Infrastructural Readiness and the Promise of Digital Pedagogy: A Five-Country Comparative Study on the Sustainability of eLearning in Sub-Saharan Africa

Musa Wakil Bara, Abubakar Sani Jato and Abdurahman Abatcha

Department of /computer Science

Mai Idris Alooma Polytechnic Geidam, Yobe State-Nigeria

ABSTRACT

The proliferation of digital technologies has elevated e-learning from a peripheral instructional tool to a central pillar of educational policy in Sub-Saharan Africa (SSA). Yet, the promise of digital pedagogy remains unequally distributed across the region's diverse national contexts. This comparative study examines the infrastructural readiness of five Sub-Saharan African nations Nigeria, Ghana, Kenya, South Africa, and Rwanda to implement and sustain e-learning programmes. Drawing on a systematic review of recent empirical studies, policy documents, international reports, and institutional assessments published between 2020 and 2026, the paper evaluates each country's readiness across five dimensions: internet connectivity, device access, power supply reliability, policy frameworks, and teacher digital competency. Findings indicate that while South Africa and Rwanda demonstrate relatively stronger policy coherence and infrastructure investment, all five countries face structural vulnerabilities including persistent urban-rural divides, unreliable electricity, and inadequate device provisioning that threaten the long-term sustainability of e-learning. The study concludes with country-specific and cross-national recommendations to bridge these divides and accelerate equitable digital education across the sub-region.

Keywords: *e-learning, digital pedagogy, infrastructural readiness, Sub-Saharan Africa, educational technology, digital divide, Nigeria, Ghana, Kenya, South Africa, Rwanda*

1. INTRODUCTION

The global expansion of digital technologies has transformed educational landscapes worldwide, compelling governments, institutions, and educators to reconsider how knowledge is produced, transmitted, and assessed. E-learning broadly defined as the use of electronic technologies to access educational curricula outside of a traditional classroom has become an especially critical intervention in regions where population growth, teacher shortages, and geographical barriers constrain conventional schooling. Sub-Saharan Africa (SSA), which is home to the world's fastest-growing population and where more than 130 million children were reported out of school in 2022, stands at a pivotal juncture where digital pedagogy could either serve as a transformative equaliser or a new axis of inequality (UNESCO, 2022).

The COVID-19 pandemic heightened awareness of the region's digital vulnerabilities. As school closures forced institutions to pivot to remote learning, the inadequacy of existing digital infrastructure became starkly visible. Governments scrambled to deploy online platforms with varying degrees of success, exposing deep asymmetries in connectivity, device ownership, teacher preparation, and power supply all critical preconditions for sustainable e-learning. The International Finance Corporation (IFC, 2020) estimates that by 2030, over 230 million jobs in SSA will require digital skills, underscoring the urgency of building robust digital education systems now.

Despite growing policy interest in e-learning across the continent, comparative empirical analyses of national readiness remain scarce, particularly those integrating infrastructure, policy, and pedagogical dimensions simultaneously. This study addresses that gap by conducting a five-country comparative analysis of e-learning readiness, focusing on Nigeria, Ghana, Kenya, South Africa, and Rwanda nations that collectively represent the geographic, political, and economic diversity of SSA and have each articulated national digital education strategies. The central research questions guiding this investigation are: (1) To what extent are these five countries infrastructurally ready to run sustainable e-learning programmes? (2) What are the principal strengths and weaknesses of each country's e-learning ecosystem? (3) What targeted interventions can accelerate readiness and sustainability?

The remainder of this paper is structured as follows: Section 2 reviews relevant literature on e-learning readiness frameworks and SSA contexts; Section 3 describes the methodology; Sections 4 through 8 provide country-specific analyses; Section 9 presents a comparative synthesis; Section 10 offers recommendations; and Section 11 concludes the study.

2. LITERATURE REVIEW

2.1 Conceptualising E-Learning Readiness

E-learning readiness refers to a multidimensional construct encompassing the degree to which individuals, institutions, and national systems are prepared to engage in and sustain digital learning. Seminal frameworks such as the Technology Acceptance Model (TAM) (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) have been widely applied in SSA studies to understand user-level barriers, particularly the roles of perceived ease of use and perceived usefulness in e-learning adoption (Adeyinka et al., 2024; Osei et al., 2025). However, these individual-level models must be situated within broader structural contexts that account for infrastructure, policy, and socioeconomic factors unique to developing countries (Bervell & Umar, 2021).

Institutional and national readiness frameworks complement individual-level models. Studies such as that of Assefa, Rorissa, and Alemneh (2021) applied digital readiness assessments across African countries and found that infrastructure consistently emerged as the most significant predictor of e-learning sustainability. The 2024 Oxford Insights Government AI Readiness Index similarly ranked SSA as the lowest-scoring region globally, with an average readiness score of 32.70, noting that infrastructure, while its strongest domain, still averaged only 42.06 (Oxford Insights, 2024). These findings suggest that even among relatively better-prepared countries, substantial gaps persist.

2.2 Infrastructure as a Precondition for E-Learning

Researchers consistently identify four foundational infrastructure pillars for viable e-learning: reliable internet connectivity, adequate computing devices, stable electricity, and functional Learning Management Systems (LMS) (Dhawan, 2020; Adeyinka et al., 2024). In SSA, each of these pillars faces contextual challenges. Internet penetration, while growing from roughly 320 million mobile internet users in 2023 toward a projected 518 million by 2030 (GSMA, 2024) remains unevenly distributed, with rural penetration rates averaging 23% compared to 57% in urban areas (ITU, 2024; International Telecommunication Union, 2024).

Electricity access is an equally acute constraint. Frequent power outages and what Nigeria terms 'epileptic power supply' severely disrupt digital learning environments (Ibitoye & Adenikinju, 2007; Ayamolowo et al., 2019). In South Africa, the phenomenon of load shedding government-managed rolling blackouts to protect the national grid has disrupted LMS functionality in universities and exacerbated inequalities between affluent and under-resourced institutions (Khoza, 2024; Faloye & Ajayi, 2022). The systemic and episodic nature of these power failures means that even where connectivity and devices exist, uninterrupted digital learning remains elusive.

2.3 Policy Architecture and Pedagogical Readiness

A recurring theme in the literature is the gap between progressive policy articulation and actual implementation. Multiple SSA nations have enacted national ICT-in-education policies, developed e-learning strategies, and signed international commitments to digital education, yet monitoring and evaluation mechanisms are often weak, financing is fragmented, and federal-local coordination is insufficient (Athena Centre for Policy and Leadership, 2026). As Kayombo and Mlyakado (2015) found in Tanzania, most teachers were unaware of national ICT policies, a finding mirrored in Nigeria, Ghana, and Kenya (Chukwu & Ibrahim, 2021; Adjei, 2023). Teacher digital competency, encompassing technical skills, pedagogical integration, and confidence in using digital tools, is now recognised as the decisive mediating variable between digital infrastructure and learning outcomes (Nyathi & Joseph, 2024).

3. METHODOLOGY

This study adopts a qualitative comparative research design grounded in systematic document analysis. A multi-country comparative framework was employed to examine Nigeria, Ghana, Kenya, South Africa, and Rwanda across five standardised dimensions: (1) Internet connectivity and penetration, (2) Device access and affordability, (3) Electricity reliability, (4) Policy framework and institutional readiness, and (5) Teacher and learner digital competency.

Data were drawn from peer-reviewed journal articles, UNESCO and World Bank reports, GSMA Mobile Economy publications, government strategy documents, and recent institutional assessments published between 2020

and 2026. Sources were selected based on relevance, recency, and scholarly credibility. A thematic coding approach was used to extract country-specific evidence under each dimension. The comparative synthesis in Section 9 uses an evaluative matrix to enable cross-country assessment.

4. Nigeria: Ambition Constrained by Structural Deficits

4.1 Internet Connectivity

Nigeria presents a paradoxical case: it is Africa's most populous nation (approximately 224 million people) with an expanding digital economy, yet its e-learning infrastructure remains deeply fragmented. National internet usage exceeded 103 million users (45.5% penetration) by early 2024, alongside 164.4 million active internet subscriptions (DataReportal, 2024; Athena Centre for Policy and Leadership, 2026). However, these aggregate figures mask severe school-level and rural deficits. As research by Adeleke (2021) and Akanbi and Akanbi (2012) reveals, the digital divide follows lines of geography, gender, and income, with rural communities having negligible broadband access. Studies by Sawyerr-George and Agina-Obu (2023) confirm that internet usage among university students is inconsistent, limited by high data costs and unstable connections.

4.2 Device Access and Power Supply

Device ownership remains a critical bottleneck. The high cost of smartphones, tablets, and laptops places them beyond the reach of most Nigerian households, and the government has yet to implement a credible universal device distribution programme (Chukwu & Ibrahim, 2021; UNICEF Nigeria, 2025). Power supply constitutes arguably the most fundamental barrier. Nigeria struggles with providing a consistent and reliable electricity supply, characterised by frequent outages, inadequate generation capacity, and an outdated grid (Ibitoye & Adenikinju, 2007; Ayamolowo et al., 2019). During the NaijaCoder 2023 coding initiative held in Abuja Nigeria's most urban and best-connected city power outages were experienced at least once per day, compelling instructors to maintain daily backup plans (NaijaCoder Research Team, 2023). This illustrates that even in optimal urban conditions, electricity instability fundamentally compromises digital learning.

4.3 Policy Framework

Nigeria has developed a coherent policy architecture for digital education, including the National Policy on ICT in Education (NPICE) 2019, the National Digital Literacy Framework (NDLF) 2023, and the National Digital Learning Policy (NDLP) 2023. The Nigeria EdTech Strategy 2023, launched by the Federal Ministry of Education, aims to integrate digital tools in classrooms and increase access to online learning (World Economic Magazine, 2025). The MIVA Open University, affiliated with uLesson, received Open Distance eLearning accreditation, signalling growing institutional engagement. However, financing remains fragmented, monitoring is weak, and federal-state coordination is insufficient, resulting in implementation falling far short of stated ambitions (Athena Centre for Policy and Leadership, 2026; World Bank, 2024).

4.4 Strengths and Weaknesses

Nigeria's primary strengths lie in its large and youthful population that creates significant demand for scalable e-learning, its growing EdTech startup ecosystem (including platforms like uLesson with over 2 million live lesson attendances and 5 million downloads), and its comprehensive policy frameworks. Weaknesses include epileptic power supply, high data costs, inadequate school-level device access, sharp urban-rural digital divides, and weak policy implementation mechanisms. Nigeria has the world's highest number of out-of-school children,

estimated at 10.5 million at primary level alone, which further limits the baseline from which e-learning expansion must begin (UNICEF Nigeria, 2025).

5. Ghana: Progressive Policies, Implementation Gaps

5.1 Internet Connectivity and Device Access

Ghana's digital education landscape is characterised by progressive national policies that have yet to translate into equitable classroom outcomes. According to the Ghana Living Standards Survey (2020), only 39.7% of Ghanaians had internet awareness, with a stark urban-rural divide of 51.6% versus 27.4%. This is compounded by limited access to computing devices: Africa Education Watch (2024) reports that only 15% of public primary schools and 13% of junior high schools had functioning ICT laboratories by the end of the 2022/2023 academic year. While mobile phones are widely owned with 97% of urban households having access according to Tsapali et al. (2023) government policy has traditionally banned mobile phone use during pre-tertiary schooling, ironically undermining the dominant technology through which most Ghanaians access the internet (WATHI, 2024).

5.2 Electricity and Infrastructure

While national electricity coverage exceeds 80%, only 44% of primary schools and 63.9% of junior high schools had access to electricity as of 2020 (The Borgen Project, 2025). Poor internet connectivity in rural schools persists despite investment, and the few computers provided by the government have been criticised for poor quality, unknown brands, and inflated costs (WATHI, 2024). A digital divide between urban and rural schools is growing, and UNESCO (2023) has emphasised that these geographical disparities in devices, electricity, and connectivity must be addressed with urgency.

5.3 Policy Framework

Ghana has incorporated digitalisation as a cross-cutting issue into successive Education Sector Strategies. The Ghana Education Strategic Plan (ESP) 2018-2030 explicitly targets ICT integration at all educational levels. A significant milestone was reached in June 2023 when UNESCO assisted Ghana in creating a National ICT Competency Framework for Teachers, mandating ICT skills integration in pre-service and in-service teacher training (Abedi et al., 2023; UNESCO, 2024). In 2023, Ghana also launched the ICT Competency Framework for Teachers, and wireless internet was installed in approximately 700 senior high schools and several teacher training colleges (Gunu et al., 2022; Abedi et al., 2023). In 2024, the Smart Schools Project launched an initiative to distribute 1.3 million free tablets to high school students (The Borgen Project, 2025). However, education spending as a share of GDP has declined from 4.3% in 2020 to 3.1% in 2023, well below the UNESCO target of 4-6%, and approximately 82% of the education budget in 2022 went to employee compensation, severely limiting funds for infrastructure (Oxford Business Group, 2024).

5.4 Strengths and Weaknesses

Ghana's principal strengths include its stable democratic governance, a tradition of progressive education reform, strong civil society engagement in education, and emerging community-level innovations such as the ASANKA offline learning management device, which currently reaches over 400,000 students annually (GPE Blog, 2023). Teacher smartphone ownership ranges between 30% and 65%, offering a potential foundation for mobile-first pedagogical interventions (AUDA-NEPAD, 2025). Weaknesses include declining education budget allocations, poor rural infrastructure, low digital literacy (only approximately 21.1% of the population possesses ICT skills), and a persistent

gender digital gap where 27.8% of men versus fewer women hold digital competencies (American University of Beirut, 2024). Policy discontinuity where ICT initiatives launched by one government are abandoned by its successor remains a systemic risk (WATHI, 2024).

6. Kenya: Leading Regional Innovation with Persistent Rural Gaps

6.1 Internet Connectivity and Device Access

Kenya occupies a leading position among SSA nations in digital education innovation, driven by a strong mobile money ecosystem and a government long committed to technology-led development. Records from the start of 2024 show 66.04 million cellular mobile connections in Kenya, of which 93.7% were broadband connections ranging from 3G to 5G, though reliable internet access remains out of reach for many schools (JEPA Africa, 2025). The M-Shule SMS-based learning platform, which uses artificial intelligence to deliver personalised content to learners without smartphones, exemplifies Kenya's capacity to build contextually appropriate e-learning solutions, having reached over 20,000 households (JEPA Africa, 2025). Eneza Education, also Kenya-based, serves over 3 million learners via SMS-based adaptive platforms (IMARC Group, 2024).

6.2 The Digital Literacy Programme

Kenya's flagship Digital Literacy Programme (DLP), first envisioned in 2013 and restructured in 2015, has been implemented across all public primary schools with a multi-agency approach involving the Ministry of Education, KICD, the Teachers Service Commission, Kenya Power, and the Ministry of ICT (DigiSchool, n.d.; ICT Authority Kenya, 2022). The programme has trained over 75,000 teachers in public primary schools in readiness for digital integration (Ministry of ICT Kenya, n.d.). In partnership with UNESCO and Huawei under the DigiSchool project, 13 schools were connected to the internet via Kenya's National Optic Fiber Backbone Infrastructure in 2023 (UNESCO, 2023). Implementation proceeds through three phases, the third of which, running from 2023 to 2029, aims to enable learners to produce with technology rather than merely consume it (Kenya News Agency, 2023).

6.3 Challenges

Despite these achievements, critical challenges persist. Teacher willingness to integrate technology is uneven: research from Kakamega County shows that only teachers receiving ongoing mentorship achieve significantly higher technology integration rates than those attending one-off training sessions (JEPA Africa, 2025). Language barriers hinder digital literacy, particularly for learners unfamiliar with English, the dominant language of most EdTech platforms (JEPA Africa, 2025). Device theft has been reported as a teething problem within the DLP (Kenya News Agency, 2023). Kenya, Ghana, and South Africa are reviewing student loan schemes to make them more equitable, following UNESCO's 2023 Global Education Monitoring Report, which urged governments to expand affordable, inclusive higher education (educations.com, 2025).

6.4 Strengths and Weaknesses

Kenya's strengths include its pioneering e-learning policy framework, a vibrant EdTech startup ecosystem, high mobile penetration, a government commitment evidenced by multi-billion investment in the DLP, and international partnerships with UNESCO, Huawei, and World Vision. Kenya's National Digital Masterplan (2023-2027) provides a further roadmap built on six pillars including digital infrastructure and digital skills (OECD.AI, 2025). Weaknesses include persistent rural connectivity deficits, uneven teacher readiness, language barriers in

digital content, and the challenge of maintaining and replacing devices in resource-constrained schools.

7. South Africa: Advanced Capacity, Deep Inequality

7.1 Connectivity and Infrastructure

South Africa represents the most technologically advanced educational system among the five countries studied, yet it simultaneously embodies the continent's starkest digital inequalities. The Oxford Insights Government AI Readiness Index (2024) ranks South Africa as one of Africa's top performers, with a score slightly above 50, reflecting stronger institutional capacity (Oxford Insights, 2024). Internet penetration is relatively high and the country boasts the continent's most developed fixed-line broadband infrastructure. Smartphone ownership among teachers exceeds 90%, offering a strong foundation for mobile-first educational interventions (AUDA-NEPAD, 2025). South Africa's Department of Basic Education has invested in school internet connectivity projects and partnered with private firms to distribute free e-learning resources, resulting in a 200% increase in usage of digital learning platforms between 2020 and 2023 (World Economic Magazine, 2025).

7.2 Load Shedding and Its Impact on E-Learning

The most singular threat to South Africa's e-learning sustainability is the endemic power supply problem known as load shedding. Load shedding refers to government-imposed rolling blackouts implemented to protect the national electricity grid from total collapse, managed by Eskom (Erero, 2023). Load shedding has negatively affected families, firms, and the entire economy, halting digital tools, LMSs, and other online teaching and learning devices during class time (Khoza, 2024). Studies confirm that rural and township areas experience prolonged electricity deprivation through load reduction, which is developmentally segregative as it mainly affects poor and rural communities (Maggott et al., 2022; Khoza, 2024). Khoza (2024) further reveals that internet modems fail to function during load shedding, effectively cutting access even where connectivity infrastructure is physically present.

A study of LMS use in South African universities found that load shedding, combined with unaffordable data costs and lack of devices, creates a multifaceted digital divide that reshapes the learning process at a fundamental level (Faloye & Ajayi, 2022). Research on music schools illustrates that students from disadvantaged backgrounds find it particularly difficult to navigate disruptions caused by power cuts, limiting their ability to utilise electronic resources and online platforms that serve as more affordable alternatives (Yende & Madolo, 2024).

7.3 Policy and Pedagogical Readiness

South Africa's policy framework includes the landmark 2004 E-Education White Paper, which articulated the national vision for digital education equity. A 2024 evaluation of this policy found that while it has provided a foundational vision, implementation in a rapidly evolving digital landscape presents unique challenges (Tandfonline, 2024). Studies of secondary schools in the Tshwane North District using the TPACK framework revealed significant discrepancies in educators' access to digital resources, technical skills, and knowledge of e-learning policies, with under-resourced schools lagging significantly behind well-equipped urban institutions (Nyathi & Joseph, 2024). South Africa's National Digital and Future Skills Strategy further commits the government to systemic skills development, though its rollout has been uneven (GSMA, 2024).

7.4 Strengths and Weaknesses

South Africa's strengths include the most sophisticated EdTech institutional ecosystem in SSA, strong university LMS uptake, high teacher smartphone ownership, leading companies like GetSmarter and Siyavula serving learners continent-wide, and a mature policy architecture. Its principal weaknesses are the chronic load shedding crisis, extreme socioeconomic inequality rooted in apartheid-era structural disparities, the high cost of data, and persistent disparities between urban and peri-urban/rural schools. The country can run e-learning programmes at an institutional level, but equitable national e-learning at scale remains compromised by infrastructure and inequality.

8. Rwanda: A Model of Political Will in a Resource-Constrained Context

8.1 Connectivity and Infrastructure

Rwanda presents the most instructive case of determined government-led digital education expansion in SSA. Under the Smart Rwanda Master Plan and the National Strategy for Transformation (NST1), the country has pursued universal school internet connectivity with unusual political consistency. In 2013, the government of Rwanda and Korea Telecom (KT) signed a 25-year deal that has since delivered 4G coverage to 98% of the population by 2018, with median mobile download speeds reaching 38.37 Mbps by January 2023, up from 16.9 Mbps in 2020 (Freedom House, 2023). Internet penetration, measured at 30.5% in 2023 by DataReportal, remains below the sub-regional aspirations, particularly given that 83% of Rwanda's approximately 13 million citizens live in rural areas (PMC, 2022; World Bank, 2022).

Rwanda's School Connectivity Programme, launched in March 2023, aims to connect all primary and secondary schools to high-speed internet by end of 2024, deploying Starlink satellite internet in 500 schools as an initial phase (TechAfrica News, 2023). Progress has been substantial: in the 2023-2024 academic year, 3,082 schools had internet access, rising to 4,184 out of 4,996 schools nationwide by 2026 (KT Press, 2026). The remaining 812 schools are mostly in remote regions where electricity access remains limited.

8.2 Teacher Readiness and Digital Skills

Rwanda has invested heavily in teacher digital capacity. The Capacity Development for ICT in Education (CADIE) project, funded by KOICA and implemented by the Rwanda Basic Education Board (REB), trained 43,000 teachers and 446 education officers in ICT use (ILO, 2023). The One Laptop Per Teacher initiative, launched in 2021, aimed to equip all public school teachers with laptops by end of 2024; by August 2021, one in eight teachers had received devices, reaching 135 secondary schools (ILO, 2023). By 2023, 57% of teachers had laptops across the country (Developing Telecoms, 2023). Thomas Ndayambaje, a Senior Technologist at Rwanda's Ministry of ICT, noted in 2026 that the education system has moved to fully digital operations: 'No teacher is afraid of computers anymore or hesitant to use them because our system is now fully digital. Nothing in education is done manually anymore' (KT Press, 2026). The Digital Skills Foundation Program has trained teachers and students with internationally accredited certificates, with Musanze District recording a 44.9% completion rate (REB, 2023).

8.3 Policy Coherence and Challenges

Rwanda's strength lies in an unusual degree of policy coherence and sustained political will. Unlike many SSA nations where ICT initiatives are abandoned when governments change, Rwanda has maintained digital education as a cross-governmental priority across successive national strategies. The Digital Ambassadors Programme (DAP), a youth-led digital inclusion initiative in partnership with the World Economic Forum and the Digital Opportunity Trust, extends

Rwanda's digital reach into communities (ILO, 2023). However, significant challenges remain. Fewer than 10% of Rwandans were digitally literate in 2019, and while the government targeted 60% adult digital literacy by 2024, achieving this goal within the timeline has proven difficult given that most infrastructure is in urban and peri-urban areas (Freedom House, 2023; UNITAR, 2024). Rural electrification, with only 46.6% of the population on the national grid as of 2022, constrains the pace of school connectivity rollout (Freedom House, 2023). Internet data costs remain high, and communities, particularly women and youth in rural areas, often do not prioritise digital learning (UNITAR, 2024).

8.4 Strengths and Weaknesses

Rwanda's strengths include outstanding political commitment to digital education, the most systematic school connectivity programme in SSA, consistent multi-stakeholder investment from government and development partners, high mobile speeds relative to regional norms, and successful teacher training at scale. Weaknesses include low overall internet penetration, limited electrification outside Kigali, high data costs, persistent rural-urban digital divides, and a small economic base that renders the country highly dependent on external funding for infrastructure investment.

9. COMPARATIVE ANALYSIS AND EVALUATIVE MATRIX

Table 1 presents a synthesised comparative evaluation of all five countries across the five readiness dimensions. Ratings reflect the overall trajectory and structural conditions in each country based on evidence reviewed in this study.

Table 1: Comparative E-Learning Readiness Matrix for Five SSA Countries

Dimension	Nigeria	Ghana	Kenya	South Africa	Rwanda
Internet Connectivity	Moderate (urban); Low (rural)	Low-Moderate	Moderate-High	High (urban); Moderate (rural)	Moderate (growing rapidly)
Device Access	Low	Low	Moderate	Moderate-High	Low-Moderate (improving)
Electricity Reliability	Very Low	Moderate	Moderate	Low-Moderate (load shedding)	Low-Moderate (rural gaps)
Policy Framework	Strong (weak implementation)	Moderate (budget declining)	Strong	Strong	Very Strong (coherent)
Teacher Digital Competency	Low	Low-Moderate	Moderate	Moderate (urban); Low (rural)	Moderate-High (improving)
Overall Readiness	LOW	LOW-MODERATE	MODERATE	MODERATE-HIGH	MODERATE

Source: researchers'

The matrix reveals a regional gradient of readiness. South Africa leads on infrastructure and capacity but is critically constrained by load shedding and inequality. Rwanda leads on policy coherence and government commitment but is constrained by electrification and internet penetration. Kenya occupies a middle position with a well-designed policy framework but implementation unevenness. Ghana and Nigeria both exhibit strong policy intentions undermined

by budget deficits, electricity unreliability, and low device penetration. The GSMA (2024) projects that SSA will have 560 million mobile broadband subscriptions by 2024, growing at 8-10% annually, yet the critical question for all five countries is whether this mobile growth will translate into pedagogically meaningful, sustainable e-learning or remain a consumer connectivity gain without educational depth.

A cross-cutting finding is that rural-urban inequality constitutes the single most consistent barrier across all five countries. While urban centres Lagos, Accra, Nairobi, Cape Town, and Kigali increasingly approximate global digital standards, rural schools in all five nations continue to face compounded deficits of electricity, connectivity, devices, and trained teachers. The IFC's projection that 50-55% of all jobs in Kenya, 35-45% in Nigeria and Rwanda, and 35-45% in Ghana will require digital skills by 2030 (IFC, 2020) lends particular urgency to addressing these rural deficits.

10. RECOMMENDATIONS

10.1 Cross-National Recommendations

First, all five governments must establish dedicated and ring-fenced budget lines for digital education infrastructure, shielded from political budget cycles. UNESCO's benchmark of 4-6% of GDP for education spending should serve as a minimum floor, with explicit sub-allocations for digital infrastructure, device provision, and teacher training. Ghana's decline from 4.3% in 2020 to 3.1% in 2023 represents a cautionary trajectory that must be reversed (Oxford Business Group, 2024).

Second, governments should adopt a mobile-first e-learning strategy given the regional reality that mobile phones are the most widely owned digital devices. This includes lifting restrictions on appropriate in-school mobile phone use (as Ghana should consider), developing locally relevant mobile-compatible content, and partnering with telecoms operators to zero-rate access to educational platforms a model demonstrated by Eneza Education's partnership with Airtel Africa in 2023 (Market Data Forecast, 2026).

Third, solar-powered learning infrastructure should be deployed systematically in off-grid communities. uLesson's deployment of 50,000 solar-powered digital learning kits in off-grid schools across northern Nigeria and northern Ghana in 2024 provides a replicable model for all five countries (Market Data Forecast, 2026). Rwanda's use of solar-powered systems and satellite technology since 2022 for rural schools further validates this approach.

Fourth, regional knowledge-sharing platforms should be established under AU and AUDA-NEPAD coordination, allowing countries to share EdTech curricula, teacher training modules, and digital content repositories, reducing duplication and cost. The AUDA-NEPAD African EdTech 2030 Vision provides an emerging framework for such coordination (AUDA-NEPAD, 2025).

10.2 Country-Specific Recommendations

For Nigeria, the most urgent intervention is electricity infrastructure. The government must prioritise and ring-fence public investment in last-mile power grid extension and renewable energy alternatives for schools, without which no e-learning strategy can function. Additionally, the National Open University of Nigeria (NOUN) and MIVA Open University should be leveraged as institutional anchors for national e-learning quality standards, while the NPICE 2019 implementation must be accompanied by enforceable monitoring frameworks at state level.

For Ghana, the primary recommendation is to reverse the declining education budget trajectory and protect the 23% national

commitment. The Smart Schools Project's tablet distribution initiative is promising but must be accompanied by sustained teacher training and reliable power. Removing the pre-tertiary mobile phone prohibition and replacing it with a structured mobile learning policy would unlock the primary access device that Ghanaian students already own. The ASANKA offline LMS device model should be scaled nationally through government procurement.

For Kenya, the DigiSchool programme's third phase (2023-2029) should be accelerated with particular focus on teacher mentorship moving away from one-off training sessions toward communities of practice that sustain pedagogical integration. Content localisation in Kiswahili and other major languages will be critical for reaching learners in communities where English remains a barrier to EdTech engagement.

For South Africa, resolving the load shedding crisis is not solely an educational challenge but a national infrastructure imperative whose resolution will have the largest immediate impact on e-learning access. In the medium term, schools and universities should invest in backup power systems (solar-plus-storage), and the government should consider subsidising these systems for rural schools. Addressing data affordability through the 'zero-rating' of educational platforms and leveraging the Competition Commission's findings on high data prices would expand practical internet access for learning.

For Rwanda, the priority is completing rural school electrification and sustaining connectivity investments through domestic revenue mobilisation, reducing dependence on volatile external funding. Community digital literacy programmes targeting women and youth in rural areas, as piloted through UNITAR (UNITAR, 2024), should be institutionalised within the national Digital Ambassadors Programme. The government should develop local language digital content in Kinyarwanda to reduce barriers for learners with limited English proficiency.

11. CONCLUSION

This comparative study has assessed the e-learning readiness of Nigeria, Ghana, Kenya, South Africa, and Rwanda through a multidimensional infrastructural lens. The evidence is clear: all five countries can run some form of e-learning, and all five have demonstrated institutional commitment to digital education. However, the sustainability of e-learning at national scale reaching every learner equitably, regardless of geography, income, or gender remains an aspiration rather than a reality in each case.

The study affirms that e-learning readiness is not a single threshold to be crossed but a gradient of capacity characterised by enabling and constraining factors in dynamic tension. South Africa's advanced infrastructure and severe inequality, Rwanda's policy coherence and resource constraints, Kenya's innovation and implementation gaps, Ghana's progressive frameworks and declining budgets, and Nigeria's enormous potential and structural deficits each represent distinct challenges requiring contextually differentiated responses.

The broader lesson is that digital pedagogy cannot be implemented as a technological overlay on unaddressed structural deficits. E-learning sustainability demands that electricity come before devices, connectivity before content, teacher confidence before curriculum, and equity before scale. The GSMA's projection of 518 million mobile internet users in SSA by 2030 represents a genuine technological opportunity (GSMA, 2024), but converting

mobile penetration into measurable learning outcomes will require sustained political will, adequate financing, cross-sector coordination, and above all a commitment to leaving no community behind. The five nations studied here have, in different ways, demonstrated that will. The task now is to translate it into durable, equitable digital learning systems that can serve the next generation of Sub-Saharan African students.

References

Abedi, A., et al. (2023). ICT in pre-tertiary and secondary education in Ghana: Evaluating national policy implementation. West African Journal of Education, 14(1), 34–56.

Adeleke, F. (2021). Community-level digital divide in Nigeria: Income, internet access, and educational outcomes. Digital Policy, Regulation and Governance, 23(4), 215–232.

Adeyinka, T., et al. (2024). Barriers and enablers of e-learning adoption among Nigerian undergraduate students: An evaluative analysis. E-Learning Innovations Journal. https://el-journal.org/index.php/journal/article/view/95

Adjei, K. (2023). Integrating digital literacy into Ghanaian education: Challenges and opportunities. Journal of African Digital Education, 10(2), 112–128.

Africa Education Watch. (2024). ICT lab access in public schools: Ghana national audit report 2022/2023.

Akanbi, A., & Akanbi, C. (2012). Digital divide and e-learning: Analysis of determinants in Nigeria. International Journal of ICT Research and Development, 5(2), 17–29.

Assefa, S., Rorissa, A., & Alemneh, D. (2021). Digital readiness assessment of countries in Africa: A case study research. Proceedings of the Association for Information Science and Technology, 58(1), 400–404.

Athena Centre for Policy and Leadership. (2026, January). From connectivity to classroom impact: Integrating digital literacy in Nigeria's education system. https://athenacentre.org/publication/from-connectivity-to-classroom-impact

AUDA-NEPAD. (2025). AUDA-NEPAD unveils transformative draft African EdTech 2030 vision and plan. https://www.nepad.org/news/auda-nepad-unveils-transformative-draft-african-edtech-2030-vision-plan

Ayamolowo, S., et al. (2019). Power supply challenges in Nigeria and implications for digital education. Nigerian Journal of Energy and Infrastructure, 11(3), 44–58.

Bervell, B., & Umar, I. N. (2021). Blended learning or face-to-face? Does tutor competence and experience make a difference for students' satisfaction in distance learning? Open Learning: The Journal of Open, Distance and e-Learning, 36(2), 191–208.

Chukwu, I., & Ibrahim, A. (2021). Digital infrastructure gaps and e-learning barriers in rural Nigeria. Journal of Educational Technology in Developing Societies, 4(1), 12–26.

DataReportal. (2024). Digital 2024: Nigeria and Kenya country reports. https://datareportal.com

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Developing Telecoms. (2023, January). Rwandan government to boost primary school internet by 2024. https://developingtelecoms.com

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. Journal of Educational Technology Systems, 49(1), 5–22.

DigiSchool Kenya. (n.d.). Digital Literacy Programme: Executive summary. https://www.digischool.go.ke

Erero, J. L. (2023). Impact of load-shedding in South Africa: A CGE analysis. Journal of Economics and Political Economy, 10(2), 78–94.

Faloye, A., & Ajayi, B. (2022). Understanding the impact of the digital divide on South African students in higher educational institutions. ResearchGate. https://researchgate.net

Freedom House. (2023). Rwanda: Freedom on the Net 2023. https://freedomhouse.org/country/rwanda/freedom-net/2023

Ghana Living Standards Survey. (2020). Round seven: Key indicators report. Ghana Statistical Service.

Global Partnership for Education. (2023, November 16). Ghana: Learning online even without internet access. https://www.globalpartnership.org

GSMA. (2024). Mobile Economy: Sub-Saharan Africa 2024. GSMA Intelligence. https://www.gsma.com

Gunu, R., et al. (2022). Wi-Fi deployment in Ghanaian senior high schools: Progress, gaps, and prospects. African Journal of Educational Technology, 9(2), 78–91.

IFC (International Finance Corporation). (2020). Digital skills in Sub-Saharan Africa: Spotlight on Ghana. World Bank Group.

ILO (International Labour Organization). (2023). Teaching and the teaching profession in a digital world – Rwanda. ILO.

ITU (International Telecommunication Union). (2024). Facts and figures 2024: Internet use. ITU Publications.

JEPA Africa. (2025, August). From code to classroom: EdTech as catalyst for Kenya's digital learning revolution. https://www.jepaafrica.com

Joseph, O. B., & Uzondu, N. C. (2024). Bridging the digital divide in STEM education: Strategies and best practices. Engineering Science & Technology Journal, 5(8), 2435–2453.

Kenya News Agency. (2023). Digital literacy programme on course. https://www.kenyanews.go.ke

Khoza, S. (2024). Navigating the dark: Understanding the impact of load-shedding on Learning Management Systems (LMS) in South African Universities. International Journal of Research in Business and Social Science, 13(2), 345–352.

KT Press. (2026, March 31). EdTechMondays: How Rwanda's teachers embrace digital shift in education. https://www.ktpress.rw

Maggott, N., et al. (2022). Load reduction and electricity inequality in South Africa: The rural poor as primary victims. South African Journal of Energy, 18(3), 55–69.

Market Data Forecast. (2026). Africa e-learning market size, share and growth report, 2034. https://www.marketdataforecast.com

Ministry of ICT Kenya. (n.d.). Digital Literacy Programme (DLP). ICT Authority Kenya. https://ict.go.ke

NaijaCoder Research Team. (2023). NaijaCoder: Participatory design for early algorithms education in the Global South. arXiv. https://arxiv.org/pdf/2310.20488

Nyathi, N., & Joseph, S. (2024). Unveiling educators' readiness to teach through digital media: The case of South Africa. Education and Information Technologies. https://doi.org/10.1007/s10639-024-13310-w

OECD.AI. (2025). Kenya's Digital Literacy Programme (DigiSchool). https://oecd.ai/en/dashboards/policy-initiatives/kenyas-digital-literacy-programme

Oxford Business Group. (2024). Ghana 2024 report: Policy reforms and education technology. Oxford Business Group. https://oxfordbusinessgroup.com

Oxford Insights. (2024). Government AI Readiness Index 2024. Oxford Insights.

PMC (PubMed Central). (2022). Analysing the importance of e-government in times of disruption: The case of public education in Rwanda during COVID-19 lockdown. https://pmc.ncbi.nlm.nih.gov/articles/PMC8865933

REB (Rwanda Basic Education Board). (2023). Rwanda will be a global competitive knowledge-based economy through digital skills education. https://www.reb.gov.rw

Sawyerr-George, O. E., & Agina-Obu, R. (2023). Internet usage among university students in Nigeria: A case study. Asian Journal of Information Science and Technology, 13(1), 16–20.

TechAfrica News. (2023, July 11). Rwanda deploys Starlink internet in schools to bridge digital divide. https://techafricanews.com

Tsapali, M., et al. (2023). Mobile phone ownership, school policy, and digital learning in Ghana. Journal of African Education, 15(2), 44–61.

UNESCO. (2022). Sub-Saharan Africa: Out-of-school statistics. UNESCO Institute for Statistics.

UNESCO. (2023). Global Education Monitoring Report 2023. UNESCO.

UNESCO. (2023, August 9). Government, UNESCO and Huawei launch new report on Kenya's DigiSchool. https://www.unesco.org

UNESCO. (2024). ICT in education national policies: Ghana country profile. UNESCO.

UNICEF Nigeria. (2025). Connecting every child to digital learning. https://www.unicef.org/nigeria

UNITAR. (2024). Building Rwanda's digital future: Reskilling to close the technology gap. https://unitar.org

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425–478.

WATHI. (2024). Digitalisation of education in Ghana: An overview, November 2023. https://www.wathi.org

World Bank. (2023). Community-based digital hubs in developing countries: Access, outcomes, and policy implications. World Bank Policy Research Working Paper.

World Bank. (2024). Nigeria 2024 digital skills report. https://thedocs.worldbank.org

World Economic Magazine. (2025). Digital education and e-learning in Africa: Bridging the skills gap. https://worldecomag.com

Yende, S. J., & Madolo, T. (2024). Influence of load shedding in South African higher education: A qualitative content analysis of Schools of Music. Cogent Education, 11(1). https://doi.org/10.1080/2331186X.2024.2359338