

Digital Readiness and Infrastructure Gaps for E-Learning in Conflict-Affected East African Universities

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Abstract: This study investigates digital readiness and infrastructure gaps for e-learning in conflict-affected university settings across East Africa, where prolonged civil conflict and institutional fragility have disrupted higher education continuity. The purpose was to assess digital habits, device access, and institutional infrastructure among lecturers and students, and to identify barriers that could inform policy and capacity-building measures to close the readiness-infrastructure gap. A descriptive cross-sectional mixed-methods design was employed, drawing on Diffusion of Innovation, Digital Divide, and Technology Readiness Index theories. Data were gathered from 287 lecturers and 1,918 students, together with six institutional representatives, across universities in Sudan, South Sudan, and Kenya, using faculty and student questionnaires, institutional infrastructure checklists, and key informant notes. Quantitative data were analyzed descriptively and comparatively, while qualitative responses underwent thematic analysis; as a single time-point design, causal inferences are limited. Findings revealed strong digital habits and near-universal smartphone ownership, alongside persistent infrastructural deficiencies, with laptop access below 25% among students and unreliable electricity and bandwidth undermining learning continuity, particularly in Sudan and South Sudan. Kenyan universities showed stronger institutional readiness but faced scaling challenges from high enrolment and bandwidth costs. The study concludes that a widening readiness-infrastructure gap exists, where individual willingness outpaces institutional capacity. These findings imply the need for coordinated investment in reliable digital infrastructure and mobile-optimized, low-bandwidth pedagogies to sustain equitable e-learning in fragile contexts.

Keywords: Digital readiness, E-learning infrastructure, Conflict-affected universities, Readiness–infrastructure gap, Diffusion of Innovation Theory, Technology Readiness Index, Digital Divide Theory, Mobile-first learning, Higher education resilience, East Africa

Highlights

What is already known about this topic:

- African higher education faces infrastructure and connectivity challenges.
- Conflict-affected universities often lack reliable power, internet, and ICT support.
- Research focuses on digital literacy, overlooking infrastructural readiness.

What this study contributes:

- Empirical evidence from six universities in Sudan, South Sudan, and Kenya.
- Finds a mobile-first environment: high user readiness, weak infrastructure.
- Introduces the "readiness–infrastructure gap" concept.

Implications for theory, practice, and/or policy:

- Adoption depends on infrastructure and policy, not just motivation.
- Calls for mobile-optimized solutions and investment in power/connectivity.
- Supports regional, donor-backed action aligned with SDG 4, 9, 10.

Introduction

The rapid expansion of digital technologies in higher education has transformed how teaching, learning, and assessment are organized globally. However, this transformation is deeply uneven across regions. In Sub-Saharan Africa, particularly in conflict-affected countries such as Sudan and South Sudan—universities face profound disparities in connectivity, digital infrastructure, and institutional preparedness. Despite growing awareness of the benefits of e-learning, the structural fragility of power supply, bandwidth limitations, and low institutional investment continue to hinder sustainable digital transformation.

The COVID-19 pandemic accelerated the urgency for e-learning adoption, revealing not only pedagogical innovation but also systemic inequality in access and institutional capacity. While universities in relatively stable contexts have transitioned to blended or fully online models, institutions in fragile or post-conflict regions remain dependent on ad-hoc, mobile-based arrangements. Within this reality, digital readiness, the extent to which individuals and institutions are prepared to adopt and effectively use digital technologies, emerges as a critical determinant of higher education resilience and equity.

On December 15, 2013, a civil war broke out in South Sudan, leading to the suspension of academic activities in conflict-affected areas, the displacement and relocation of universities, significant loss of students and academic staff, and the collapse of institutional funding mechanisms (Mayai, 2022). The ongoing civil conflict in Sudan, which erupted on April 15, 2023, has had equally devastating effects on higher education. Approximately 87% of university students have been displaced, forcing institutions to adopt distance learning as the only viable mode of instruction (Naranjo Alcaide, 2025; Abugabr Elhag & Baleela, 2025). Collectively, these disruptions underscore how recurrent armed conflicts continue to erode educational infrastructure and threaten the sustainability of academic systems in both Sudan and South Sudan.

Although Kenya is often perceived as one of the more stable nations in East Africa, it continues to experience conflict-related disruptions that directly and indirectly affect its education sector. As of 30 June 2026, Kenya hosted 857,065 refugees and asylum seekers, comprising 630,946 registered refugees and 226,119 asylum seekers, with the majority originating from Somalia (54%), South Sudan (24.5%), and Ethiopia (5.8%). This large displaced population creates substantial demand for education services and requires additional resources to effectively integrate refugee learners into Kenya's national education system (UNHCR, 2026; World Bank, 2024).

Within its borders, persistent insecurity in the arid and semi-arid northern counties—marked by resource-based and inter-communal violence—has created localized learning crises and hindered access to education for displaced and marginalized populations (Adhola & Ajulu-Okungu, 2025). In addition to regional instability, electoral violence has repeatedly disrupted academic operations in urban centres. Notably, Eldoret, home to University of Eldoret and several tertiary institutions, has historically been an epicentre of post-election unrest, especially during the 2007–2008 crisis that caused mass displacement and severe property loss (Gutierrez-Romero, 2021). Periodic election-related tensions continue to threaten academic continuity in this region, situating Kenya within broader discussions of conflict- and post-conflict educational contexts (Pacheco & Johnson, 2017). Thus, Kenya's higher-education landscape is best understood as operating within a fragile and conflict-affected ecosystem, shaped by both domestic and regional instability.

This study builds on the *Enhancing Higher Education e-Learning Structures and Modules in Conflict Regions of East Africa (EAGLE)* Project, which spans six partner universities in Kenya, Sudan, and South Sudan. Through analyzing the results of the EAGLE Work Package 1 (WP1) survey, the research explores both the human and infrastructural dimensions of digital preparedness and how lecturers,

students, and university systems align (or fail to align) with the demands of modern e-learning environments.

Theoretical Orientation

The study is anchored on three complementary theoretical perspectives that together frame digital readiness as both a behavioral and structural process:

1. Diffusion of Innovation Theory (Rogers, 2003) provides a lens for understanding how new technologies spread through social systems. It explains the progression from awareness and persuasion to adoption and confirmation, emphasizing factors such as relative advantage, compatibility, complexity, trialability, and observability. Within conflict-affected universities, this theory highlights how limited exposure, infrastructural uncertainty, and peer influence shape technology uptake.
2. Technology Readiness Index (Parasuraman, 2000) introduces the human dimension of adoption by measuring optimism, innovativeness, discomfort, and insecurity toward technology use. It clarifies how lecturers and students balance enthusiasm for innovation with apprehension stemming from skill gaps, cost, and institutional instability.
3. Digital Divide Theory (van Dijk, 2005) situates technological inequality within broader social and economic structures. It differentiates among access divides (devices, connectivity), skills divides (digital literacy and confidence), and usage divides (effective participation in digital ecosystems). This framework illuminates why readiness is not uniform across or within institutions and how structural fragility amplifies disparities in e-learning outcomes.

Together, these theories provide a robust analytical scaffold to explain how technological adoption and digital equity unfold in fragile higher education ecosystems—where enthusiasm and capacity often coexist with infrastructural insufficiency and systemic constraints.

Purpose of the Study

The primary purpose of this study is to assess the state of digital readiness and infrastructural adequacy for e-learning across selected universities in East Africa affected by conflict and instability. Specifically, the study aims to:

1. Evaluate the digital habits, device ownership, and prior e-learning experiences of lecturers and students;
2. Examine institutional infrastructure for internet access, power reliability, and ICT support; and
3. Identify key barriers and propose policy and capacity-building measures that can close the readiness–infrastructure gap.

Through integrating data from lecturers, students, and IT administrators, the study contributes empirical evidence to inform strategic e-learning investments, policy frameworks, and digital inclusion strategies that strengthen the resilience and equity of higher education systems in fragile contexts.

Literature

Digital readiness in higher education represents the extent to which institutions, faculty, and students possess the infrastructure, skills, and attitudes necessary to engage effectively in e-learning. Globally, digital transformation in education has expanded rapidly, yet this expansion remains profoundly unequal. Studies by UNESCO (2023) emphasize that readiness is a multi-dimensional construct

encompassing not only device ownership and connectivity but also institutional leadership, policy maturity, and digital literacy. In developed regions, universities have achieved high levels of integration through robust learning management systems (LMS), stable broadband, and faculty development programs. However, in developing and conflict-affected regions, infrastructural fragility continues to undermine the promise of e-learning.

Digital Infrastructure and Readiness Gaps

In Sub-Saharan Africa, the digital divide remains a defining characteristic of higher education systems. Assefa et al. (2021) found that most African nations score below the global mean on broadband speed and national readiness indices, with urban–rural disparities exacerbating inequitable access. Similarly, Mukuni (2019) describes the “hope and disillusionment” of African digital infrastructure, where early optimism about technology-enabled education is constrained by high data costs, low connectivity, and unstable power supply. The Afrobarometer (2022) policy brief reported that only a small proportion of African households own both a computer and an internet-enabled phone, revealing a continent-wide digital deficit that disproportionately affects education.

These infrastructural challenges are compounded by weak institutional investment. Van der Merwe, Serote, and Maloma (2023), in a systematic review of e-learning implementation in African universities between 2016 and 2022, identified persistent weaknesses in ICT infrastructure, technical support, and faculty training. They concluded that despite numerous donor-supported initiatives, many universities remain dependent on ad-hoc systems that cannot support large-scale digital learning. Similarly, studies conducted across Ghanaian higher education institutions found that, although online learning enabled teaching and learning to continue during the COVID-19 closures, students experienced persistent barriers, including unreliable internet connectivity, poor Wi-Fi, high data costs, unstable electricity supply, and limited access to suitable digital devices (Agormedah et al., 2020; Ogbonnaya et al., 2020; Demuyakor, 2021; Addae et al., 2022).

The readiness of faculty and learners is therefore deeply intertwined with institutional and infrastructural realities. Pete and Soko (2020) documented that while many African faculty members possessed intermediate digital skills and relied heavily on smartphones and laptops, unstable internet and unreliable electricity severely limited continuity in teaching. They observed that device ownership alone does not translate into digital readiness; without stable infrastructure and institutional policy, e-learning remains fragmented and reactive rather than transformative.

Human and Institutional Dimensions of Readiness

Beyond infrastructure, digital readiness also encompasses psychological, pedagogical, and institutional factors. Nabwire, Soko, and Gachanga (2024), in their study at the Open University of Kenya (OUK), demonstrated that effective learner support mechanisms significantly enhance engagement and satisfaction in online environments. Their findings highlighted the role of mobile applications, Panopto lecture capture, WhatsApp communication groups, and weekly synchronous sessions in creating inclusive digital experiences. Drawing on expectancy–value theory (Eccles & Wigfield, 2020), they argued that motivation to participate in e-learning is reinforced when institutions provide accessible tools, technical support, and community interaction.

Comparable evidence from South Africa reinforces these patterns. Subban, Soni, and Padayachee (2021) reported that while students were comfortable with LMS platforms such as Moodle, deficiencies in internet stability, software provision, and access to campus labs impeded consistent participation. Mafunda and Swart (2020) similarly found that engineering students in South Africa possessed adequate ICT proficiency but lacked self-regulation and institutional support systems. At Walter Sisulu University, only 32% of new students owned personal computers, while nearly all relied on smartphones

for coursework, underscoring a “mobile-first” learning culture that thrives despite infrastructural inadequacies.

In Somalia, Ahmed et al. (2021) extended the Technology Acceptance Model (TAM) to assess ICT readiness among university students. They established that perceived usefulness, ease of use, and infrastructure availability significantly influenced ICT adoption. These findings parallel those of Soko, Pete, and Mureithi (2025), who examined awareness and use of artificial intelligence (AI) tools among African academics. Applying Rogers’ (2003) Diffusion of Innovation theory, they found that adoption clustered around accessible, low-complexity technologies such as ChatGPT and Grammarly, while institutional barriers—policy ambiguity, high data costs, and low bandwidth—remained decisive constraints.

Collectively, these studies suggest that African higher education institutions face a persistent “readiness–infrastructure gap”, where the enthusiasm and adaptive skills of faculty and students surpass institutional and infrastructural capacity. This mismatch results in uneven access, inconsistent quality, and limited scalability of digital learning.

E-Learning in Fragile and Conflict-Affected Contexts

The problem of digital readiness becomes more acute in conflict-affected environments. D’Apice et al. (2025) proposed a model for e-learning in Myanmar’s conflict zones emphasizing low-bandwidth design, offline accessibility, and asynchronous flexibility. Their model aligns with the realities of Sudan and South Sudan, where unstable power grids, damaged facilities, and funding interruptions hinder consistent e-learning delivery. Research on education in post-conflict regions such as South Sudan (Aman Africa, 2023) indicates that the destruction of infrastructure and displacement of academic personnel drastically reduce institutional resilience and digital investment.

In such contexts, mobile phones often become the most reliable medium of access. Nabwire et al. (2024) and Pete & Soko (2020) both show that smartphones dominate digital learning ecosystems in Africa, with WhatsApp, Google Meet, and Zoom serving as principal channels for teaching and peer interaction. Yet, reliance on mobile technologies introduces new pedagogical challenges: limited screen size, poor compatibility with LMS interfaces, and high data consumption restrict deeper engagement and assessment functionality (Amoah et al., 2024).

Theoretical and Conceptual Underpinnings

The literature collectively situates digital readiness within a triadic theoretical frame. First, the Diffusion of Innovations Theory (Rogers, 2003) explains how new technologies diffuse through social systems based on factors such as perceived advantage, compatibility, and complexity. Adoption in African universities often follows early adopters’ experimentation, informal peer networks, and institutional encouragement (Soko et al., 2025). Second, the Technology Readiness Index (Parasuraman, 2000) illuminates individual dispositions toward technology—optimism, innovativeness, discomfort, and insecurity—that influence readiness levels. Studies across African universities (Ahmed et al., 2021; Subban et al., 2021) confirm that optimism and innovativeness are widespread but tempered by systemic discomfort and insecurity due to unreliable connectivity. Third, the Digital Divide Theory (van Dijk, 2005) conceptualizes inequality in four layers—motivation, access, skills, and usage—providing a holistic view of how social, economic, and infrastructural disparities reproduce educational inequities.

In addition, emerging frameworks such as Pedagogical Readiness for Digital Innovation (Arxiv, 2025) and Critical Success Factors (Selim, 2007; van der Merwe et al., 2023) underscore the need to integrate human, technological, and institutional variables in assessing readiness. Together, these perspectives

guide the present study's multidimensional exploration of digital preparedness in conflict-affected East African universities.

Digital Readiness and Infrastructural Gaps

The reviewed literature converges on three main insights. First, infrastructure—bandwidth, power, and device access—remains the most persistent barrier to equitable e-learning in Sub-Saharan Africa. Second, users (students and lecturers) exhibit substantial digital adaptability and motivation, but institutional policies and resources lag behind this enthusiasm, producing a systemic readiness–infrastructure gap. Third, the situation is especially acute in fragile contexts where conflict and instability magnify infrastructural and financial vulnerabilities.

Yet, despite increasing attention to online learning in Africa (Pete & Soko, 2020; Nabwire et al., 2024; Soko et al., 2025), few studies have conducted cross-country comparative analyses focused on *conflict-affected universities*. The intersection between infrastructural deficits and user readiness remains underexplored, as does the role of institutional resilience in mediating these constraints. This study therefore seeks to fill that gap by providing empirical evidence from six universities across Sudan, South Sudan, and Kenya, linking digital readiness to infrastructural capacity, institutional support, and contextual fragility.

Methodology

Research Design

This study adopted a descriptive cross-sectional research design, integrating both quantitative and qualitative approaches to examine digital readiness and infrastructural gaps across selected universities in conflict-affected regions of East Africa. The design aligns with Creswell and Plano-Clark's (2018) mixed-methods framework, which allows for triangulation of institutional, faculty, and student perspectives to generate a comprehensive understanding of readiness levels.

The study sought to assess baseline digital capacity among partner universities in Sudan, South Sudan, and Kenya. The descriptive design was chosen for its capacity to capture prevailing attitudes, infrastructure conditions, and digital practices at a single point in time while revealing cross-institutional variations and contextual nuances.

Respondents and Context

The study included 2,205 lecturers and students, comprising 287 lecturers and 1,918 students, together with six institutional representatives from participating universities in Kenya, Sudan, and South Sudan. Lecturers and students were invited through their respective universities and participated voluntarily after receiving information about the purpose of the study. This approach enabled willing respondents with relevant experience of university teaching, learning, and digital technologies to share their perspectives. Institutional representatives were purposively selected based on their administrative or technical roles and their knowledge of university policies, infrastructure, and digital learning systems.

Respondents came from diverse academic disciplines, including education, business, engineering, science, and social sciences. Students had a mean age of 24.7 years, while lecturers had a mean age of 42.3 years, reflecting a combination of digitally experienced learners and mid-career educators adapting to emerging teaching approaches. Including students, lecturers, and institutional representatives enabled the study to assess digital readiness at both individual and institutional levels. The institutional representatives provided administrative and policy information on internet connectivity, power reliability, ICT infrastructure, and related facilities.

Contextually, the universities in Sudan and South Sudan operated under significant infrastructural constraints, including unstable electricity, limited broadband, and Intermittent civil unrest affecting physical access to campuses. Kenyan partner institutions, though relatively stable, reported high enrolments and bandwidth congestion, revealing a different dimension of infrastructural strain.

Data Collection Instruments and Procedures

Three instruments were used: (i) Faculty and Student Questionnaires, (ii) Institutional Infrastructure Checklists, and (iii) Key Informant Notes. The questionnaires captured quantitative and qualitative data on:

1. Access to devices (smartphones, laptops, tablets, desktops);
2. Internet and power availability;
3. Prior experience with online learning;
4. Use of learning management systems (LMS) and videoconferencing tools; and
5. Perceived institutional support and barriers.

Data items were measured using five-point Likert scales (1 = Strongly Disagree to 5 = Strongly Agree) assessing readiness indicators such as self-efficacy, institutional support, connectivity, reliability, and affordability. The institutional checklists, completed by ICT officers and administrators, collected objective data on ICT infrastructure: bandwidth capacity, Wi-Fi coverage, laboratory facilities, server redundancy, and power backup systems. Additionally, key informant notes captured contextual explanations on institutional strategies, digital policy frameworks, and operational challenges. Data collection was coordinated by country-based research teams, following ethical clearance from partner universities and informed consent protocols for all respondents.

Data Analysis

Quantitative data were analyzed using descriptive statistics (frequencies, percentages, and means) to determine patterns of readiness and access across participant groups. Comparative analysis across countries employed cross-tabulations and mean-score ranking to highlight variations in infrastructure and digital competence.

Qualitative responses from open-ended items and institutional notes were subjected to thematic analysis, following Braun and Clarke's (2006) six-step framework: familiarization, coding, theme generation, review, definition, and reporting. Themes were aligned with the study's theoretical lenses—Diffusion of Innovation, Technology Readiness Index, and Digital Divide Theory to interpret how infrastructural and behavioral factors interacted within fragile contexts.

Findings were then triangulated across the three respondent groups to strengthen validity and ensure a balanced interpretation of both user experiences and institutional realities.

Validity and Reliability

Instrument validity was established through expert review and pilot testing with 45 respondents at a non-participating institution. Construct validity was reinforced by aligning questionnaire items with validated scales from previous readiness studies (Pete & Soko, 2020; Nabwire et al., 2024; van der Merwe et al., 2023).

Reliability testing using Cronbach's alpha yielded coefficients ranging from 0.81 to 0.89 across key scales, indicating high internal consistency. Triangulation of data sources (students, lecturers, and institutions) enhanced credibility and minimized response bias. Ethical considerations, including

informed consent, data confidentiality, and voluntary participation, were rigorously observed in compliance with institutional review protocols.

Analytical Framework

The study's analytical interpretation drew upon three interrelated theoretical constructs:

- Rogers' Diffusion of Innovation Theory (2003) to explain behavioral adoption and innovation diffusion patterns among faculty and students;
- Parasuraman's Technology Readiness Index (2000) to assess individual predispositions toward technology use; and
- van Dijk's Digital Divide Theory (2005) to contextualize infrastructural inequalities and socio-economic disparities.

This triangulated framework enabled the integration of micro-level behavioral insights and macro-level infrastructural diagnostics, allowing a holistic analysis of how institutional fragility mediates e-learning readiness.

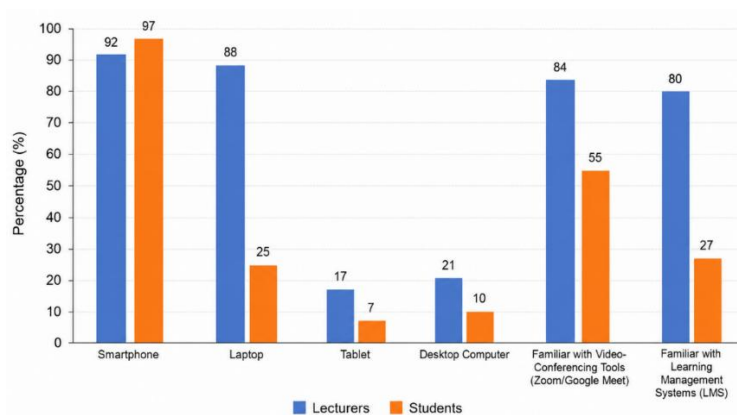
Results and Discussions

Access to Devices and Connectivity for E-Learning

Access to digital technologies differed considerably between lecturers and students. As shown in Figure 1, smartphones were the most widely available devices, reported by 92% of lecturers and 97% of students. Laptop access was also high among lecturers at 88%, but much lower among students at 25%. Access to tablets and desktop computers was limited for both groups. Only 17% of lecturers and 7% of students reported access to tablets, while desktop computer access was reported by 21% of lecturers and 10% of students.

Lecturers also demonstrated greater familiarity with formal digital learning platforms. Familiarity with video-conferencing tools such as Zoom and Google Meet was reported by 84% of lecturers, compared with 55% of students. Similarly, 80% of lecturers were familiar with learning management systems, compared with only 27% of students. These findings suggest that although smartphone access was high among both groups, students had more limited access to laptops, desktop computers and institutional learning platforms.

Figure 1. Device Ownership and Digital Devices Familiarity among Lecturers and Students



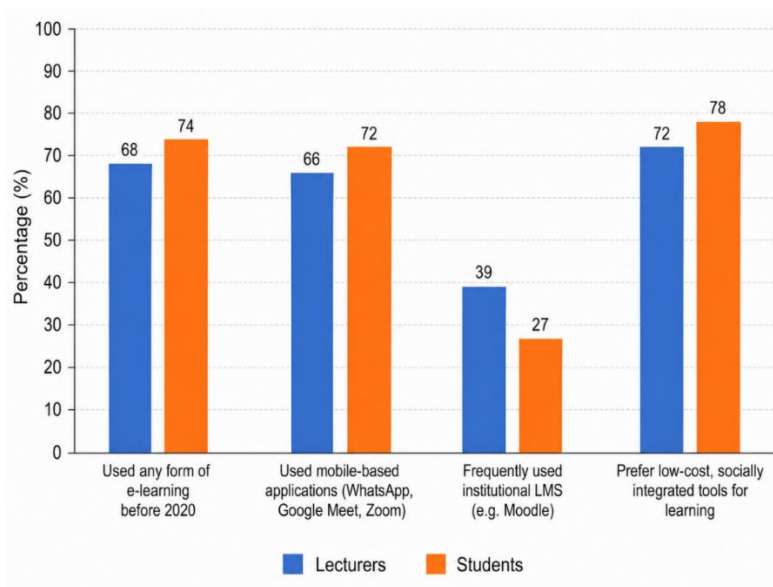
The comparatively low use of desktop computers may be explained by constraints in power reliability and network stability, especially in Sudan and South Sudan; however, the survey data cannot establish this causal link directly. Desktops require constant electricity, while tablets depend on reliable charging cycles and stable Wi-Fi for full functionality. Respondents described “frequent power interruptions” and “limited range of shared Wi-Fi,” making portable and battery-efficient devices (like smartphones) far more practical. This finding is consistent with van Dijk’s (2005) Digital Divide Theory, where access is not only about device ownership but the sustainability of use given infrastructural barriers.

These findings also corroborate prior regional studies showing infrastructural fragility as the key bottleneck to digital education (Pete & Soko, 2020; van der Merwe et al., 2023; Mukuni, 2019). In line with Digital Divide Theory (van Dijk, 2005), the disparity between device availability and functional connectivity illustrates a *second-level divide* whereby users are connected, but not equitably or sustainably.

Prior E-Learning Experience and Digital Platform Used

Analysis of digital habits presented in Figure 2, revealed that 68% of lecturers and 74% of students had used some form of e-learning before 2020, primarily through mobile-based applications such as WhatsApp, Google Meet, and Zoom. The use of institutional LMS platforms (e.g., Moodle) was markedly lower, with only 39% of lecturers and 27% of students reporting frequent engagement.

Figure 2. Prior E-Learning Experience and Digital Platform Used



These patterns suggest diffusion model, where individuals adopt technologies that are low-cost, socially integrated, and flexible mirroring the Diffusion of Innovation Theory (Rogers, 2003), which predicts faster adoption for innovations perceived as simple, compatible, and observable.

Qualitative responses reflected this sentiment:

“I use my phone for almost everything such as research, assignments, and classes. But sometimes, the internet cuts off mid-session.” (Student, South Sudan)

“Moodle is great, but most of us can’t access it without Wi-Fi; so we share notes through WhatsApp.” (Lecturer, Sudan)

Such adaptations echo findings by Nabwire, Soko, and Gachanga (2024), who observed that *learner support strategies leveraging familiar platforms* (e.g., WhatsApp and mobile apps) increase motivation and participation in low-resource settings.

Institutional Readiness and Infrastructure Gaps

Institutional infrastructure checklists revealed wide disparities in bandwidth capacity, power reliability, and ICT staffing. Kenyan universities reported the most advanced infrastructure namely fiber connectivity, on-campus Wi-Fi, and computer labs averaging 50–70 stations. In contrast, Sudanese and South Sudanese institutions operated under strained conditions: shared bandwidth under 20 Mbps, limited solar backup, and aged computer equipment. Most institutions lacked dedicated digital transformation policies or ICT maintenance budgets, relying instead on project-based or donor support.

This pattern is broadly consistent with the Technology Readiness Index (Parasuraman, 2000), indicating that *organizational optimism and innovativeness* exist among educators and administrators, but are counterbalanced by *systemic discomfort and insecurity* stemming from resource fragility. As one IT administrator noted:

“Even when staff are trained, the infrastructure limits what they can do. We have ideas but not the bandwidth.” (Administrator, Sudan)

Institutional readiness therefore remains the weakest link in the digital ecosystem, an observation consistent with earlier African studies (Subban et al., 2021; Pete & Soko, 2020).

Thematic Analysis of Qualitative Data

Thematic analysis of open-ended responses produced five interconnected themes, summarizing perceptions of readiness and infrastructural challenges:

1. Mobile-First Learning and Flexibility – Smartphones and social media apps (especially WhatsApp and Google Meet) dominate as teaching and learning tools, reflecting adaptability to limited resources.
2. Infrastructural Fragility – Electricity instability, poor bandwidth, and lack of redundancy constrain teaching continuity, especially in conflict-affected areas.
3. Institutional Capacity Gaps – Absence of digital policies, inadequate ICT personnel, and dependency on donor funding reduce sustainability.
4. Digital Motivation versus Resource Constraint – High enthusiasm among both faculty and learners contrasts with infrastructural limitations, creating a *readiness–infrastructure gap*.
5. Resilience and Improvisation – Respondents reported creative coping mechanisms, such as offline file sharing, asynchronous video delivery, and blended schedules that align with local power cycles.

These themes collectively illustrate a paradox: digital optimism amid infrastructural deprivation, consistent with similar findings from Nabwire et al. (2024) and D’Apice et al. (2025).

The Cross-Country Comparative Analysis

A comparative lens highlights contextual differences across the three countries:

- Kenya demonstrates the highest institutional readiness, benefiting from national e-learning policy frameworks, stable power supply, and affordable data bundles. Yet, rising enrolment and limited lab capacity strain available infrastructure.
- Sudan displays moderate readiness, constrained by unreliable power and political instability. Universities rely on mobile data and local area networks, with few centralized systems.
- South Sudan remains the least digitally equipped, where power outages and limited funding severely restrict institutional innovation. Despite this, students exhibit high motivation, with most using smartphones as their sole learning device.

These findings align with the multi-layered inequities observed in the African Council for Distance Education (ACDE, 2020) report and reaffirm the contextual salience of Digital Divide Theory in explaining variations across national systems.

Interpreting the Readiness–Infrastructure Gap

The results reveal that human readiness in East African universities has outpaced infrastructural readiness. Lecturers and students exhibit adaptability, self-directed learning, and openness to innovation, but institutions lack the bandwidth, equipment, and policies to translate these attributes into sustainable digital ecosystems.

Through the lens of Diffusion of Innovation, this reflects an early adoption stage characterized by individual experimentation but insufficient organizational routinization. The Technology Readiness Index further clarifies the behavioral dimension—respondents are optimistic yet constrained by external systems. Finally, the Digital Divide Theory situates these disparities within broader socio-economic and geopolitical structures that perpetuate unequal access to digital opportunity.

These findings align with global research highlighting infrastructure as the decisive factor in e-learning equity Mukuni (2019) and extend regional literature (Pete & Soko, 2020; Nabwire et al., 2024) by demonstrating how conflict and fragility amplify readiness gaps in East Africa. The study thus conceptualizes the “readiness–infrastructure gap” as both a developmental and structural challenge that transcends technology itself, implicating governance, policy, and investment priorities. This pattern also reflects a broader global shift toward mobile-first internet use, in which smartphones increasingly serve as the primary or sole means of digital access, particularly in lower-resource settings (Khim & Bon, 2025).

Conclusion and Recommendations

Findings

The study examined digital readiness and infrastructure gaps for e-learning among 2,205 lecturers, students and institutional representatives in universities in Kenya, Sudan and South Sudan. The findings showed that lecturers and students were generally motivated and willing to use digital technologies, but their participation was constrained by unreliable electricity, limited internet bandwidth, inadequate Wi-Fi coverage, outdated ICT equipment and insufficient institutional support. Similar infrastructural barriers have been reported in other African higher education contexts (Mukuni, 2019; Pete & Soko, 2020; Subban et al., 2021).

Smartphones and mobile applications, particularly WhatsApp and Google Meet, were the most commonly used tools because they were accessible, familiar and suitable for low-resource environments. The limited use of institutional learning management systems showed that users preferred technologies that were simple, affordable and compatible with their existing practices. This

finding supports the Diffusion of Innovation Theory, which argues that innovations are adopted more rapidly when they are perceived as easy to use, compatible and beneficial (Rogers, 2003).

The study also identified a clear readiness–infrastructure gap, in which individual motivation and adaptability were stronger than institutional and technological capacity. This finding is explained by the Technology Readiness Index, which shows that optimism and innovativeness can coexist with discomfort and insecurity when users lack adequate institutional and technical support (Parasuraman, 2000).

Differences in device access, connectivity, power reliability and effective use of digital platforms also support the Digital Divide Theory. The findings demonstrate that the digital divide extends beyond ownership of devices to include the quality, affordability and sustainability of access (van Dijk, 2005). These inequalities were more evident in the conflict-affected and resource-constrained university contexts.

Conclusions

The study concludes that digital transformation in universities located in conflict-affected areas of East Africa is possible, but it cannot be sustained through individual enthusiasm alone. Although lecturers and students have embraced mobile-based learning, institutional infrastructure and formal e-learning systems have not developed at the same pace.

From the perspective of Diffusion of Innovation Theory, the widespread use of smartphones and social applications represents a grassroots form of technology adoption based on affordability, simplicity and compatibility with users' daily practices (Rogers, 2003). However, the limited use of formal learning management systems indicates that digital innovations have not yet been fully institutionalised.

The Technology Readiness Index further explains that lecturers and students display optimism and willingness to use digital technologies, but their readiness is weakened by inadequate technical support, equipment and institutional systems (Parasuraman, 2000). The Digital Divide Theory shows that unequal access to reliable electricity, bandwidth, suitable devices and institutional resources creates different levels of digital participation across the three countries (van Dijk, 2005).

The study therefore concludes that sustainable digital learning requires coordinated investment in human capacity, infrastructure, institutional policy and resilience planning. This conclusion is consistent with the African Council for Distance Education which emphasise that digital transformation depends on the alignment of technology, governance and human capital (ACDE, 2020).

Recommendations

1. Strengthen digital infrastructure: Governments, universities and development partners should invest in reliable broadband, campus Wi-Fi, modern ICT equipment and alternative power systems, including solar backup (ACDE, 2020).
2. Adopt accessible technologies: Universities should prioritise mobile-friendly, low-bandwidth and downloadable learning materials. This responds to the Diffusion of Innovation Theory by promoting technologies that are affordable, simple and compatible with users' circumstances (Rogers, 2003).
3. Institutionalise digital learning: Universities should establish clear policies on e-learning, data management, ICT maintenance, infrastructure financing and staff development. This would move digital adoption from individual experimentation to institutional practice.
4. Improve training and technical support: Continuous training should be provided to lecturers, students and administrators. In line with the Technology Readiness Index, training should be

accompanied by adequate ICT support and infrastructure to reduce discomfort and insecurity associated with technology use (Parasuraman, 2000).

5. Reduce digital inequalities: Institutions should provide device-support programmes, affordable internet access, reliable power and inclusive digital services. These measures would address the material and usage inequalities identified by Digital Divide Theory (van Dijk, 2005).
6. Develop resilient learning systems: Universities should expand asynchronous teaching, offline content, flexible learning schedules and community learning hubs to maintain continuity during crises (Mukuni, 2019).
7. Strengthen regional collaboration: Universities should share digital resources, expertise and good practices through regional networks and cross-border partnerships (ACDE, 2020).
8. Monitor digital readiness: Regular assessments should be conducted to measure device access, connectivity, digital skills, platform use, infrastructure and institutional preparedness.

These recommendations contribute to SDG 4 on quality education, SDG 9 on innovation and infrastructure, SDG 10 on reduced inequalities and SDG 16 on strong institutions.

Future Research

Future studies should use mixed-method and longitudinal approaches to examine how digital readiness develops into stronger institutional capacity and sustained e-learning adoption over time. Comparative studies involving more East and Central African countries, as well as public and private universities, could also show how policy, funding, governance and economic conditions influence digital resilience. Further research should investigate the relationship between infrastructure investment, lecturers' digital competence and student learning outcomes. Multi-level analysis could help separate individual factors from institutional influences. Intervention studies should also assess the effectiveness of digital-skills training, low-bandwidth teaching approaches and infrastructure improvements in fragile higher education settings.

Qualitative case studies are needed to explore how universities in conflict-affected areas maintain learning during disruption. Such studies could document local coping strategies, partnerships and leadership practices that support continuity. Policy-focused research should also examine funding models, regional collaboration and cross-border digital education frameworks to determine how long-term investment can transform digital readiness into sustainable institutional strength.

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This study is linked to the following SDG(s): SDG 4 (Quality Education), SDG 9 (Innovation & Infrastructure), and SDG 10 (Reduced Inequalities).

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The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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