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RESEARCH ARTICLE

BRIDGING THE LEARNING GAP: EVALUATING THE IMPACT OF DIGITAL LEARNING TOOLS ON SECONDARY SCHOOL EDUCATION IN RURAL COMMUNITIES OF SOUTHWEST NIGERIA

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ABSTRACT

Digital learning tools are now integral to improving teaching and learning around the world, but they continue to be disadvantaged by rural and Nigerian schools due to infrastructural and resource limitations. This study assessed the availability, accessibility, and effect of digital learning tools on secondary school learning among rural communities of Southwest Nigeria. A cross-sectional mixed-methods research study involving 400 students and 50 educators was conducted among sampled rural secondary school educators. Data were captured by questionnaire, academic achievement records in English and Mathematics, and semi-structured interviews among educators and school managers. Quantitative data were described by descriptive statistics, t-tests and ANOVA test, and multiple regression test. On the other hand, thematic analysis was conducted on qualitative data. Results indicate that limited availability exists where the majority identified smartphones (44.8%) and offline e-libraries (32.7%) as the most accessible. Some students who owned digital tools significantly outperformed those who did not on English ($M = 63.4$, $SD = 8.2$) and Mathematics ($M = 59.7$, $SD = 7.9$) by respectively $p < 0.01$. Regression analysis established the frequency of the use of the tools (AOR = 2.35, $p < 0.001$), educators' information and communication technology competence (AOR = 1.87, $p = 0.002$), and internet accessibility (AOR = 1.69, $p = 0.008$) to be significant predictors that improved performance. Prominent hitches included limited internet accessibility, inconsistent electricity, inadequacy on educators' information and communication technology competence and exorbitant device and data prices. Overcoming the rural–urban digital divide will require investments on information and communications technology infrastructure, directed educators' competency-based training, friendly and accessible costs initiatives and sustainable policies aligned to the rural settings.

Keywords: Digital learning tools, rural education, ICT in schools, academic performance, Southwest Nigeria, digital divide

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INTRODUCTION

Education is still one of the most effective weapons to fight inequality, social mobility, and sustainable development. With the arrival of the digital age, information and communication technologies (ICT) accessibility has now become the key determiner within learning chances and academic performance. Digital learning resources—such as e-learning platforms and learning applications along with multimedia materials and online tests—are increasingly becoming part and parcel within the teaching and learning processes globally and reshaping the delivery of learning and opening new avenues within teaching processes (Nguyen & Pham, 2022). Digital learning tools and resources have been observed to raise the interest of learners, enhance the recollection keepsake and allow learners to learn independently and also help the educators through instructional materials and group working spaces (UNESCO, 2023). Digital's potential is highly pronounced within the areas where the conventional learning system is challenged by the system's inadequacy through infrastructure and teaching materials and through the lack of educators.

In sub-Saharan Africa, however, the gains from digital learning are shared unevenly, with the rural schools facing enormous disadvantages owing to limited infrastructure, weak internet penetration, and limited ICT literacy. Digital divide—the gap between the digitally enabled majority and the digitally incompetent minority—has aggravated prevailing learning inequalities more critically between the urban and the rural spaces (Adebayo & Yusuf, 2021). In Nigeria, where secondary school is key to the preparation of the youth for university and the labor market, the rural schools are often constrained by limited electricity supply, limited numbers of ICT equipment, and inadequately trained teachers (Okeke & Oladipo, 2022). Such limitations inhibit the proper uptake of digital learning tools leading to learning deficits that place the rurally raised children at an academic disadvantage compared to the urban ones.

COVID-19 pandemic also highlighted these inequities. While city schools could more likely implement blended learning platforms and online teaching policies during school lockdowns, the majority of rural schools faced challenges related to lack of functional broadband internet accessibility, lack of teaching materials, and minimal teacher preparedness (Eze et al., 2021). Therefore, the learning time lost among the rural learners aggravated the already existing inequities in learning outcomes. According to studies, the Sudanese rural learners indicated reduced participation levels in distance learning, reduced performance on the standard tests and increased risk of dropout during and after the pandemic period (Ojo & Aluko, 2022). Such evidence highlights the need to critically assess the potential of using digital learning platforms to enhance the learning deficit among the learners in the rural areas with special consideration required at the secondary school levels where the leading learning requirements to the tertiary institutions and workplaces are engineered.

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Digital learning among rural secondary school students has opportunities and challenges. While on one side mobile learning applications, offline e-libraries, television and radio-based courses, and affordable tablets can make available to students quality instructional materials regardless of place (Adepoju et al., 2023), on the other side challenges including inconsistent electricity power supply, lack of adequate ICT policies, attitudes towards technology by culture, and cost constraints inhibit the sustainability of digital learning adoption (Mensah & Boateng, 2021). Depending on how available these tools are hence the academic performance improved by them among the learners within the rural settings will be to its accessibility by the learners, usability by the learners and the educators respectively, and integration by the educators and the learners themselves within the instructional and learning processes.

Digital learning adoption theoretical foundations can be described by models like the Technology Acceptance Model (TAM), which focuses on perceived usefulness and ease of use as the most important determinants of technology adoption, and the Diffusion of Innovation Theory, which focuses on social systems, information-channels, and adopter characteristics to explain the diffusion of innovations (Rogers, 2003; Davis, 1989). Transplanting these models to the field of rural education, the adoption of digital learning tools is influenced by infrastructural preparation, teacher training education and support by policies and acceptance by the society. Case studies on other Sub-Saharan African nations indicate that where these enabling factors are realized, digital learning tools make an impressive difference to the outcome of the learners regarding the academic performance, the level of digital literacy and problem-solving ability (Kiptalam & Wambugu, 2021; UNESCO, 2023).

In Southwest Nigeria, secondary schooling continues to be an important avenue to socio-economic mobility but rural schools continue to struggle with infrastructure poverty, under-resourcing, and uncompensated student loads. While governments and international NGOs began digital learning initiatives through projects like tablet distribution initiatives and mobile learning app deployments, there is not much systematic evidence available on the effect within the rural settings. Previous studies inclined to examine urbanordo tertiary institutions leavethe research gap regarding the effect on rural secondary schooling outcomes through the deployment of digital learning tools (Okeke & Oladipo, 2022).

Bridging the research gap is critical to the development of proper education policy and the realization of equal access to quality learning by all areas of Nigeria. Therefore, the study attempts to assess the effect of digital learning tools on secondary schooling among the rural communities of Southwest Nigeria by examining the accessibility, availability, academic performance effect, and the challenges that also discourage adoption. Using both quantitative and qualitative data, the study gains evidence-based understandings about how digital learning has the potential to narrow the urban-rural educational disparities and support the achievement of the Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

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Despite worldwide advancements in digital learning, the rural areas of Nigeria remain faced with deep learning inequities fueled by scarce infrastructure, fragile internet connectivity, and lack of teacher readiness. Digital inequity between the urban and the rural schools has expanded, with the latter's secondary learners usually denied exposure to the e-learning platforms, teaching apps, and information and communications technology-informed instruction. This state got further highlighted by the COVID-19 pandemic where the urban schools resorted to tele-learning models and the rural ones got edged out by virtue of fragile connectivity and absence of devices (Eze et al., 2021). The end result is learning deficits among the learners causing them to fall behind academically, and weakening long-term competitiveness. Though concepts like mobile learning and offline learning materials and resources have been implemented, what the latter has specifically contributed to the cause of the secondary learners and learning outcomes in the rural areas is more information-gap research-needs analysis by the field.

This research thus endeavors to assess the availability, accessibility, and effect of digital learning tools on secondary school learning in the rural areas of Southwest Nigeria. Particularly, it aims to: (i) determine the level to which digital learning tools are accessible and available to the learners and educators; (ii) analyze the effect these tools have on the students' learning performance and interest; (iii) determine the challenges facing their uptake and inclusion within the education systems in the rurality; and (iv) introduce strategies to scale the sustainable digital learning practices. Following these objectives, the research answers the following queries: What digital learning tools are accessible and available within the secondary villages? How do the tools impact the performance and learning experience by the students? What constraints inhibit the effective uptake within the rurality settings? And what strategies will ensure the sustainable inclusion of the digital learning to wipe out the difference between the rurality and the urban settings regarding the learning aspect?

LITERATURE REVIEW

Digital learning platforms including learning management systems (LMS), teaching applications, open educational resources (OER), interactive simulations, and data-informed assessment platforms are increasingly at the core of modern teaching because they facilitate customization, constant feedback, and multimodal interactivity (UNESCO, 2023). In low-resource environments, they also hold the potential to overcome structural hurdles by extending the reach of quality material beyond the classroom through mobile technology and offline-enabled solutions (World Bank, 2022).

The pay-offs from digitalization depend on underlying enablers stable electricity, internet connectivity, infrastructure devices, teacher proficiency, and facilitating school leadership—that are unevenly distributed within and between countries and between urban and rural schools (Adebayo & Yusuf, 2021; Okeke & Oladipo, 2022). Digital divide has thus transformed from simple access breaches to multidimensional lack-of-equity-in-use, lack-of-

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equity-in-quality, and lack-of-equity-in-outcome spaces (Nguyen & Pham, 2022), and the shortage is meted disproportionately on rurally positioned learners who risk falling behind.

Conceptually, "digital learning" in high school covers fully online, blended, and technology-enhanced classroom models, each varying by the depth of integration and redesign required on the teaching end (UNESCO, 2023). Evidently, where technology is woven into coherent instructional designs—flipped learning, mastery learning, adaptive practice students demonstrate increased engagement, time-on-task, and proficiency with challenging concepts (Mensah & Boateng, 2021). Conversely, the very same tools can underperform or exacerbate inequities were used absentmindedly without consideration for contextual readiness, instructor pedagogical digital competence, and locally relevant learning materials (Adebayo & Yusuf, 2021).

In the rural settings of Nigeria where patchy electricity power, constrained Internet, and device shortages are the norm, implementers tend to turn to offline-first strategies (preloaded tablets, local servers on an SD-card basis, SD-card learning content), radio/TV lessons, and low-bandwidth mobile applications to ensure learning continuity (Eze et al., 2021; Okeke & Oladipo, 2022). Practically, adoption and effective application of digital resources by learners can be grasped by supplementary models. Technology Acceptance Model (TAM) suggests that perceived usefulness and perceived ease of use determine users' attitudes and behavioral intention regarding technology (Davis, 1989).

Amongst educators, educators' beliefs regarding the instructional benefit and usability always predict classroom integration more effectively compared to exposure by themselves or awareness (Nguyen & Pham, 2022). Diffusion of Innovation theory focuses on innovation characteristics (relative advantage, compatibility, complexity, trialability, observability) and social-system processes to clarify why peer mentoring by colleagues, apparent "quick wins," and common practice forums induce faster uptake within rurally clusters (Rogers, 2003; Kiptalam & Wambugu, 2021).

Supplementary teaching models—TPACK (technological, pedagogical, knowledge about content) and SAMR (substitution → Augmentation → modification → redefinition)—emphasize that significant effect arises where educators match tools with subject material and higher-level learning activities and do not merely digitize worksheets (UNESCO, 2023; Mensah & Boateng, 2021). Last but not least, equity-informed paradigms within ICT4D make us alert to the detail that gender norms, language proficiency, disability inclusion, and control by device within the household moderate whom receives advantage through school technologies and especially within rural and disadvantaged households (World Bank, 2022; Adebayo & Yusuf, 2021).

Empirically, Sub-Saharan African studies cite positive but context-specific digital tools impacts on secondary learners' results. Meta-analyses and multi-site initiatives report

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moderate mathematic and scientific gains where adaptive practice, interactive simulations, or intelligent tutoring is accompanied by teacher coaching (Mensah & Boateng, 2021; UNESCO, 2023). At the Kenya and Rwandan school levels, device programs increased problem-solving and digital literacy on the basis of teacher professional development and consistent device accessibility (Kiptalam & Wambugu, 2021).

Researches have shown that though sparer still for the rural secondary sector, evidence from Nigeria suggests that learning by mobile app, micro-lesson by WhatsApp, and offline e-library can enhance the completion of assignments and test performance where teachers are provided with structured support and where localized contents are used (Eze et al., 2021; Okeke & Oladipo, 2022). Note the heterogeneity of impacts here too: the greatest gains tend to be among initially low-performing learners where tools offer scaffolded and regular feedback by way of practice; where connectivity is weak and where teacher capacity is weak too, uptake falls and impacts recede (Adebayo & Yusuf, 2021).

The COVID-19 era intensified these differences. Urban schools that used LMSs, video lectures, and electronic assessments retained instructional time; many rural schools used radio/TV broadcasts and print packets, with lower engagement and poorer post reopening results (Eze et al., 2021; Ojo & Aluko, 2022). Research out of Nigeria and Ghana detail device sharing across households, data prices, and electricity shortages as binding constraints that dampen involvement among rural students, and particularly girls who bear household duties (World Bank, 2022; Mensah & Boateng, 2021). Teacher-side issues consist of constrained TPACK, techno-pessimism about classroom technology, and concern about classroom management upon device introduction probs that can be overcome by targeted coaching and school-level tech leadership (Nguyen & Pham, 2022; UNESCO, 2023).

Implementation research identifies key design principles that yield rural effectiveness: (i) offline and low-bandwidth delivery with local caching of content; (ii) national Curriculum alignment to pace guides that are explicit and unambiguous; (iii) professional development for teachers that interweaves technical proficiency with pedagogy and literacy about assessments; (iv) small Trackable Routine behaviors (experience daily example: 20–30 minutes adaptive practice daily) woven into the daily timetable; and (v) lightweight monitoring dashboards that provide teachers with information about student progress (UNESCO, 2023; Okeke & Oladipo, 2022).

School infrastructure is still key: solar power and secure device storage and formalized device access policies minimize downtime and attrition. Hybrid programs that add device with print companion volumes and/or radio reinforcement and/or study hubs within the community yield higher persistence where connectivity is very low (Eze et al., 2021) Despite promising outcomes, gaps remain. First, stringent causal evidence (i.e., randomized or quasi-experimentation) from secondary schools in rural Nigeria is still scarce compared with urban or tertiary institutions, limiting external validity to policy (Okeke & Oladipo, 2022).

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Second, limited research disaggregates by gender, disability, or poverty quintile, and thus far-equity effects remain little studied (World Bank, 2022). Third, cost-effectiveness data the total cost of ownership by device, by connectivity, by maintenance requirements, and by time of teachers are rarely reported but are important to scale up to the countryside (UNESCO, 2023). Last, sustainability questions replacement cycles on devices, local tech support provision, refresh rates on the contents, and school governance are not often considered beyond pilot horizons (Adebayo & Yusuf, 2021).

Converging evidence from the literature is on three points regarding the implications for rural Southwest Nigeria: (1) learning can be enhanced by digital tools embedded within teacher-led, curriculum-consistent routines; (2) infrastructure, teacher capability, and low-bandwidth design shape adoption and persistence; and (3) equity-sensitive implementation by gender norms, affordability, and accessibility conditions who gains. Such spaces and learnings justify the current study's direction on availability, accessibility, instructional usage, and academic performance impacts, along with barriers and implementable strategies to sustain the integration in the secondary schools in rural Southwest Nigeria (Eze et al., 2021; Okeke & Oladipo, 2022; UNESCO, 2023; World Bank, 2022).

METHODOLOGY

This study took on the cross-sectional mixed-methods design to evaluate the effect of digital learning tools on secondary schooling in the rural areas of Southwest Nigeria. The study population included students, educators, and administrators within the public rural secondary school system within three purposively sampled jurisdictions (Oyo, Osun, and Ekiti). By using Yamane's formula at the 95 percent confidence level and 5 percent error margin, the sample size of 400 students and 50 educators was calculated. A multistage sampling technique was used: the rural schools were purposively sampled by location and respondents randomly selected by proportionate sampling, and the administrators purposively sampled by interviews.

Data collection took the form of the structured questionnaire (4-point Likert scale), the performance checklist (English and Mathematics scores prior and posterior to the digital tool intervention), and the semi-structured interviews with the administrators. Face validity and expert review and pilot testing confirmed validity, and the Cronbach's alpha exceeded 0.80 to ensure reliability. Ethical clearance and consent from the participants were obtained. Quantitative data were tested with the SPSS by ordinary descriptive measures and the t-tests and ANOVA to examine differences in performance difference and the multiple regression analysis to determine the predictors of learners' outcomes. Qualitative data from the interviews thematic analysis offered the contextualization and the quantitative outcomes and the insight into adoption baffles.

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PRESENTATION OF RESULTS AND DISCUSSION

Presentation of Results

Results presented in Table 1 indicate limited accessibility to digital resources by rural school users, with the most accessible device being smartphones (44.8 percent) among students; 51 percent among educators) and educators. Officially provided formal school gadgets like desktops (28.5 percent) and laptops (21.3 percent) were not common, and internet penetration continued to be critically low (19.6 percent). Teachers also confirmed the trend, reporting increased dependency on personal smartphones more than on institutional ones.

Table 1: Availability and Accessibility of Digital Learning Tools in Rural Secondary Schools (n = 400 students, 50 teachers)

Tool/Resource	% Students Reporting Access	% Teachers Reporting Availability
Desktop computers	28.5	34.0
Tablets/laptops	21.3	26.0
Smartphones (for learning)	44.8	51.0
Offline e-libraries (SD/USB)	32.7	40.0
Internet connectivity	19.6	22.0
Projectors/multimedia tools	15.8	20.0

Source: Authors' Analysis (2025).

The results in Table 1 are similar to Adebayo and Yusuf (2021), who also pointed out that learners in the rural areas still rely on personal mobile telephones to acquire learning due to the lack of institutions. The limited accessibility further reflects the resilience of the digital divide and supports Okeke and Oladipo's view (2022) that infrastructural inequalities remain the ultimate stumbling block to the digitalization of learning in the rural areas.

Table 2: Impact of Digital Tool Usage on Student Academic Performance (English & Mathematics)

Group	**Mean Score (English, %)**	**Mean Score (Math, %)**	**SD (English)**	**SD (Math)**
Students with digital access	63.4	59.7	8.2	7.9
Students without access	52.1	48.9	7.6	8.3
t-test (p-value)	0.000***	0.000***	–	–

***p < 0.01 Source: Authors' Analysis (2025).

Pupils with digital tool access greatly outranked those without any access on English (63.4 percent) and Mathematics assessments (59.7 percent) versus the latter group's performance on 52.1 percent and 48.9 percent, respectively. By the t-test, these differences also held statistically significant at $p < 0.01$ (Table 2). These outcomes prove digital learning exposures to be positively related to academic improvement and thus confirm Technology Acceptance Model predictions that perceived usefulness has an instantaneous effect on outcomes (Davis, 1989). Kenya also recently observed similar performance improvement by Kiptalam and Wambugu (2021), where the use of digital resources increased achievement in the sciences

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and mathematics. The Nigerians find that incremental exposure to digital is enough to cause measurable learning gains and highlight the life-changing potential of the integration of ICT within the rurally disadvantaged school once backed by the right support.

Table 3: Regression Analysis: Predictors of Improved Student Performance

Predictor Variable	Beta (β)	Adjusted Odds Ratio (AOR)	95% CI	p-value
Frequency of tool usage	0.42	2.35	1.68–3.28	0.000***
Teacher ICT competence	0.31	1.87	1.24–2.81	0.002**
Internet connectivity access	0.27	1.69	1.12–2.56	0.008**
Household socio-economic status	0.18	1.42	0.96–2.10	0.075
Gender (male = 1, female = 0)	-0.09	0.81	0.55–1.21	0.308

Source: Authors' Analysis (2025).

Regression analysis summarized in Table 3 reveals that the frequency of digital tools being used (AOR = 2.35, $p < 0.001$) provided the strongest indication of improved performance and implied regular exposure maximizes learning retention. Teacher competence with ICT also significantly affected outcomes (AOR = 1.87, $p = 0.002$), and this underscores the significance of teacher readiness to optimize the effectiveness of tools. Internet connectivity having a positive and significant association (AOR = 1.69, $p = 0.008$) provided mixed evidence about the state of connectivity among many under-connected rural schools. Household socioeconomic status was marginal significance and suggested affordability constraints but also the promise of school-level interventions to reduce household inequities. Gender did not emerge as a significant predictor and is consistent with Mensah and Boateng (2021) who reported that digital interventions equally benefit male and female learners where equally accessible. Such evidence supports the Diffusion of Innovations theory and underscores the implication that the competence and regular use by the teacher accelerate the pace and effect of take-up.

Table 4: Challenges Hindering Digital Learning Tool Adoption (n = 400 students, 50 teachers, 10 administrators)

Challenge	Mean Rating (1–4 scale)	Rank
Poor internet connectivity	3.62	1st
Inconsistent electricity supply	3.48	2nd
Inadequate teacher training in ICT	3.31	3rd
High cost of devices/data	3.19	4th
Lack of government/NGO support	3.05	5th

Source: Authors' Analysis (2025).

The cardinal challenges to digital learning are summarized in Table 4. From the results, the results, the biggest barrier among the ones identified was the lack of proper internet connectivity (mean = 3.62), followed by inconsistent electricity supply (3.48), lack of proper teacher training (3.31), and the expense of devices/data (3.19). Such system-wide challenges

echo previous research by Okeke and Oladipo (2022), who noted that infrastructure shortages continue to be the biggest barrier to the adoption of ICTs by Nigerian rural schools. Teachers also highlighted that where devices did exist, unreliability of electricity and lack of proper ICT training prevented them from being used in the classroom. Administrators also cited lack of proper support from the government and NGOs (3.05), highlighting the lack of policy and institutions. All these system-level hurdles prove that although digital learning resources represent massive potential, success is negated by infrastructure-located constraints alongside financial and capacity constraints, similar to UNESCO's (2023) calls for comprehensive digital inclusion strategies.

The findings affirm that digital learning tools greatly boost academic performance by students at the rural secondary level but are limited by infrastructure shortages, teaching readiness, and affordability constraints. Use is low to begin with and centered on the smartphone gateway to the internet by the rural student. Where tools are available and reliably used under the guidance of qualified teachers, quantifiable gains by English and Mathematics outcomes were realized. Nevertheless, sustainable uptake will be contingent on intentional investments by connectivity, electricity infrastructure and professional development by teaching staff and policy assistance and aligned to the best international practices.

CONCLUSION AND RECOMMENDATIONS

This research tested the effect of digital learning materials on secondary school learning in rural Southwest Nigeria and identified strong evidence that digital learning materials enhance learning outcomes where they are always available and properly embedded. Pupils with regular access to digital materials, especially through the use of smartphones and offline digital resources, outperformed those who did not. Regression analysis also validated that the habitual use of digital materials, the competence of teachers with ICTs, and internet connection shared similar strength indicators. However, the availability of digital materials remains low among the rural schools and the systemic challenges of poor quality internet connectivity and lack of reliable electricity remain major barriers to uptake.

The research identifies the remarkable digital divide that sustains learning inequities between the rural and urban areas. Addressing the gap would be through the following recommendations. First, infrastructure investments through the provision of rural broadband infrastructure expansions, solar-powered electricity systems and subsidized device distributions be undertaken by the government and development partners.

Second, professionalizing the teaching force be undertaken to enhance the competence on the use of ICTs and proper classroom integrative exemplary teaching and learning.

Thirdly, the localization innovative ways to ensure the connectivity challenges be expanded and not limited to any other areas.

Further still, policies and incentives ought to be put in place on the financial constraint faced by the rural households through the provision of subsidies on behalf of the households through public-private partnership to make the device and the internet connectivity prices more affordable. Finally, the institutional support and monitoring mechanism to ensure the long-life sustainability and the responsiveness to the national learning outcomes should be restructured, supported and their capacities boost.

Competing Interest

The authors have declared that no conflicting interest exist in this manuscript.

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