



Bridging the EdTech Divide Under Resource Constraints: How a Rural Principal Navigated Resource Scarcity to Elevate Learning Quality

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Abstract

The global expansion of educational technology has highlighted a stark disparity in digital transformation between urban and rural schooling systems. In marginalized primary schools, severe infrastructure deficits and limited teacher digital literacy frequently impede meaningful EdTech integration. This qualitative single-case study investigated how a primary school principal conceptualized and enacted innovative leadership strategies to optimize technology-assisted learning within a resource-constrained rural context (SDN Satap 12 Konawe Selatan, Indonesia). Data was collected over an eight-week field engagement through semi-structured interviews, direct classroom observations, and documentary analysis involving the school principal, teaching staff, elementary students, and administrative personnel. Utilizing an interactive thematic analysis framework, the study revealed that principal leadership innovation operated across four interconnected dimensions: localized peer-mentoring circles, adaptive rotational hardware management, offline content pre-loading, and administrative tool modeling. Despite severe hardware shortages and unstable internet connectivity, these frugal leadership practices successfully enhanced teacher digital self-efficacy, expanded pedagogical diversity, and elevated student learning engagement. The study contributes a grounded model of "frugal digital leadership" to educational management literature, demonstrating that administrative vision and cultural empowerment can effectively offset material scarcity. These findings imply that educational policymakers should prioritize contextualized leadership capacity building and offline EdTech management strategies over top-heavy hardware distribution alone when driving digital equity in rural schools.

Keywords: Digital Leadership, Educational Technology, Principal Innovation, Resource-Constrained Schools, Rural Primary Education

Introduction

The global expansion of digital infrastructure and educational technologies has initiated a systemic paradigm shift across primary and secondary schooling systems, reconfiguring the parameters of institutional management, pedagogical delivery, and curriculum implementation (Luo et al., 2024). In the contemporary educational landscape, digital transformation extends beyond the superficial installation of technological hardware or software; it demands a



fundamental reorientation of instructional frameworks toward the development of twenty-first-century learner competencies, including critical reasoning, complex problem-solving, collaborative inquiry, and digital literacy (Ghavifekr & Yue, 2022). Within this complex ecosystem, school principals occupy a critical strategic node as primary agents of organizational change. The leadership practices of principals directly dictate the extent to which technological innovations are integrated into daily classroom instruction or remain underutilized peripheral artifacts (Schmitz et al., 2023). Consequently, understanding the mechanisms through which school leaders drive, support, and sustain technology integration has emerged as a major priority within educational management and policy literature worldwide.

Over the past decade, scholarly discourses surrounding educational administration have increasingly transitioned from examining conventional bureaucratic management toward exploring transformational, instructional, and digital leadership paradigms. Digital leadership, defined as the strategic deployment of a leader's digital literacy, vision, and governance capacity to cultivate an innovative institutional culture, has become central to effective school management (Sunu, 2022). Empirical studies demonstrate that principals who exhibit strong digital leadership positively influence teachers' attitudes toward technology adoption, elevate their technological pedagogical content knowledge (TPACK), and foster higher levels of instructional efficacy (Luo et al., 2024). Furthermore, school leaders who proactively establish collaborative structures, such as Professional Learning Communities (PLCs), provide the organizational scaffolding necessary for teachers to experiment with interactive media, digital assessment tools, and learner-centered instructional strategies (Rasdiana et al., 2024). Through strategic visioning, professional empowerment, and resource mobilization, principal leadership functions as the primary catalyst bridging institutional policy mandates with actual classroom practice.

Despite the extensive body of literature documenting the positive outcomes of principal digital leadership, existing scholarship exhibits a notable contextual and conceptual limitation. A substantial majority of empirical research on educational technology leadership has focused on urban, affluent, or well-resourced school environments characterized by high-speed internet connectivity, abundant hardware provision, and high baseline digital literacy among educators (Ghavifekr & Yue, 2022; Schmitz et al., 2023). Conversely, significantly less empirical attention has been directed toward understanding how digital leadership operates within resource-constrained, marginalized, or rural educational settings, particularly within developing nations (Hasanah & Yaqin, 2025; Widodo et al., 2024). In rural primary schools, such as the "one-roof" (Satap) integrated schools in Indonesia, principals face systemic obstacles, including acute deficits in computer hardware, unstable network connectivity, severe budget limitations, and pronounced gaps in teacher digital competence (Abubakar & Aspin, 2025).

This empirical and theoretical deficit creates a pressing problem in current educational leadership literature. Standard digital leadership frameworks frequently assume the presence of baseline technological infrastructure, thereby offering limited practical or theoretical guidance for school leaders operating in low-resource environments. When structural conditions prevent the full-scale acquisition of advanced EdTech tools, conventional top-down technological strategies often fail, leading to low teacher adoption, heightened techno-anxiety, and organizational inertia (Caratiquit & Javier, 2025). While recent scholarship highlights that resource limitations do not automatically preclude pedagogical innovation, there is a lack of rigorous qualitative evidence detailing the exact mechanisms through which principals in rural contexts enact "frugal digital leadership", defined as the creative, adaptive, and strategic optimization of limited digital assets to foster pedagogical quality (Zeng et al., 2025). Consequently, an empirical investigation into how rural principals navigate infrastructural deficits to cultivate sustainable technology-assisted learning environments represents an essential, yet under-researched, avenue of inquiry.

To address this significant gap in the literature, this study presents a comprehensive, qualitative case study investigating the innovative leadership practices of a primary school principal in optimizing technology utilization at SDN Satap 12 Konawe Selatan, a rural school located in Southeast Sulawesi, Indonesia. By examining an institution operating under explicit hardware and connectivity constraints, this paper moves beyond idealized models of digital

transformation to explore grounded, context-sensitive leadership strategies. Specifically, this research aims to accomplish three main objectives:

1. To analyze the specific structural dimensions and conceptual forms of leadership innovation enacted by the school principal to facilitate technology integration.
2. To examine the adaptive management strategies utilized by the principal and teaching staff to mitigate severe technological infrastructure deficits and build localized human resource capacity.
3. To evaluate the qualitative shifts in classroom dynamics, pedagogical diversity, and student learning engagement resulting from principal-led technology initiatives.

This study makes several distinct theoretical, empirical, and practical contributions to the field of educational administration and technology integration. Theoretically, it expands current digital leadership frameworks by conceptualizing a model of frugal digital leadership tailored to resource-scarce environments, demonstrating that leadership vision and cultural empowerment can offset hardware limitations. Empirically, it enriches the literature on rural education in developing countries by providing detailed qualitative evidence from a marginalized Indonesian "one-roof" primary school, a context underrepresented in Scopus-indexed literature. Practically, the findings offer actionable insights for educational policymakers, local government authorities, and rural school administrators seeking to design cost-effective, sustainable, and capacity-focused digital transformation strategies in marginalized schooling systems globally.

Methods

Research Design

This study employed a qualitative, single-case study design to investigate the innovative leadership practices of a primary school principal in facilitating technology-assisted learning within a resource-constrained rural context. Qualitative inquiry is well suited for exploring complex institutional phenomena, localized administrative decisions, and real-world interactions in their natural operational settings. A case study approach was specifically selected because it enables an in-depth, holistically grounded examination of a bounded system, in this instance, SDN Satap 12 Konawe Selatan, an integrated "one-roof" (Satap) primary school located in Southeast Sulawesi, Indonesia. By adopting a case study framework, the study systematically captured how leadership strategies, resource limitations, and instructional adaptations intersected within a specific socio-economic environment.

Data Source and Participant Selection

Participants were selected using a purposive sampling strategy to ensure that all data sources possessed direct experience, relevant insight, and operational involvement in the school's digital initiatives. The primary key informant was the school principal (N=1), who was chosen due to his direct responsibility for formulating institutional policies, managing school budgets, and initiating EdTech strategies. To evaluate the execution and instructional impact of these policies, primary school teachers (N=6) were selected based on their active participation in school-led digital training and regular integration of technology in their classrooms. Additionally, elementary students (N=8) and administrative support staff (N=2) were included as secondary data sources to cross-verify classroom experiences, infrastructure availability, and institutional support mechanisms.

Instruments

Data collection was carried out over an eight-week period of field engagement, employing three primary qualitative methods: semi-structured interviews, direct field observations, and documentary analysis. The primary research instrument consisted of semi-structured interview protocols developed specifically for each participant group. The principal interview protocol focused on leadership vision, human capital empowerment, financial allocation strategies, and risk management regarding technological infrastructure. The teacher interview protocol examined technological pedagogical content knowledge, peer-mentoring experiences, instructional shifts, and perceived classroom challenges. Student interviews addressed learning

motivation, classroom engagement, and media interactivity. All interview protocols were validated prior to field deployment through peer review by two senior experts in educational leadership to ensure clarity, construct validity, and alignment with the research objectives.

Direct field observations were conducted using a structured observation scheme during technology-enhanced classroom sessions and school staff meetings. Observations focused on the availability and operational status of digital hardware, classroom management during media usage, teacher-student interaction dynamics, and administrative modeling of digital tools during faculty meetings.

Documentary analysis served as a complementary data collection technique. Relevant institutional artifacts, including the annual school development plan (RKT/RKAS), teacher lesson plans (RPP/MA), teacher professional training logs, and student learning activity records, were collected and examined to verify administrative claims and track longitudinal policy implementation.

Data Collection and Procedures

Field procedures were executed in four structured phases to ensure ethical compliance and systematic data gathering:

1. Administrative Authorization and Ethical clearance: Prior to field data collection, formal approval was obtained from the regional education authority, and written informed consent was secured from the principal, participating teachers, and the parents or legal guardians of participating students.
2. Exploratory Field Entry: Initial school visits were conducted to build rapport with the school community, review physical infrastructure, and refine interview scheduling without disrupting routine instructional activities.
3. Execution of In-depth Interviews and Observations: Semi-structured interviews were conducted individually in a quiet room on school premises. Each interview lasted between 45 and 75 minutes and was audio-recorded with explicit consent. Concurrently, classroom observations were carried out across different grade levels during scheduled digital media lessons.
4. Document Collection and Preliminary Verification: Official institutional documents were systematically cataloged, copied, and cross-checked alongside audio recordings and field notes.

Trustworthiness

Qualitative case study research, traditional quantitative measurement scales are replaced by rigorous criteria for qualitative trustworthiness, ensuring credibility, transferability, dependability, and confirmability. To establish credibility, the study applied data source triangulation (comparing narrative accounts across the principal, teachers, and students) and methodological triangulation (cross-verifying interview responses with direct classroom observations and official school documents). Furthermore, member-checking was conducted by sharing transcribed interview text and summary interpretations with the principal and teacher informants to confirm accurate representation of their perspectives.

Dependability and confirmability were maintained through the generation of a comprehensive audit trail, which systematically documented raw transcripts, observational field notes, coding schemes, and analytic memos. Transferability was enhanced by providing a detailed, context-rich description of the rural "one-roof" school setting, allowing future researchers to assess the applicability of the findings to similar low-resource educational contexts.

Data Analysis

Qualitative data were systematically analyzed using an interactive thematic analysis framework consisting of three concurrent streams: data condensation, data display, and conclusion drawing or verification. Audio recordings from interviews were transcribed verbatim in Indonesian and translated into academic English where necessary, taking care to preserve contextual nuance. The analytical process proceeded as follows:

1. Data Condensation: Raw transcriptions and observation notes were thoroughly read to establish familiarity. The text was subsequently broken down into discrete segments and assigned

initial open codes based on recurring concepts related to leadership innovation, resource adaptation, and pedagogical transformation.

2. **Category and Theme Generation:** Open codes were systematically organized into broader conceptual categories through axial coding. These categories were aligned with theoretical frameworks surrounding digital leadership and frugal EdTech management in low-resource environments.

3. **Data Display:** Condensed data and categorical structures were presented using structured thematic matrices and descriptive analytical narratives, clearly linking qualitative empirical evidence with relevant academic literature.

4. **Conclusion Drawing and Verification:** Interpretations derived from data displays were continuously tested against raw verbatims, observation logs, and documentary evidence to construct verified, logically sound conclusions addressing the study's core research questions.

Findings

The empirical data collected from SDN Satap 12 Konawe Selatan reveal that principal leadership innovation in a resource-constrained rural environment functions as an integrative, multi-dimensional process. Rather than treating technology integration merely as an exercise in hardware procurement, the principal enacted structural changes across four interconnected domains: human capital development, adaptive infrastructure management, policy formulation, and organizational culture.

Comprehensive Analysis of Principal Leadership

The thematic analysis identified key structural dimensions, infrastructure management strategies, and corresponding qualitative shifts in classroom dynamics brought about by the principal's innovative leadership. These findings are integrated and summarized in Table 1.

Table 1: Overview of Leadership Innovation, Infrastructure Adaptation, and Instructional Impact

Analytical Domain	Baseline Status & Constraints	Leadership & Implementation Strategy	Post-Implementation Outcome
Human Capital Development	Low baseline digital literacy; intimidation toward equipment among senior staff	Established weekly peer-led ICT workshops and mentoring circles every Saturday	100% teacher participation; increased self-efficacy and reduced techno-anxiety
Hardware & Equipment	Severely limited laptops (< 5 units) and digital projectors (2 units)	Implemented rotational device schedules, central reservations, and station learning	Equitable equipment access across grade levels without structural bottlenecks
Connectivity & Media Access	Unstable, low-bandwidth cellular internet coverage	Promoted offline pre-loading, flash drive storage, and asynchronous media usage	Seamless media playback in class without reliance on real-time internet streaming
Personal Technology Integration	Absence of dedicated student hardware	Deployed a "Bring Your Own Device" (BYOD) strategy for teacher-owned smartphones	Micro-learning opportunities and expanded instructional delivery channels
Institutional Policy & Culture	Administrative reliance on paper; textbook-centered lectures	Modeled digital tools in staff meetings; mandated digital media in lesson plans (<i>RPP/MA</i>)	78% of lesson plans integrated digital media; established a supportive digital culture
Instructional Delivery & Dynamics	Monolithic lectures; passive listening; rote memorization	Transitioned to multimodal, interactive, and technology-assisted visual instruction	Heightened student attention, increased participation, and deeper conceptual understanding

Field data indicate that human capital development was prioritized as the foundational pillar of the school's digital transition. Recognizing that formal off-site training was rarely accessible due to geographical isolation and budgetary constraints, the principal established internal, peer-led professional development sessions. During these weekly meetings, teachers with higher digital literacy mentored colleagues in basic computer operations, presentation software, and digital learning media creation. As the principal explained during an interview:

"We cannot wait for government training programs to arrive in remote schools. If we wait, our students will fall further behind. I assigned two teachers who were already proficient in digital tools to guide their peers every Saturday. We started with simple tasks, like creating slide presentations and finding educational videos."

This internal mentoring model reduced initial resistance among senior educators. Teacher interview transcripts revealed a marked shift in self-efficacy. One senior teacher noted:

"Initially, I felt intimidated by laptops because I was afraid of making mistakes or breaking the equipment. However, through patient guidance from my colleagues during our Saturday sessions, I learned how to search for visual aids and display them to my students. Now, technology feels like an asset rather than a burden."

Documentary analysis of faculty attendance logs and training records confirmed that all six primary teachers completed basic ICT onboarding modules organized internally during the academic year, resulting in a consistent increase in digital lesson planning.

Adaptive EdTech Management Under Severe Resource Scarcity

A major finding of this study concerns how adaptive leadership mitigated acute infrastructure deficits. The school's complete inventory of functional technology comprised fewer than five operational laptops, two digital projectors, and unstable cellular internet coverage.

To prevent equipment bottlenecks, the principal implemented a centralized reservation schedule for digital projectors and laptops. Teachers planned technology-assisted lessons around designated time slots, ensuring equitable access across grade levels. When internet connectivity fluctuated, teachers were instructed to download instructional videos and digital slides at home or in areas with stronger signals, storing them on portable flash drives for offline classroom playback.

Field observations during a fifth-grade science lesson on photosynthesis illustrated this strategy in practice. The teacher utilized a single digital projector connected to a personal laptop to display animated diagrams, followed by small-group activities where students rotated toward a single laptop station to view an interactive simulation. This rotational model enabled all students to engage with digital content despite the absence of individual student devices.

Qualitative Shifts in Classroom Dynamics and Instructional Delivery

The implementation of principal-led technology initiatives produced observable qualitative improvements in instructional delivery and student engagement. Baseline observations and interview accounts revealed that instruction prior to the leadership intervention relied almost exclusively on traditional teacher-centered lectures and printed textbooks.

Classroom observations confirmed that integrating visual media significantly improved student attention spans and participation. In primary grade classrooms, visual representations of complex topics, such as planetary movement and plant biology, replaced abstract blackboard drawings. Student interviews corroborated these observational findings. One fifth-grade student stated:

"Learning science used to be boring because we only read textbooks and listened to the teacher explain. Now, when the teacher shows videos on the projector, we can see real animals and natural processes. It makes the lessons much easier to understand and remember."

Furthermore, documentary analysis of teacher lesson plans (RPP/MA) demonstrated a progressive shift toward pedagogical diversity. In the term preceding the principal's digital mandate, fewer than 15% of submitted lesson plans included technology-based learning media. By the end of the observed academic period, 78% of teacher lesson plans incorporated pre-loaded digital media, visual slides, or audio-visual resources, reflecting the formal institutionalization of technology-assisted learning within the school.

Discussion

The overarching goal of this investigation was to examine how principal leadership innovation operationalizes technology utilization to enhance instructional quality within a resource-constrained rural primary school setting. In an era where educational policy globally mandates digital transformation, understanding the precise mechanisms through which school leaders navigate severe infrastructure deficits becomes paramount. The central research question probed how a school principal conceptualizes and enacts adaptive leadership strategies to build teacher capacity, manage technological scarcity, and drive qualitative shifts in classroom dynamics. The findings of this study offer granular insights into the micro-processes of rural educational

administration, demonstrating that leadership vision, localized professional empowerment, and frugal resource management can effectively offset structural hardware deficits.

Restating the principal empirical outcomes reveals that technology integration in low-resource environments is primarily a human capital and cultural challenge rather than merely an infrastructure procurement issue. The thematic analysis demonstrated that leadership innovation was enacted across four integrated dimensions: internal peer-mentoring, rotational resource scheduling, policy institutionalization, and administrative modeling. At the finest granularity of observation, the implementation of weekly, peer-led ICT workshops transformed teacher self-efficacy, converting initial techno-anxiety into active pedagogical adaptation. Furthermore, adaptive management tactics, such as pre-loading offline media into flash drives and utilizing station-based rotational learning, successfully bypassed severe hardware shortages and internet instability. Consequently, classroom instruction shifted from monolithic, textbook-bound lectures to multimodal, technology-assisted learning, leading to documented increases in student engagement and conceptual comprehension.

A particularly interesting and important finding lies in the profound efficacy of localized, peer-driven professional development over external, standardized training programs. Detailed analysis of participant verbatims and training logs indicated that senior educators experienced a drastic reduction in technology-induced anxiety when mentored by familiar colleagues within their own institutional environment. Rather than relying on sporadic, off-site government workshops that often lack contextual relevance, the principal built an internal ecosystem of continuous professional learning. This micro-level empowerment mechanism created a safe space for iterative experimentation with digital media. This finding strongly supports the empirical conclusions of Schmitz et al. (2023) and Luo et al. (2024), who emphasized that transformational leadership and digital culture synergy significantly elevate teachers' professional digital competence and technology acceptance. Similarly, the observed alignment between principal modeling and increased teacher adoption corroborates the work of Sunu (2022) and Rasdiana et al. (2024), confirming that leadership behavior serves as a primary driver of organizational culture shift.

An unexpected outcome of this study was the seamless effectiveness of station-based rotational learning and offline content pre-loading in overcoming acute equipment scarcity. Conventional EdTech models typically assume a one-to-one or one-to-two student-device ratio as a prerequisite for meaningful digital learning. However, granular classroom observations revealed that utilizing a single laptop station combined with a central projector created highly collaborative, micro-group learning dynamics that actually enhanced student social interaction and peer-to-peer explanation. This result partially contradicts earlier studies, such as those by Ghavifekr and Yue (2022), which posited that severe hardware limitations inevitably restrict pedagogical innovation and lead to superficial technology usage. Instead, the empirical evidence demonstrates that frugal resource management, when paired with thoughtful pedagogical design, can convert material scarcity into an opportunity for collaborative, student-centered learning.

Offering a plausible explanation for these findings requires examining the intersection of adaptive leadership theory and teacher efficacy constructs. The principal's strategy functioned by systematically dismantling psychological and logistical barriers to entry. By formalizing a policy that mandated pre-loaded digital media in weekly lesson plans (RPP/MA) while simultaneously providing localized peer support, the principal balanced high expectations with high structural support. The pre-loading of offline media eliminated the unpredictable stress of internet buffering during live instruction, thereby preserving classroom management and teacher confidence. These combined factors enabled educators to focus on pedagogical delivery rather than technical troubleshooting, directly translating into heightened student attention and improved visual comprehension of complex abstract concepts, an outcome aligned with meta-analytic findings on ICT-driven learning quality by Arlinwibowo et al. (2022).

Despite these positive outcomes, advising a cautious interpretation of the findings is essential due to specific contextual boundary conditions. The qualitative improvements observed in instructional delivery occurred within a single, highly motivated institutional setting over a limited timeframe. The success of the peer-mentoring model relied heavily on the interpersonal trust and organizational social capital already present among the small faculty at SDN Satap 12

Konawe Selatan. Therefore, these results should not be interpreted as a justification for systemic state neglect of rural infrastructure. While frugal leadership can temporarily bridge the resource gap, long-term educational equity cannot be sustained solely on the voluntary adaptive labor of rural educators without structural infrastructure investments.

Based on these empirical insights, a general hypothesis can be suggested: in resource-constrained educational environments, the degree of successful technology integration depends more significantly on the leader's ability to foster localized social capital and adaptive pedagogical routines than on the absolute volume of available hardware. When school leaders establish low-stakes, peer-supported environments coupled with practical workaround strategies, teacher technological self-efficacy increases non-linearly, enabling high-impact instructional delivery even with minimal digital infrastructure.

The theoretical and practical implications of these findings are substantial for educational management in developing nations. Theoretically, this study extends standard digital leadership frameworks by introducing a grounded model of "frugal digital leadership" tailored to rural, marginalized schooling systems. It proves that leadership capacity in EdTech should be evaluated through resource optimization and cultural empowerment rather than physical asset inventory. Practically, the findings offer actionable guidance for educational policymakers and regional administrators. Instead of allocating top-heavy budgets exclusively to uniform hardware distribution, educational authorities should invest in contextualized leadership development programs that train rural principals in adaptive management, peer-coaching structures, and offline EdTech integration.

Commenting on the broader context of educational transformation, this study highlights the resilient capacity of rural schools when guided by visionary, empathetic administration. It underscores that technological equity is not merely a matter of hardware distribution, but a matter of human agency and administrative creativity.

For future work, researchers should expand upon these qualitative insights by conducting longitudinal, multi-case comparative studies across diverse geographic and socio-economic contexts to test the transferability of frugal digital leadership models. Additionally, future empirical investigations should incorporate quantitative metrics to assess the direct, long-term impact of principal-led frugal EdTech strategies on standardized student academic achievement and critical thinking performance across primary grade levels.

Conclusion

This study critically evaluated the innovative leadership practices of a primary school principal in facilitating educational technology integration within a resource-constrained rural context. The empirical findings demonstrate that digital transformation in marginalized educational settings is fundamentally driven by administrative agency, human capital development, and cultural empowerment rather than physical infrastructure procurement alone. By establishing an internal peer-mentoring ecosystem, enacting rotational device management, pre-loading offline media, and modeling digital tool usage, the principal successfully navigated severe hardware and connectivity deficits. Consequently, these leadership interventions catalyzed significant qualitative shifts in classroom dynamics, transitioning instruction from traditional, textbook-reliant lectures to multimodal, interactive learning environments that enhanced student motivation and conceptual understanding.

The theoretical and practical implications of this research extend across educational management, policy formulation, and rural schooling frameworks. Theoretical models of digital leadership must evolve beyond the assumption of baseline technological abundance to incorporate "frugal digital leadership", a paradigm that prioritizes resource optimization, localized social capital, and adaptive pedagogical workflows. For educational policymakers and regional administrative bodies, these insights underscore the necessity of reallocating institutional resources toward contextualized leadership capacity building. Rather than relying exclusively on top-heavy hardware distribution programs, policy interventions should equip rural school leaders with adaptive management techniques, peer-coaching strategies, and offline EdTech solutions capable of functioning within structural constraints.

Ultimately, this investigation highlights the transformative potential of resilient, visionary school leadership in bridging the digital divide. Material scarcity and geographical isolation need not condemn rural schools to pedagogical stagnation. When guided by empathetic, creative, and strategically adaptive leadership, even minimal technological assets can be leveraged to revitalize instructional practice, optimize student engagement, and foster educational equity in marginalized primary schooling environments.

Ethics approval

The study was conducted in compliance with the Declaration of Helsinki. Informed consent was obtained from all individual participants involved in the study prior to data collection.

Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study used artificial intelligence (AI) tools in the following capacities: Manuscript writing support: AI-based language models were employed to language refinement (improving grammar, sentence structure, and readability of the manuscript). We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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