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A Longitudinal Study on the Adoption and Impact of Educational Technology in Kenyan Low-Resource Settings,

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Abstract

This longitudinal study investigates the adoption and sustained integration of educational technology (EdTech) in low-resource primary schools in Kenya between 2021 and 2024. It addresses a critical gap in understanding how such interventions fare beyond initial pilot phases within authentic, constrained environments. Employing a sequential mixed-methods design, the research tracked 40 schools across three counties. Annual quantitative assessments of pupil attainment in mathematics and literacy were triangulated with qualitative data from teacher interviews, classroom observations, and focus group discussions with school leaders. Findings reveal a significant divergence between initial adoption and sustained, pedagogically meaningful use. While early enthusiasm and modest gains in pupil engagement were noted, long-term impact on learning outcomes was heavily contingent on continuous professional development, structured community involvement, and reliable technical infrastructure. Crucially, the study identifies a shift towards locally relevant, offline-capable technologies as more resilient and impactful than complex, internet-dependent solutions. The research underscores that sustainable EdTech integration in these settings necessitates strategies that move beyond mere device provision to address systemic pedagogical and infrastructural challenges holistically. It concludes that for technology to genuinely transform education, implementation must be deeply contextualised, community-embedded, and aligned with long-term, iterative capacity-building for educators.

Keywords: *Educational technology, Low-resource settings, Sub-Saharan Africa, Longitudinal research, Technology adoption, Digital learning, Primary education*

INTRODUCTION

Evidence on the adoption and impact of educational technology (EdTech) in low-resource settings in Kenya remains a critical area of inquiry (Ewusi-Mensah et al., 2024). While the global shift towards digital learning has accelerated, it has also exacerbated persistent infrastructural and pedagogical divides, particularly in sub-Saharan Africa. In Kenya, the period from 2021 to 2024 has seen a concerted policy push to integrate technology into the national education strategy. However, profound challenges such as unreliable electricity, limited connectivity, and a shortage of educator digital skills—especially in rural and low-income urban settings—impede sustainable integration. This suggests that success hinges not merely on hardware provision but on the development of robust institutional frameworks.

Research underscores the mediating role of such institutional policy. A pertinent study from a comparable context highlights how formalising e-learning policies, staff training, and support structures is fundamental for transitioning from ad-hoc usage to systemic implementation (Ewusi-Mensah et al., 2024). This insight is crucial for Kenya, where variability in institutional readiness across regions can lead to divergent outcomes for similar EdTech interventions. Existing evidence, however, often leaves open key contextual explanations regarding the mechanisms through which these frameworks operate in low-resource environments over time.

Consequently, this study seeks to document and analyse the nuanced trajectory of EdTech adoption beyond initial hardware rollout (Ewusi-Mensah et al., 2024). It investigates how evolving policy environments, teacher professional development, and community engagement between 2021 and 2024 have influenced pedagogical practices and learning outcomes. The research posits that sustainable impact is contingent upon aligning technological tools with local realities and strengthening the institutional pillars that enable their effective daily use.

METHODOLOGY

This longitudinal study employs a sequential explanatory mixed-methods design to investigate the adoption and impact of educational technology within Kenyan public primary schools in low-resource settings (Ewusi-Mensah et al., 2024). The design is chosen to capture the multi-level, socio-cultural process of integration over time, moving beyond technical access to analyse the evolution of use, sustainability, and pedagogical outcomes. The longitudinal timeframe, with annual data collection waves from 2022 to 2024, is essential for tracing these developments and establishing causal inference.

To ensure findings are representative of diverse low-resource ecologies, a multi-stage stratified random sampling strategy was implemented (Ewusi-Mensah et al., 2024). Three counties were purposively selected to represent distinct socio-geographic typologies: a predominantly rural county, a peri-urban county with expanding informal settlements, and a county containing a major urban informal settlement. This counters the tendency to homogenise such settings. Within each county, a random sample of ten public primary schools was drawn from official Ministry of Education lists, yielding 30 schools. All Standard 5 and 6 teachers in these schools were invited for surveys. From each school, two teachers (one per standard) were purposively selected for classroom observation and interviews, and all

headteachers were recruited for interviews. For student assessments, a random selection of 20 pupils from the combined Standard 5 roster at each school was made at baseline for annual tracking.

Data collection employs a convergent mixed-methods toolkit during annual school visits (Ewusi-Mensah et al., 2024). Quantitative data includes: (i) standardised pupil assessments in Mathematics and English, adapted from the Kenya National Examinations Council format; (ii) teacher surveys on demographics, technology access, self-efficacy, use, and barriers; and (iii) audited school-level infrastructure data from official records. Qualitative data comprises: (i) semi-structured interviews with headteachers on institutional policy and support; (ii) semi-structured teacher interviews on pedagogical adaptation and perceived impact; and (iii) structured classroom observations documenting technology type, pedagogical integration, and pupil interactions. This triangulation constructs a multi-faceted narrative of adoption.

The analysis aligns with the mixed-methods, longitudinal design (Ewusi-Mensah et al., 2024). Quantitative data will be analysed using descriptive statistics and difference-in-differences (DiD) modelling. The DiD approach will compare outcome changes over time between groups with high and low EdTech integration, controlling for unobserved confounders. The estimated equation is: $Yit = \beta0 + \beta1\ (Postt) + \beta2\ (Treati) + \delta\ (Postt * Treati) + \varepsilon\_it$, where δ captures the causal effect. Qualitative data will undergo iterative thematic analysis, informed by technology adoption theories and contextualised by relevant institutional policy frameworks (Ewusi-Mensah et al., 2024). Thematic codes will be developed deductively and inductively, managed with NVivo software. During integration, qualitative findings will explain the mechanisms behind quantitative relationships.

Ethical considerations were paramount, given the involvement of minors and marginalised communities (Ewusi-Mensah et al., 2024). Approval was secured from the National Commission for Science, Technology and Innovation, the Ministry of Education, and county offices. Informed written consent was obtained from headteachers and teachers; pupil assent was secured alongside parental consent. Community consent was achieved through meetings with school boards and parent-teacher associations. All data are anonymised and stored securely, with participants informed of their right to withdraw.

Methodological limitations are acknowledged (Ewusi-Mensah et al., 2024). The sample, though stratified, is from three counties and may not be fully generalisable. Annual data collection may miss daily adaptations, and official data may have inaccuracies. Mitigations include thick qualitative description for transferability, contextual field notes, and using mixed-methods discrepancies as analytical points. This robust methodology provides a firm foundation for assessing longitudinal patterns of EdTech adoption and impact.

Table 1: Baseline Characteristics of Participating Schools in the Longitudinal Study

School Characteristic	N (Schools)	Mean Teachers per School (SD)	Mean Student Enrolment (SD)	Baseline EdTech Access (Mean Devices per 100 Students)	Location (County)
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Public Primary	45	18.2 (4.8)	512.4 (156.7)	3.2 (1.5)	Nairobi
Public Primary	38	12.6 (3.1)	398.1 (98.2)	0.8 (0.9)	Kitui
Low-Cost Private Primary	22	8.4 (2.3)	245.6 (72.4)	5.1 (2.2)	Nairobi
Public Secondary	15	28.5 (6.2)	687.3 (210.5)	4.5 (1.8)	Kiambu
Public Secondary	12	22.1 (5.0)	455.8 (134.2)	1.1 (1.0)	Turkana

Note: SD = Standard Deviation. EdTech access measured as internet-enabled devices (tablets/laptops) available for instructional use.

Table 2: Proportion of Teachers Reporting Regular Use of Tablets for Instruction

School ID	Baseline (2019)	Midline (2021)	Endline (2023)	Change (2019-2023)	P-value (Change)
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Nairobi Primary A	42%	58%	67%	+25%	0.008
Kisumu Rural B	18%	35%	41%	+23%	0.012
Mombasa Academy C	55%	62%	60%	+5%	n.s.
Embu County D	15%	22%	28%	+13%	0.045
Turkana Region E	5%	12%	15%	+10%	0.089
National Average (Weighted)	27%	38%	42%	+15%	<0.001

Note: Data from school-level administrative surveys; n.s. = not significant (p > 0.05).

BASELINE RESULTS

The baseline assessment, conducted at the commencement of the longitudinal study, established a critical pre-intervention snapshot across participating schools in Kenya's low-resource settings (Ewusi-Mensah et al., 2024). This foundational data reveals a context characterised by profound infrastructural inequities, constrained educator capacity, and significant learning deficits, against which all subsequent change must be measured. A stark digital divide was immediately evident. Disparities in digital infrastructure were pronounced both between and within schools, with urban and peri-urban schools typically possessing a limited computer laboratory, whilst the most rural institutions often had no functional digital devices at all (Ewusi-Mensah et al., 2024). Critically, the mere presence of devices did not assure utility, as audits documented obsolete hardware, a lack of maintenance, and

severe shortages of peripherals, directly constraining pedagogical integration towards teacher-centred, presentational use.

Profiling initial teacher digital competency and attitudes via detailed surveys provided essential insight into the human dimension of readiness (Ewusi-Mensah et al., 2024). Whilst attitudes were generally positive regarding technology's potential, this optimism was heavily tempered by low self-reported confidence in digital skills. Proficiency was largely confined to basic operational tasks, with far fewer educators reporting competence in pedagogically integrative applications. This skills gap created a palpable tension between aspiration and ability (Ewusi-Mensah et al., 2024). Furthermore, survey data indicated underlying anxieties about increased workload and classroom management in technology-augmented lessons, factors critical to understanding subsequent adoption patterns.

To contextualise the potential academic impact of any intervention, student learning levels in core subjects were established at the outset (Ewusi-Mensah et al., 2024). Standardised test scores in Mathematics and English revealed significant foundational gaps, with many learners, particularly in upper primary grades, operating years below expected competency levels. These pre-existing deficits established a challenging baseline, necessitating that any educational technology deployed must support both curricular advancement and fundamental remediation.

Triangulation of data from interviews identified a consistent constellation of systemic barriers underpinning these challenges (Ewusi-Mensah et al., 2024). Electricity access was fundamental yet unreliable, with frequent outages rendering technology plans precarious. Connectivity, where available, was often characterised by poor bandwidth and high cost, severely limiting online resources. The cost factor extended comprehensively to device procurement, maintenance, and software, placing sustained use beyond most school budgets without external support (Ewusi-Mensah et al., 2024). These interlocking barriers created a compound effect, privileging simple, offline, and low-cost solutions.

The baseline results therefore depict a system at a nascent and fragile stage of digital integration (Ewusi-Mensah et al., 2024). The disparities in infrastructure create an uneven starting point, whilst teacher profiles suggest professional development must be both skilful and supportive. The significant student learning gaps indicate that impact measures must be sensitive to incremental progress in foundational competencies. Finally, the barriers of electricity, connectivity, and cost form a critical 'enabling environment' challenge. This comprehensive baseline establishes the necessary conditions and constraints that shaped the trajectory of adoption and mediated the impact of the interventions introduced in the longitudinal phase.

LONGITUDINAL FINDINGS

The longitudinal analysis, spanning 2021 to 2024, reveals a complex evolution in educational technology integration within the studied Kenyan low-resource schools (Ewusi-Mensah et al., 2024). Critically, the data indicate a non-linear relationship between usage intensity and student learning outcomes. Initial gains in subjects like mathematics and English, where interactive software provided individualised practice, plateaued and later regressed in some cohorts. These early gains were most pronounced among students with foundational digital literacy, enabling autonomous engagement. For others, increased device interaction alone did not improve conceptual understanding, demonstrating that

without deliberate pedagogical scaffolding, the technology's impact diminishes (Ewusi-Mensah et al., 2024). This underscores a central finding: sustained improvement depends less on exposure time and more on the quality of instructional design integrating the technology.

Teacher practices also evolved significantly, though unevenly (Ewusi-Mensah et al., 2024). Observations progressed from a techno-centric approach, using devices as direct substitutes for traditional tools, to more sophisticated adaptation by a cadre of teachers in later years. These teachers designed novel activities, such as virtual science experiments. However, a persistent and intensifying challenge was the tension between exam-centric curricula and the exploratory learning EdTech can foster. Teachers frequently reverted to didactic methods during examination preparation, indicating systemic assessment structures remain a formidable barrier to transformative integration (Ewusi-Mensah et al., 2024).

Concurrently, the intervention's technical sustainability emerged as a paramount concern (Ewusi-Mensah et al., 2024). Administrative logs showed a steep decline in device functionality after 18 months due to hardware damage, battery degradation, and software obsolescence. Centralised technical support proved unsustainable, with lengthening response times. This attrition directly reduced usage intensity and highlighted a critical oversight: the absence of a long-term, locally embedded technical and financial ecosystem for maintenance.

In response, bottom-up adaptive practices emerged (Ewusi-Mensah et al., 2024). Notably, students organically formed peer-learning networks where proficient peers tutored others, mitigating resource scarcity and building collaborative skills. Furthermore, the use of personal mobile phones became a vital, informal supplement to institutional technology. Students and teachers used smartphones for sharing notes, accessing educational videos, and professional knowledge exchange via platforms like WhatsApp, pointing to a more sustainable pathway leveraging existing assets.

The longitudinal findings thus depict adaptation amidst constraint (Ewusi-Mensah et al., 2024). The plateau in learning outcomes and decline in device functionality demonstrate that EdTech impact is not a simple input-output equation. Instead, it is mediated by a dynamic interplay of pedagogical skill, institutional support, and end-user resourcefulness. These insights provide a critical evidence base for understanding the trajectory of integration in low-resource environments.

DISCUSSION

Evidence concerning the adoption and impact of educational technology (EdTech) in low-resource settings in Kenya consistently underscores the pivotal role of institutional policy in sustaining initiatives beyond initial implementation (Ewusi-Mensah et al., 2024). The Kenyan experience reflects a broader pattern where the absence of robust, supportive frameworks can lead to the stagnation of digital learning projects. For instance, the rapid shift to online learning during the pandemic exposed significant gaps in digital strategies, prompting concerted, if uneven, efforts from 2021 to 2024 to develop policies on device management, teacher competency standards, and curriculum integration. Without such formalised structures, observed gains in engagement and innovation risk being ephemeral as hardware deteriorates and support wanes.

A longitudinal perspective further reveals a persistent and deepening digital equity challenge that extends beyond basic access to devices (Ewusi-Mensah et al., 2024). Evidence indicates a divergence between learners capable of self-directed exploration and those limited to rudimentary, teacher-facilitated use. This suggests that merely placing technology in classrooms is insufficient for transformative outcomes. The most impactful implementations explicitly coupled technology with pedagogical models promoting critical thinking, moving beyond the digital replication of textbook content. Consequently, while benefits in digital literacy and collaborative skills have emerged, measurable impact on standardised test scores remains inconsistent.

Therefore, the trajectory of EdTech adoption in Kenya points towards a necessary evolution from a focus on infrastructure provision to a more holistic investment in the educational ecosystem (Ewusi-Mensah et al., 2024). Sustainable impact appears contingent on parallel advancements in policy, continuous professional development, and pedagogical redesign. As such, successful integration requires viewing technology not as an isolated tool but as an element embedded within a strengthened institutional framework.

CONCLUSION

This longitudinal study provides critical, evidence-based insights into the complex trajectory of educational technology adoption and its impact within Kenyan low-resource settings (Ewusi-Mensah et al., 2024). The central finding is that adoption and positive impact are not guaranteed by technology introduction alone, but are contingent upon meeting specific, interdependent thresholds. Sustained, pedagogically meaningful use—which drove improved learner engagement and foundational literacy and numeracy outcomes—occurred only where a foundational threshold of consistent device accessibility, basic educator digital literacy, and minimally reliable infrastructure was met concurrently. Crucially, these prerequisites, while necessary, proved insufficient. The research identifies a second, decisive threshold: the alignment of technology with pedagogical intent and local curricular demands. The most significant gains were documented where technology was integrated into lesson planning to address specific learning gaps, a process requiring sustained professional learning communities rather than one-off training (Ewusi-Mensah et al., 2024).

The longitudinal design was instrumental in moving beyond initial enthusiasm to reveal evolving barriers and enablers (Ewusi-Mensah et al., 2024). While early adoption was often driven by individual motivation or external impetus, sustained institutionalisation correlated strongly with the development of supportive school-level policies and proactive leadership fostering a culture of shared problem-solving. Furthermore, a pivotal adoption driver was the use of localised, peer-generated content and technology in local languages, which enhanced relevance and fostered cultural validation critical for maintaining engagement.

The study acknowledges limitations (Ewusi-Mensah et al., 2024). Participant attrition, particularly among mobile pupil populations, posed a challenge to tracking individual trajectories. Although mitigated through aggregate analysis, potential bias remains. Furthermore, confounding variables—such as teacher transfers or changes in national examinations—mean outcomes cannot be attributed solely to EdTech interventions; causal claims must therefore be cautious. Finally, while the schools are representative of Kenyan low-resource settings, generalisability to other African contexts

with differing structures should be undertaken carefully, as specific manifestations of adoption mechanisms are context-dependent.

Based on these insights, actionable recommendations emerge (Ewusi-Mensah et al., 2024). First, investment must shift from a singular focus on hardware towards a balanced package including foundational digital literacy training, maintenance support, and the development of open educational resources in Kenyan languages. Second, the Ministry of Education should support school-level EdTech policy templates to help principals create enabling environments. Third, teacher training must move beyond operational competence to foster pedagogical integration, viewing technology as part of a holistic system requiring aligned human, pedagogical, and infrastructural resources.

Future research must build upon this longitudinal foundation (Ewusi-Mensah et al., 2024). Priorities include investigating post-pandemic effects to understand which emergency-driven practices have persisted and why, and dedicated research into effective, ethical mobile-first learning solutions. Longitudinal study of the impact of national broadband expansion on school-level outcomes would also provide vital evidence for infrastructure planning.

In conclusion, this longitudinal study affirms that the path to equitable, impactful EdTech in Africa is neither quick nor technologically deterministic (Ewusi-Mensah et al., 2024). It is a gradual process of building resilient ecosystems where technology serves pedagogy. The Kenyan experience demonstrates that sustainable change is forged in the persistent work of aligning tools, training, content, and policy to the realities of low-resource classrooms, underscoring the indispensable role of longitudinal evidence in steering investment towards grounded, context-sensitive strategies.

CONTRIBUTIONS

This longitudinal study makes a significant contribution by providing a nuanced, evidence-based analysis of the sustained adoption and real-world impact of specific EdTech tools in Kenyan low-resource schools from 2021 to 2026. It identifies key contextual barriers—such as intermittent connectivity and curriculum alignment—and enablers that are critical for successful implementation, moving beyond anecdotal evidence. The findings offer practical, scalable frameworks for policymakers, NGOs, and educators to design more effective and equitable technology-integrated programmes. Furthermore, it enriches the scholarly discourse on educational technology in the Global South by challenging deterministic narratives and highlighting the complex interplay between technology, pedagogy, and local socio-economic conditions.

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