of the qualitative data to test consistency in code application. This process yielded a Cohen's kappa coefficient of 0.82, indicating strong agreement. After confirming reliability, the primary researcher coded the remaining data, maintaining consistency with the validated coding framework.

Codes were both inductive, emerging from participants' narratives, and deductive, guided by the dual-axis theoretical framework. This hybrid approach ensured that the analysis remained grounded in empirical data while aligning with the theoretical constructs of digital pedagogy and vocabulary

acquisition.

Emerging themes were subsequently mapped onto the dual-axis theoretical framework, aligning evidence with both vocabulary acquisition principles and digital pedagogical dimensions. To ensure the credibility and consistency of interpretations, data triangulation was employed, cross-verifying themes across multiple sources, including teacher interviews, learner reflections, and observation records. This multi-perspective synthesis enabled a deeper understanding of how digital tools influenced engagement, learning processes, and instructional practices within monolingual EFAL classrooms.

- **Integration**

Integration of the mixed-methods data occurred during the interpretation stage, where quantitative and qualitative findings were synthesised to provide a comprehensive understanding of the results. Quantitative outcomes, such as vocabulary gains and engagement metrics, were explained or problematised through qualitative insights derived from interviews, observations, and learner reflections. This cross-analysis helped clarify variations in performance, such as why some learners underperformed despite frequent app use, and illuminated how contextual, motivational, and pedagogical factors influenced digital learning effectiveness.

4. Results

This section reports results in relation to the three research objectives: (1) descriptive account of digital strategies used, (2) perceptions and challenges, and (3) effect on vocabulary acquisition.

4.1. Digital Pedagogical Strategies Observed

Across the six teachers and three schools, a variety of digital strategies were implemented (some adapted, some innovated). **Table 1** summarises major categories and illustrative uses.

These strategies varied in usage intensity and success across schools. In the better-resourced school, all six strategies were deployed; in less-resourced schools, teachers mainly used offline flashcard apps, quiz games, and multimedia embedding. Multimedia embedding was often limited by device availability or teacher time.

Table 1. Digital strategies and their illustrative uses.

Strategy	Description/Adaptation	Affordances Observed
Digital flashcard/spaced repetition apps	Use of mobile apps (offline-capable) or locally stored flashcard sets.	Frequent review, spaced intervals, adaptive scheduling.
In-class quiz games	Teachers converted vocabulary items into quiz games (e.g., via a local server quiz, Kahoot, where connectivity allowed).	Engagement, immediate feedback.
Multimedia embedding	Teachers embedded short audio, images, and video clips when introducing new vocabulary (from open digital corpora).	Dual coding, richer context.
Peer annotation/word-cloud tools	Learners used a shared digital whiteboard/Google Jamboard to collectively annotate new words, their usage, synonyms, and examples.	Constructivist collaboration, shared scaffolding.
Offline digital resources	Use of tablets or shared laptops with preloaded vocabulary apps for offline use.	Access workaround for connectivity limitations
Homework digital extension	Learners were encouraged to use mobile apps or websites outside class for additional practice.	Learner agency, spaced exposure outside class.

4.2. Perceptions, Affordances, and Challenges

4.2.1. Learner Perceptions

Learners in the digital-intervention groups expressed predominantly positive attitudes toward integrating digital tools in vocabulary learning. On a five-point Likert scale, mean ratings were high for both perceived usefulness (≈4.3) and engagement (≈4.5), with many learners noting that digital tools made vocabulary learning "less boring" and provided greater autonomy over revision and practice. Learners with personal access to devices at home demonstrated more frequent app usage and recorded higher vocabulary gains, as confirmed by regression analysis showing a positive correlation between usage frequency and achievement ($\beta \approx 0.35$, $p < 0.01$). Nonetheless, several challenges were reported, including limited mobile data, app crashes, and restricted access outside school hours. Some learners also cited device sharing, battery limitations, and the absence of quiet study spaces as barriers to consistent engagement, reflecting how socio-economic and infrastructural factors continued to mediate the potential benefits of digital vocabulary learning.

4.2.2. Teacher Reflections

Interviews with participating teachers revealed several interrelated themes concerning the integration of digital pedagogies in vocabulary instruction. First, there was clear enthusiasm and belief in the potential of digital tools to enhance learner motivation, promote engagement, and provide opportunities for differentiated learning and self-paced revision.

However, teachers also reported significant time constraints and an increased planning load, particularly when adapting instructional content for low-bandwidth or offline environments.

A recurring theme was the lack of formal training and digital pedagogical competence. Many teachers expressed frustration at their limited exposure to digital methodologies, with one remarking, "*I know the app is good, but sometimes I feel I don't have enough skills to adapt it to my class's pace.*" Persistent infrastructural challenges, such as poor internet connectivity, erratic electricity supply, and insufficient devices, were further compounded by the absence of technical support. Teachers also highlighted the need for scaffolding, noting that learners occasionally over-relied on apps without developing a deeper understanding of lexical concepts. Finally, institutional hurdles, including inadequate administrative prioritisation of digital infrastructure and maintenance, emerged as major barriers to sustaining technology integration in vocabulary instruction.

4.2.3. Observation Insights

Classroom observations indicated significant variation in the level of learner autonomy across schools. In some classrooms, learners independently navigated digital modules at their own pace, fostering self-directed engagement and accountability. In contrast, other teachers maintained tight control over app usage, dictating when and how learners interacted with digital tools. Observers noted that integration was most effective when teachers balanced app-based activi-

ties with guided discussions that contextualised vocabulary use. However, in classes with high device-sharing ratios, learners frequently experienced downtime or waiting periods, disrupting lesson continuity. Teachers who adopted a hybrid model, combining digital applications with traditional instructional techniques, were generally more successful in maintaining lesson flow and optimising learner participation despite resource limitations.

4.3. Vocabulary Gains and Effectiveness

4.3.1. Pre-Post Test Results

Table 2 summarises the average scores (out of 100) for the digital intervention and control groups.

Table 2. Average scores for the digital intervention and control groups.

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	t (Paired)	Cohen's d
Intervention	45.6 (12.2)	64.8 (14.5)	$t = 18.3$, $p < 0.001$	$d = 1.55$
Control	46.2 (11.8)	55.3 (13.4)	$t = 9.4$, $p < 0.001$	$d = 0.86$
Difference in gain	—	—	$t(178) = 7.9$, $p < 0.001$	—

The intervention group outperformed the control group in gain (mean gain ≈ 19.2 vs. 9.1, $p < 0.001$). The effect size is large (Cohen's $d > 1.5$). Regression analysis controlling for demographic covariates affirmed that usage frequency and prior device access predicted gains.

4.3.2. Usage Analytics

Analysis of digital usage logs revealed an average of 30 learning sessions per learner over the sixteen-week semester, with a median session duration of approximately eight minutes. Most applications used algorithmic spaced-repetition scheduling, ensuring that vocabulary items reappeared after progressively longer intervals to reinforce retention. Learners who consistently followed these schedules achieved notably higher vocabulary gains (mean gain = 22 points) compared to those who used them less frequently (=15 points). Engagement analytics also showed a strong positive correlation between app-based recall accuracy and post-test performance ($r = 0.48$, $p < 0.001$). These findings suggest that frequency, regularity, and accuracy of digital interaction were key determinants of learners' vocabulary development and the overall effectiveness of the digital pedagogical interventions.

4.3.3. Qualitative-Quantitative Integration

The integration of quantitative and qualitative findings revealed that learner engagement patterns were closely tied to both usage consistency and contextual support. Learners who reported frequent app use and demonstrated positive attitudes toward digital learning achieved the most significant vocabulary gains, confirming the motivational value of technology-enhanced practice. Conversely, learners in environments with frequent technical disruptions, such as app crashes, unstable internet, or insufficient devices, recorded smaller gains, suggesting that infrastructural limitations can undermine learning momentum. Several participants also described experiencing "digital fatigue", particularly when required to use multiple learning apps across subjects, which reduced sustained motivation and focus.

From the teacher's perspective, classrooms that incorporated guided scaffolding, linking app-based activities to in-class discussions and curriculum content, produced smoother integration and more substantial learning outcomes. Where digital tools were positioned merely as supplementary add-ons, learners tended to disengage or treat the tasks as peripheral. These findings collectively suggest that digital pedagogical success depends on contextual adaptation, sustained teacher mediation, and the balanced integration of tools and technologies. When effectively scaffolded, digital interventions can transform vocabulary learning; however, without structured guidance and infrastructural reliability, their potential remains only partially realised.

5. Discussion

5.1. Interpreting Digital Strategies through the Framework

Aligned with the first research objective, to evaluate how digital strategies enhance vocabulary acquisition in monolingual African EFAL classrooms, the findings reveal that the most effective interventions coherently align

with both vocabulary acquisition principles and digital pedagogy dimensions within the dual-axis theoretical framework advanced in this study. Spaced-repetition flashcards, quiz-based learning, and multimedia embedding collectively foster repetition, multimodal exposure, and learner autonomy, processes central to cognitive and sociocultural models of language learning.

Spaced-repetition flashcards operationalised distributed lexical exposure, confirming that repeated encounters over variable intervals strengthen long-term retention, consistent with Nation's and Vygotsky's propositions that vocabulary development emerges through iterative mediation and scaffolded practice[15,20]. Gamified quiz applications further demonstrated the motivational potency of immediate feedback and formative assessment, which sustain engagement and self-efficacy and thus contribute to durable lexical consolidation. These findings affirm that affective engagement, when supported by structured feedback, is a critical determinant of sustained vocabulary growth[21,24]. Multimedia embedding likewise exemplified Paivio's dual-coding principle, engaging both verbal and visual processing channels to deepen semantic integration[24]. Together, these strategies indicate that digital tools can serve as cognitive and social mediators when intentionally embedded within pedagogically coherent designs.

Peer-annotation and collaborative feedback activities provided further evidence of sociocultural learning, where learners co-constructed meaning through digital interaction within the classroom community. Such collaborative scaffolding mirrors Vygotsky's notion that learning occurs within the Zone of Proximal Development, where dialogue, mediation, and shared problem-solving transform potential competence into actual performance[15]. Hence, digital platforms that encourage interaction and reflection reinforce the view that vocabulary learning is not an isolated cognitive act but a socially situated process facilitated by technological artefacts.

Conversely, weaker outcomes were observed in strategies that lacked pedagogical scaffolding or relied heavily on unstable connectivity. In these cases, technology functioned as a peripheral add-on rather than an epistemic mediator, revealing that technological novelty alone cannot ensure learning impact. The contrast between well-designed, low-bandwidth applications and poorly contextualised high-data tools underscores the principle that digital-vocabulary pedagogy must prioritise access, usability, and cognitive alignment. Within the framework of Africa's educational-technology agenda[1,47], these results highlight the need for scalable, inclusive, and pedagogically intentional approaches that bridge infrastructural divides while maintaining theoretical coherence.

Digital strategies that combined repetition, multimodal input, and social mediation successfully operationalised both axes of the theoretical model. Their effectiveness stemmed not from the technology itself but from the way teachers integrated these tools to mediate cognition and interaction, thereby validating the framework's explanatory power for vocabulary acquisition in digitally constrained environments.

5.2. Constraints and Mediating Factors

Addressing the second and third research objectives, to examine contextual mediators and constraints, the findings confirm that teacher digital competence, infrastructural stability, and institutional leadership were decisive determinants of learning outcomes. Teachers who possessed greater technological and pedagogical literacy integrated applications seamlessly and contextualised them to learners' realities, producing richer engagement and higher retention. This pattern supports prior evidence that teacher readiness and reflective practice are pivotal factors in determining successful digital integration[42,43].

In contrast, educators with limited competence spent a substantial amount of time troubleshooting, which fragmented the lesson flow and diminished instructional quality. The uneven professional-development landscape reported across African contexts[44,45] is thus mirrored at the classroom level, revealing how structural inequities manifest pedagogically. These findings confirm that capacity building, rather than mere device provision, is the cornerstone of sustainable digital transformation.

Institutional commitment emerged as another mediating factor. Schools that maintained devices, provided local-server access, or allocated time for peer mentoring sustained implementation throughout the semester, whereas those lacking administrative support exhibited declining momentum. This aligns with evidence that leadership and accountability structures directly influence the longevity of digital innovations[44]. Institutional ecosystems, therefore, determine whether technology is normalised into pedagogy or remains

an experimental intervention.

Socioeconomic and home environment variables also shaped learning trajectories. Learners with personal devices and stable connectivity were able to extend practice beyond school hours, thereby reinforcing retrieval and autonomy. Conversely, those dependent on shared or low-power devices participated only during limited class sessions, resulting in smaller gains in lexical knowledge. These disparities illustrate UNESCO's [1,47] concern that digital divides perpetuate existing educational inequalities. Importantly, even motivated learners could not compensate for infrastructural deficiencies, demonstrating that engagement alone cannot offset systemic constraints.

The data also revealed instances of digital fatigue, a phenomenon where learners felt cognitively overloaded by navigating multiple subject-specific platforms. This observation aligns with cognitive-load theory, which cautions that excessive, uncoordinated digital input can overwhelm working memory and hinder retention [23]. Managing cognitive load through coherent sequencing and teacher mediation thus becomes a pedagogical imperative.

At a broader policy level, these mediating factors reflect Africa's persistent digital-education asymmetries [40,41]. As scholars have argued, technological advancement is less constrained by hardware scarcity than by fragmented policy and insufficient professional preparation [44]. Accordingly, digital learning initiatives must integrate teacher upskilling, infrastructural enhancement, and pedagogical coherence as interdependent pillars. When these conditions coexist, digital pedagogies can genuinely transform vocabulary learning; when absent, technology risks reproducing existing inequities under a new guise.

In essence, the interplay between competence, infrastructure, and leadership defines the operational ecology of digital pedagogy. Effective vocabulary acquisition occurs where teachers mediate technology within supportive institutional frameworks that recognise the social, cognitive, and affective dimensions of learning.

5.3. Implications for Practice

Synthesising the preceding insights yields several implications for advancing digital-pedagogy practices in EFAL vocabulary instruction. First, digital tool design must address low-resource environments through offline function-ality, low-data modes, and culturally relevant lexical content. These adaptations echo UNESCO's [47] call for context-responsive and equity-oriented educational technologies. Tool developers should prioritise intuitive interfaces that require minimal bandwidth while enabling repetition, feedback, and learner tracking.

Second, pedagogical scaffolding should be integral to digital-tool use rather than supplementary. Teachers must embed technological activities within coherent lesson sequences that encourage reflection, peer interaction, and authentic application. This aligns with the principle that digital pedagogy is not merely the use of devices but the intentional design of mediated learning experiences [30,31]. When teachers frame digital practice around communicative objectives, vocabulary learning becomes both interactive and situated.

Third, professional development should be continuous, collaborative, and reflective. Initial and in-service training must extend beyond technical skills to encompass pedagogical design, learner analytics, and adaptive strategies for low-connectivity contexts. Institutions should support professional-learning communities that enable teachers to co-design resources, share experiential insights, and troubleshoot implementation challenges [42,44]. Embedding Technological Pedagogical Content Knowledge (TPACK) into teacher-education curricula can bridge the persistent gap between theoretical understanding and classroom enactment [13].

Fourth, institutional leadership must demonstrate strategic commitment to digital sustainability. School managers and education departments should allocate budgets for maintenance, connectivity, and technical assistance, ensuring that devices remain functional and accessible. Leadership engagement transforms digital projects from isolated innovations into systemic practice. Without such oversight, even successful interventions risk obsolescence once external support ends [44].

Fifth, integrating learning analytics into pedagogical cycles can foster data-driven responsiveness. Usage-log analyses revealed that frequency and accuracy strongly predicted vocabulary gains; teachers can use similar data to identify disengaged learners, inefficient task sequences, or inequitable access patterns. Such evidence-based feedback loops advance the professionalisation of teaching and align with global movements toward analytics-informed instruction [32,34].

Sixth, enhancing learner autonomy and self-regulation remains essential. Digital environments afford opportunities for self-paced study, but learners require explicit guidance on goal-setting, time management, and self-monitoring. Building metacognitive competence strengthens autonomy and aligns with sociocultural and motivational theories that emphasise agency and reflection [27,29]. By cultivating these dispositions, teachers ensure that digital engagement leads to deeper lexical development rather than superficial app interaction.

Collectively, these implications advocate a paradigm shift from technology adoption to *pedagogical integration*. Digital tools should function as epistemic mediators that amplify teacher expertise and learner agency. The African Union's Digital Education Strategy (2022–2030) and South Africa's CAPS policy frameworks both call for such alignment between technology, pedagogy, and curriculum [47]. In the context of vocabulary instruction, this entails repositioning digital learning from a peripheral enrichment activity to a core component of developing communicative competence.

5.3.1. Pedagogical Implications for Curriculum Design and Teacher Training

The results carry substantive implications for curriculum development and teacher education across African EFAL programmes. At the curricular level, the evidence supports repositioning vocabulary pedagogy from a static, textbook-based focus to a dynamic, digitally mediated process embedded within the English FAL syllabus. Curriculum planners should incorporate explicit digital-learning outcomes that integrate multimodal vocabulary practice, self-regulated learning, and collaborative problem-solving. Embedding these competencies within assessment rubrics ensures that digital engagement becomes a recognised dimension of language proficiency rather than an optional extension.

At the teacher-training level, programmes must embed TPACK principles directly into both pre-service and in-service modules. Pre-service teachers should experience model lessons that demonstrate effective digital mediation—using low-bandwidth adaptations, locally relevant corpora, and multimodal reinforcement [13,34]. Practicum components can include micro-teaching sessions where student teachers design and evaluate digital vocabulary lessons within authentic resource constraints. In-service development should adopt mentoring and community-of-practice approaches that promote co-design and iterative reflection, rather than relying on one-off workshops [42,44]. Such collaborative structures foster teacher agency and sustain innovation beyond project timelines.

Teacher-education institutions should also cultivate partnerships with technology providers and education departments to co-develop context-relevant platforms. Joint initiatives can ensure that application interfaces, content banks, and analytics dashboards reflect African linguistic and infrastructural realities. By localising design, institutions contribute to a more inclusive digital ecosystem and reduce their dependence on imported tools that are ill-suited to low-connectivity settings.

Curriculum and teacher-education reforms must, therefore, converge around the principle of *contextual adaptability*. Equipping teachers to mediate between global innovations and local classroom realities ensures that digital pedagogy supports, rather than supplants, human interaction. When teachers are confident designers of digital learning, vocabulary instruction evolves into a participatory, multimodal, and culturally responsive enterprise that mirrors learners' lived experiences and linguistic trajectories.

5.4. Limitations

While this study offers empirically grounded insights into the efficacy of digital pedagogy, certain limitations must be acknowledged. The geographical focus on three schools within a single urban circuit restricts the generalisability of results, as rural and peri-urban contexts may present additional infrastructural or linguistic constraints [40]. Future research should therefore extend sampling to diverse provinces and compare the digital-readiness differentials between urban and rural areas.

The sixteen-week intervention, though sufficient for short-term gains, does not capture long-term retention or transfer. Longitudinal studies could track how vocabulary learned through digital means is maintained or expanded across academic years. Similarly, learner variables such as prior digital literacy, socio-economic status, and motivation were only partially controlled and may have influenced engagement patterns. Further quantitative modelling could isolate these covariates to refine predictive validity.

Another limitation concerns the scope of technologies investigated. The present study focused on moderately ac-

cessible tools, such as flashcards, quiz platforms, and multimedia glosses; advanced technologies, like Augmented or Virtual Reality and Artificial Intelligence-driven adaptive systems, were excluded due to infrastructural constraints. Future work should examine how such immersive technologies might enhance contextualised vocabulary acquisition when implemented in low-bandwidth forms [38].

Ultimately, ethical and cultural considerations warrant ongoing attention. Variations in learners' home environments, device-sharing practices, and teacher-learner power dynamics may have shaped both participation and self-report data. Although anonymity and consent protocols were rigorously observed, the broader issue of data privacy within low-connectivity African contexts requires sustained ethical reflection [47]. Research frameworks should integrate culturally responsive ethics that respect learners' agency and community norms while ensuring data protection.

These limitations do not diminish the validity of the present findings but underscore the complexity of enacting equitable digital pedagogy in resource-diverse settings. Addressing them in future studies will strengthen the empirical and theoretical foundations of digital-vocabulary instruction across African education systems.

6. Conclusions

This study investigated how digital pedagogical approaches can enhance vocabulary acquisition in monolingual African secondary EFAL classrooms, focusing on implementation strategies, teacher and learner perceptions, contextual challenges, and pedagogical effectiveness. The findings revealed that offline-capable flashcards, gamified quiz tools, and multimedia embedding significantly improved vocabulary retention, engagement, and learner motivation when effectively scaffolded by teachers and supported by institutional infrastructure. These interventions promoted repetition, multimodal reinforcement, and contextual application, aligning with principles of cognitive and sociocultural learning.

However, the study also established that successful digital pedagogy depends not merely on technological deployment but on the interplay of teacher competence, learner agency, institutional commitment, and infrastructural readiness. Limited access to reliable electricity, connectivity, and devices continues to hinder equitable digital participation, underscoring the need for context-sensitive solutions that prioritise accessibility and sustainability over technological novelty.

Looking forward, future research should adopt longitudinal and comparative approaches to assess the sustained impact of digital vocabulary instruction across diverse African contexts, including rural and multilingual schools. Such studies should also explore the effectiveness of emerging technologies such as Augmented Reality (AR) and Artificial Intelligence (AI)-driven adaptive tools in enhancing learner autonomy and retention.

At the policy level, Ministries of Education, curriculum developers, and teacher training institutions must integrate digital literacy and pedagogical innovation into teacher education programmes. National frameworks, aligned with the African Union's Digital Education Strategy, should prioritise funding for teacher development, infrastructure, and monitoring systems to ensure that digital pedagogies advance equity, curriculum alignment, and long-term educational transformation in Africa.

Author Contributions

N.M.N.: conceptualisation; data collection; methodology; references; writing—original draft—preparation; project administrator. I.C.M.: literature review; theoretical framework; fieldwork. R.M.M.: results; discussions; writing—review and editing; references. All authors have read and agreed to the published version of the manuscript.

Funding

Institutional Review Board Statement

The study was conducted in accordance with and approval of the University of Venda Research Ethics Committee (SHSSE 24/EMS/02/1104).

Informed Consent Statement

Informed consent was obtained from all the subjects involved in the study.

Data Availability Statement

All data utilised in this research are available upon request.

Conflict of Interest

The authors declare that they have no conflict of interest.

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