International Journal of Current Educational Studies

2025, Vol. 4, No. 2, 30-52 ISSN 2822-4914

AI in Rural Classrooms: Challenges and Perspectives from South African Educators

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Article Info

Article Type

Original Research

Article History

Received:

22 July 2025

Accepted:

03 September 2025

Published online:

04 September 2025

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Abstract

Despite growing interest in artificial intelligence (AI) in South African education, limited research has examined how rural educators perceive and navigate AI integration. This study explores educators' perspectives, adaptive strategies, and lived realities in under-resourced rural schools. Eight educators from Eastern Cape, Limpopo, Mpumalanga, and North-West provinces were purposefully selected. Data were collected through written responses and semi-structured online interviews, and were analyzed thematically. Ethical safeguards included informed consent, pseudonyms, and confidentiality. Findings reveal that AI integration is hindered by inadequate digital infrastructure, unreliable connectivity, and limited access to devices. Educators also face insufficient digital literacy and a lack of professional development, leaving them underprepared for AI-supported teaching. Weak institutional support and gaps between policy and practice further constrain adoption. Moreover, AI tools often remain linguistically and culturally misaligned, reducing learner engagement. Equity and ethical concerns—access, data privacy, and algorithmic bias—raise the risk of exacerbating educational inequalities rather than reducing them. This study underscores the need for targeted investment in digital infrastructure, contextualized teacher training, and inclusive AI design that reflects local languages and cultures. The findings extend beyond South Africa, contributing to global debates on equitable AI adoption in education across the South.

Keywords: AI-driven teaching, Rural Schools, Teacher Perspectives, Digital Inequality, South Africa.

Citation:

Mokoena, O. P., & Seeletse, S. M. (2025). AI in rural classrooms: Challenges and perspectives from South African educators. *International Journal of Current Education Studies (IJCES), 4*(2), 30-52. https://doi.org/10.46328/ijces.199

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Introduction

The speedy acceptance of artificial intelligence (AI) technologies in education is molding teaching and learning globally (Temimi et al., 2025). According to Strielkowski et al. (2025), AI offers a unique potential to personalize learning experiences, automate administrative tasks, and provide adaptive feedback. This way, AI encourages educational effectiveness and engagement. Universally, according to Hashim et al. (2022), educational systems are steering AI-driven tools to customize instruction to varied learner needs, expand access to quality resources, and acquire modern-day skills. This universal momentum highlights the transformative aptitude of AI to create more dynamic, learner-centred educational settings. However, the integration of AI in education is not even, mainly in rural settings where infrastructural, socio-economic, and pedagogical challenges abound (Obuseh et al., 2025). Djuraev et al. (2025) concur that rural education, with limited resources, inadequate digital access, and shortages of educators, experiences unique barriers to leveraging AI's benefits. Rusca et al. (2023) explain that in South Africa, these challenges are intensified by past inequalities, infrastructural deficits, and complex socio-political contexts. Hence, understanding how rural educators perceive and steer AI integration is essential to safeguarding that AI-driven developments do not intensify existing divides but add to more equitable educational outcomes. This study explores these dynamics through the lived experiences of educators in four rural South African provinces [Eastern Cape, Limpopo, Mpumalanga, and North-West]. It situates the views of these educators within broader discourses on educational technology adoption, digital equity, and policy frameworks. It highlights important concerns for developing inclusive, context-sensitive AI education strategies that address systemic susceptibilities exclusive to rural settings.

This study concerns four predominantly rural South African provinces [Eastern Cape, Limpopo, Mpumalanga, and North-West], each representing unique educational landscapes molded by socio-economic and past factors impacting technology adoption (Mathinya, 2024). These provinces signify contexts where rural educational challenges converge with the emerging opportunities and risks of AI in education. Their selection allows for an in-depth exploration of how digital divides manifest and how local educators negotiate AI integration within systemic constraints. It highlighted issues of equity, inclusion, and capacity-building.

The Eastern Cape is among the poorest of South Africa's nine provinces (Ngumbela, 2023). It consists of regions that used to be former independent homelands of Ciskei and Transkei under different Xhosa [ethnic group] leaders. Many of its rural schools lack adequate infrastructure, such as electricity and internet connectivity. These infrastructural deficits hinder the introduction of digital learning tools and exacerbate educational inequalities. The region is predominantly Xhosa, but other ethnicities, black and white, also live there. Limpopo is also very poor (Nchabeleng, 2025). Major ethnicities are Pedi (northern Sotho), Venda, and Tsonga (also known as Shangans). The regional education system is defined by high learner-to-educator ratios, limited digital resources, and insufficient educator training in emerging technologies, which jointly impede effective AI integration. Mpumalanga, dominated by Ndebeles and then Swatis [Swazis] with other ethnicities in lower scales, blends rural and peri-urban contexts (Matimolane & Mathivha, 2025). However, it faces disparities in resource allocation and professional development, resulting in uneven capacity among educators to incorporate digital platforms meaningfully. North-West, an area consisting mainly of Setswana speakers, an opulent Bophuthatswana homeland

before democracy days, thus living in its shadows, scuffles with socio-economic deficiency and intermittent network coverage (Mokone, 2023). This province is now among the poorest, and this restricts students' and educators' access to online AI-enhanced educational resources.

Theoretical Framework

This study builds on Thongprasit and Wannapiroon's (2022) model of AI integration in education, identifying four interrelated components crucial for understanding AI adoption in education, particularly within the South African rural context. As illustrated in Figure 1, these components work synergistically to influence the successful implementation of AI-enhanced learning environments.

The framework encompasses four elements that interact dynamically to shape AI integration outcomes. First, end-users, including educators and learners, represent the human dimension of AI adoption. This component is particularly significant in rural contexts, where key concerns are directed at exclusion and empowerment within marginalized communities. The success of AI integration fundamentally depends on how these stakeholders engage with and benefit from technological innovations.

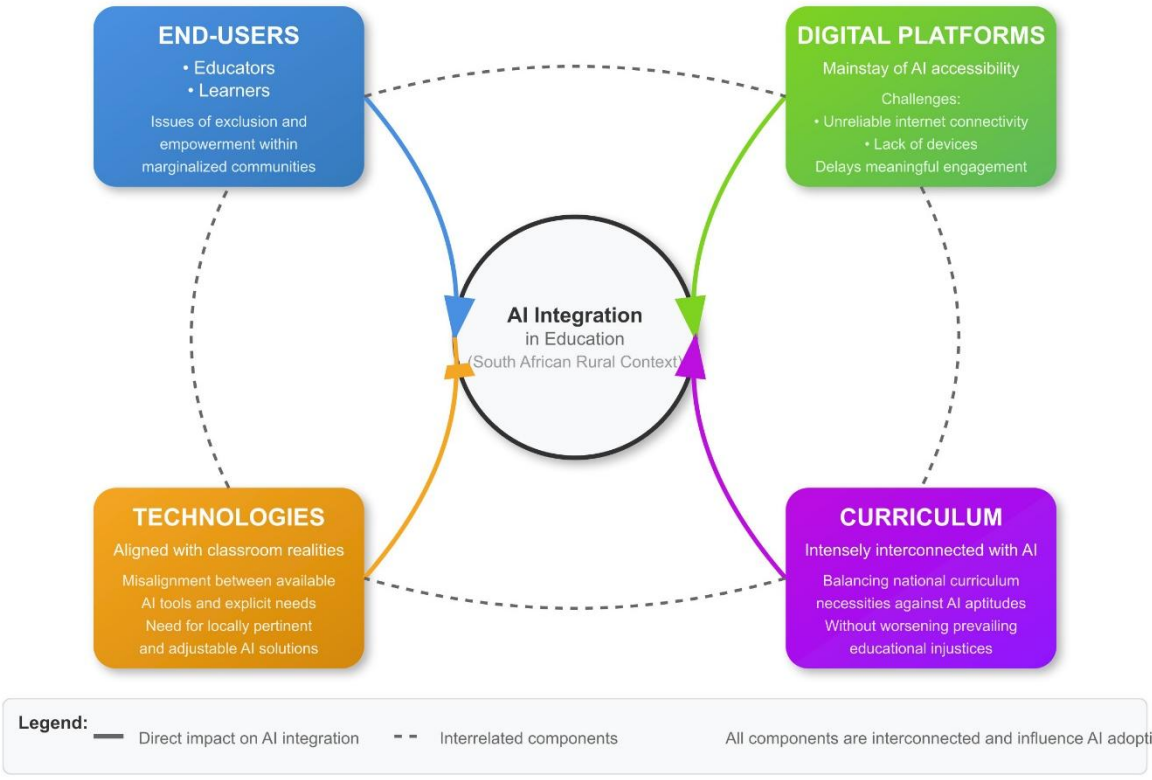

Figure 1: AI Integration in Education: Four Interrelated Components Frameworks (developed by the author)

Second, digital platforms create the technological mainstay of AI accessibility, serving as the primary conduits through which AI tools reach educational settings. However, significant challenges emerge in rural areas, where unreliable internet connectivity and a lack of appropriate devices significantly impede meaningful engagement

with AI-enhanced learning environments. These infrastructural limitations create barriers that must be addressed for effective AI implementation.

Third, the selection and deployment of technologies must be carefully aligned with the contextual realities of rural classrooms. The current misalignment between available AI tools and the explicit needs of rural education highlights the critical importance of developing locally pertinent and adjustable AI solutions. This component emphasizes that technological choices cannot be made in isolation but must respond to the specific requirements and constraints of the educational environment.

Fourth, curriculum integration represents the most complex component, as the incorporation of AI into education is intensely interconnected with existing curricular structures. The challenge lies in balancing national curriculum necessities against the capabilities and potential of AI technologies. This delicate balance is crucial to ensure that AI integration enhances rather than disrupts educational goals, and does not worsen prevailing educational injustices that already affect rural communities.

As depicted in Figure 1, these four components—end-users, digital platforms, technologies, and curriculum—are not independent entities but interconnected elements that collectively determine the success of AI adoption. Together, they emphasize the complexity of encouraging meaningful AI integration in education systems shaped by diverse curricular, infrastructural, social, and technological dynamics. The framework thus provides a comprehensive lens through which to analyze and understand the multifaceted nature of AI implementation in rural educational contexts.

Literature Review

Rural educators, particularly in low- and middle-income countries, where developmental leadership remains stagnant, struggle with entrenched systemic barriers that compromise the quality and efficacy of their educational practices (Ashta et al., 2025; Awashreh, 2025). In South Africa, the heterogeneity of rural contexts spanning vast geographic expanses and diverse cultural landscapes highlights a shared reality where educators consistently report chronic deficits in institutional support, infrastructural inadequacies, and resource scarcity. Despite these constraints, educators and learners show a marked openness to technological innovation, such as generative AI. The COVID-19 pandemic, as Al Mulla et al. (2025) argue, catalyzed a rapid and relatively effective uptake of digital platforms, accelerating digital literacy and integration. Romaioli (2022) further highlights the transformative potential of generative AI in education, highlighting its capacity to personalize content delivery and deepen learner engagement. In parallel, Indonesian studies (Aisyah et al., 2023; Nuryadin & Marlina, 2023) emphasize AI's role in enabling real-time data-driven decision-making and adaptive curriculum design. However, the post-lockdown period has revealed a persistent bottleneck, i.e., the absence of coordinated institutional backing (CIB), which Bacolod (2020) identifies as a critical impediment to AI's sustainable and meaningful integration in educational ecosystems. Worth noting, embedding AI in rural education aligns directly with Sustainable Development Goal 4 (SDG 4), which champions inclusive, equitable, and high-quality education (Heleta & Bagus, 2021; Raimi et al., 2024; Wang et al., 2025).

Slimi and Carballido (2023) conceptualize integrating artificial intelligence (AI) into educational settings as a multidimensional innovation capable of enhancing learning outcomes, increasing student engagement, and streamlining instructional efficiency. As a transformative technological infrastructure, generative AI intersects with critical facets of the teaching and learning continuum, including assessment automation, intelligent grading systems, and future-oriented skills development. However, recent reports indicate that approximately 76% of educators in the United States abstain from incorporating AI tools into their pedagogical routines (Castro et al., 2025; Murphy, 2019; Ng et al., 2023). Among those who do, Göçen and Döğer (2025) note that generative AI is primarily leveraged for communication, personalized instruction, and lesson design. In Singapore, hesitancy persists, with educators expressing uncertainty about the pedagogical value of generative AI due to ambiguous institutional oversights (Thilakarathne et al., 2025). Despite these reservations, generative AI presents unprecedented opportunities for democratizing access to knowledge, reimagining pedagogical models, and tailoring learning experiences to individual needs. Furthermore, it is a disruptive force, challenging legacy systems and prompting a reconfiguration of educational structures and practices (Estrellado & Miranda, 2023). To navigate this complexity, researchers have proposed various theoretical frameworks. Notably, Thongprasit and Wannapiroon (2022) introduced an inclusive model comprising four interdependent dimensions, i.e., end-users (educators and learners), digital platforms, intelligent technologies, and curricular alignment. This framework highlights generative AI's potential to foster creativity, empower educators, and facilitate responsive, learner-centered instruction. However, a critical gap remains, i.e., empirical evidence is still sparse regarding the practical translation of these theoretical advancements into the lived realities of educators operating in rural and resource-constrained environments. Bridging this gap is essential for ensuring equitable and sustainable generative AI adoption across diverse educational landscapes.

Despite the proliferation of generative AI initiatives in educational settings, the practical implementation of generative AI in classroom management and instructional strategies remains challenging, particularly in environments constrained by limited information and communication technology (ICT) infrastructure. As digital tools and generative AI systems continue to evolve, the systematic documentation of educators' lived experiences becomes imperative for ensuring educational innovation's inclusivity, relevance, and sustainability. However, a critical, notable gap persists in understanding educators' day-to-day realities and adaptive strategies navigating generative AI integration within diverse socio-cultural and infrastructural contexts. This study seeks to address this gap by exploring the lived experiences of educators from under-resourced rural regions in South Africa's Eastern Cape, Limpopo, Mpumalanga, and North-West provinces. The study explores four interrelated dimensions: (i) educators' experiential narratives and reflections on implementing AI-driven instructional strategies; (ii) the coping strategies they deploy to mitigate technological and institutional constraints; (iii) their insights into the transformative potential of AI in shaping pedagogical effectiveness; and (iv) the underlying factors that account for both convergences and divergences in their experiences across different rural contexts.

Topical global studies confirm that AI possesses transformative potential in rural education by addressing historical systemic hindrances such as scarcity of resources, shortage of educators, and problems caused by language issues. Tripathi et al. (2025) emphasize the ability of AI to create customized learning experiences,

flipped virtual classrooms, and natural language processing tools that can conquer disparities caused by geography and language. AI can contribute to educational equity between rural and urban areas. However, they highlight that challenges caused by infrastructure inadequacies, high costs of implementation, and insufficient educator training are substantial obstacles to the sustainable adoption of AI in these contexts.

From a viewpoint of digital equity, scholars (Ciaschi & Barone, 2024; Fiegler-Rudol, 2025; Judijanto et al., 2025) believe that access solely to AI tools is deficient. Complete digital equity entails the provision of devices, connectivity, skills, empowerment, and institutional support, among others, to enable expressive involvement in AI-enhanced learning atmospheres (Canevez et al., 2020; Liu et al., 2024). The unequal distribution of the benefits of AI risks intensifying prevailing divides if equity is incorporated in policy and practice.

Critical pedagogy scholars offer an important lens through which to examine AI integration in education (Murtiningsih & Sujito, 2024; Yadav, 2025). Gonsalves (2024) and Ncube and Tawanda (2025) concur by cautioning that generative AI may challenge practices engrossed in intellectual dialogues, autonomy, and democratic involvement. They warn that excessively depending on AI-generated knowledge can weaken reflective thinking and critical awareness, which is basic to liberatory education. As a substitute, AI should be a tool for supporting active, considerate learning that preserves learner activity and ethical perception.

Kim and Wargo (2025) believe that in rural STEM education contexts, educational leaders are optimistic about the capacity of AI to customize instruction for mixed-ability classes, decrease the burdens of administration, and open opportunities to advanced learning that is naturally not available in rural schools. However, Kim and Kim (2020) and Joseph and Uzondu (2024) consider such opportunities to be dependent on resolving infrastructural and professional development deficits. These opportunities require educational leaders to advocate for a culture that promotes resources and innovation. In addition, outlines for digital equity progressively promote a system-level tactic towards AI in education. According to Albannai and Raziq (2025), this approach includes leadership, intelligible policies, reliable access, digital capability, and authorized, technology-driven learning experiences that address many dimensions outside access alone to accomplish impartial AI integration.

The topical guidelines of the Organisation for Economic Co-operation and Development (OECD, 2023a; 2023b; 2024) emphasize the potential of AI for impartiality and inclusion by enabling adaptive learning, intelligent tutoring, and inclusive support for diverse learners. These would include learners with special needs. However, they also feature risks such as biases, privacy, socio-emotional, and technology-enabling impacts that require management to thwart reinforcement of inequalities. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) emphasizes the capability of AI to modernize teaching and hasten progress towards inclusive education goals (Xiao & Bozkurt, 2025). Positioning AI incorporation in rural education within wider dialogues on digital impartiality and critical education points to a detailed, contextualized approach. The goal is technological adoption and encouraging learner-centred, socially objective educational ecosystems that empower sidelined rural educators and learners (Indriyani, 2025). This goal entails strategic infrastructural savings, educational empowerment, critical reflection on the educational impacts of AI, and inclusive policy agendas.

Collectively, such agendas are those that collectively inspire impartial, sustainable AI-empowered learning situations worldwide and in South Africa's rural provinces.

Aim of the Study

This study explores how rural educators in four South African provinces [Eastern Cape, Limpopo, Mpumalanga, and North-West] perceive and accomplish the incorporation of AI in education. The study seeks to understand the lived experiences of these educators within the broader situation of educational technology adoption, digital equity, and policy frameworks, to inform inclusive and context-sensitive AI education strategies that address exclusive rural challenges. The research question emerged: How do educators in rural South African provinces perceive and navigate the incorporation of AI technologies in education, and what implications do their experiences have for developing equitable, context-sensitive AI education strategies?

Method

Design and Setting

This study employed a qualitative research design to explore the lived experiences and pedagogical insights of rural school educators across four economically disadvantaged South African provinces, Eastern Cape, Limpopo, Mpumalanga, and North-West, regarding the integration of generative AI-driven teaching strategies in classroom settings. An exploratory approach was chosen for its capacity to uncover detailed, context-rich understandings of complex phenomena that are often obscured by quantitative methods (Lim, 2025). It enables researchers to explore the intersection of technology and pedagogy within the authentic realities of the rural education context.

Sampling

To ensure relevance and depth, the purposive sampling technique was used to identify educators with direct experience in applying generative AI tools to facilitate learning (Kayaalp et al., 2025). In addition, extreme variation sampling was employed to capture a wide spectrum of perspectives, drawing from educators with diverse teaching contexts, technological exposure, and institutional support levels (Rubach & Lazarides, 2025). This strategy enhanced the representativeness of the sample by maximizing variation in background variables related to the phenomenon under study. The final sample achieved through saturation comprised eight participants, with two educators selected from each of the provinces.

Data Collection

All participants were affiliated with schools that had implemented generative AI-related instructional strategies. Data collection was conducted through a combination of written reflections and online semi-structured interviews, guided by a flexible interview protocol that ensured consistency across cases while allowing for the exploration of emergent themes. Participants were invited to share their experiences with generative AI tools, the challenges encountered, the coping mechanisms adopted, and their reflections on their role in shaping effective teaching

practices.

Informed consent was obtained from all participants prior to data collection. Participants were briefed on the study's objectives, assured of confidentiality, and informed of their right to withdraw at any stage. To protect their identities, pseudonyms and participant codes were used in all documentation and reporting.

Data Analysis

Data were analyzed using Thematic Content Analysis (TCA), a well-crafted method for identifying patterns and constructing meanings from qualitative data (Ebrahim & Rajab, 2025). This analytical approach facilitated the development of core themes that encapsulate the study's findings. Ethical considerations were rigorously observed throughout the research process.

Qualitative Coding and Trustworthiness Procedures

To enrich methodological rigor, the coding process was designed using iterative cycles of transparent, axial, and selective coding. This permitted a detailed and orderly investigation of the qualitative data. Preliminary open coding entailed stepwise analysis of transcriptions and replications to identify expressive units that apply to participants' experiences with generative AI integration. Clustering codes into wider categories was done at axial coding stage to explore relations and enhance developing concepts. Selective coding shaped these categories into coherent, principal themes that reproduce the intricate realities of rural educators. Reflexivity was upheld as the primary researchers engaged in continuous self-reflection journals and peer debriefings. This was to recognize and allay likely partialities connected to their positionality, previous conventions about AI in education, and the participants' socio-economic circumstances. To uphold trustworthiness, credibility was established by prolonging interviews and member checking with participants to validate interpretations and clarify ambiguities. The study demonstrated dependability by upholding a detailed audit trail recording all phases of data collection and analysis. A review of these by an external qualitative research expert was undertaken for consistency. Confirmability was upheld by open recording of analytic decisions and impulsive notes. It enabled an audit of the way that data reinforced the findings rather than researcher bias.

Sample Size Justification and Sampling Rationale

In disclaiming, the sample size of n = 8 educators may seem inadequate. However, the study involved careful and thorough purposive and deviant variation sampling to gather an inclusive range of experiences (Ahmad & Wilkins, 2024) across four economically disadvantaged rural provinces. According to White and Fletcher (2025), this approach safeguards the inclusion of assorted teaching contexts, contrasting levels of access to technology, and different institutional supports. As such, it ensures that the sample represents the dynamic veracities of rural educators in South Africa. Furthermore, data collection was rolled out until the accomplishment of thematic saturation. This indicates that the sample delivered rich, inclusive insights into multiplicative AI integration challenges. The qualitative, exploratory design of this study prioritizes depth and contextual insights over scope.

It then makes the findings transferable to comparable rural education locations branded by analogous socio-economic and infrastructural encounters.

Results

he findings of this study are organized thematically to reflect the key challenges and insights shared by rural educators across the Eastern Cape, Limpopo, Mpumalanga, and North-West provinces. From the analysis six core themes emerged, each highlighting critical dimensions of the educators' experiences with AI-driven teaching strategies (see Figure 2). These are discussed below with verbatim responses from each participant.

Figure 2. Six Core Themes of AI Integration Challenges in Rural South African Education

Verbatim Responses

Respondents EC1

“Many communities experience internet connectivity that is either too weak or totally lacking. So, students cannot consistently engage online. Government programs that prioritize developing digital skills or offering schools the essential technology do not exist. Our digital resources are in English, which excludes learners who speak local languages at home.”

Respondent EC2

“Many teachers do not even have a reliable computer at home to prepare digital lessons, let alone students having their own devices. We receive little to no continuous training on how to effectively use technology in the classroom; this leaves many educators feeling overwhelmed. When only some students have access to devices, the digital divide only worsens, deepening existing inequalities.”

Respondents Lim1

“In our school, the few computers we have are outdated and barely functioning, which discourages students from using them. There is a clear need for professional development focused on digital literacy for educators, but these programs are scarce. We must be mindful of protecting students’ data and privacy as we integrate more digital tools.”

Respondent Lim2

"Though urban centers enjoy good connectivity, rural areas remain disconnected, limiting equitable access. Government policies often exist only on paper; effective implementation to support digital education is lacking. Educational platforms rarely consider the cultural context of our learners, which reduces engagement."

Respondent Mpu1

"Investments in digital infrastructure have been insufficient and poorly coordinated, leaving many regions underserved. Without strong institutional backing, it's difficult to scale digital education initiatives nationwide. Learning material should reflect the diverse cultural backgrounds of our learners for better comprehension."

Respondents Mpu2

"Economic challenges make it hard for families to afford devices, and schools don't have resources to fill the gap. Teachers need ongoing support and training, not just one-off workshops, to become confident in using technology. We cannot ignore that some students are being left behind, and that raises serious ethical questions about fairness."

Respondent NW1

"Limited broadband coverage in our region remains a big hurdle to equitable digital learning. There is a disconnect between policymakers and educators, resulting in weak support for digital initiatives. If digital education isn't accessible for all, we risk reinforcing existing social inequalities."

Respondents NW2

"Without devices at home, students cannot complete digital assignments or participate fully in online learning. Many teachers lack the skills to navigate new digital platforms confidently, which affects teaching quality. We must address privacy concerns and establish clear policies to protect learners' digital rights."

Themes Generation and Discussion with Verbatim Response

Theme 1: Inadequate Digital Infrastructure and Limited Connectivity

Across all provinces, respondents consistently highlighted poor internet connectivity and inadequate digital infrastructure as critical barriers to AI integration. EC1 and NW1 emphasized that "many communities experience either weak or non-existent internet access, severely limiting students' ability to engage with online learning platforms". Similarly, Mpu1 and Lim2 pointed to "insufficient and poorly coordinated investments in digital infrastructure, which have left rural schools technologically underserved". These infrastructural deficits hinder the deployment of generative AI tools and exacerbate existing educational inequalities.

Theme 2: Insufficient Access to Devices and Technology

Furthermore, limited access to functional devices emerged as a pervasive issue. EC2 and Lim1 reported that "both teachers and students often lack reliable computers, with some schools relying on outdated hardware". Mpu2 and NW2 further highlighted "the economic constraints that prevent families from affording personal devices, leaving schools unable to bridge the digital divide". This scarcity of devices restricts participation in AI-enhanced learning

and reinforces systemic inequities.

Theme 3: Deficiency in Institutional and Governmental Support

Respondents also expressed concern over the disconnect between policy and practice. EC1 and Lim2 noted "the absence of government programs aimed at equipping schools with essential technologies or developing digital competencies among educators". Mpu1 and NW1 echoed this sentiment, citing "weak institutional backing and ineffective policy implementation as major obstacles to scaling digital education initiatives". The lack of coordinated institutional support undermines the sustainability and scalability of generative AI integration in rural classrooms.

Theme 4: Substandard Educator Training and Digital Literacy

The lack of comprehensive and ongoing professional development emerged as a significant barrier to effective generative AI integration. EC2 observed, "We receive little to no continuous training on how to effectively use technology in the classroom; this leaves many educators feeling overwhelmed." Mpu1 echoed this concern, stating, "Teachers need ongoing support and training, not just one-off workshops, to become confident in using technology." Lim1 added, "There is a clear need for professional development focused on digital literacy for educators, but these programs are scarce." NW2 highlighted the impact of limited digital confidence, noting, "many teachers lack the skills to navigate new digital platforms confidently, which affects teaching quality."

Theme 5: Language and Cultural Relevance Challenges

Participants emphasized the importance of culturally and linguistically inclusive digital content. Lim2 noted, "Educational platforms rarely consider the cultural context of our learners, which reduces engagement," and added, "Our digital resources are in English, which excludes learners who speak local languages at home." EC1 reinforced this concern, stating, "Unavailable digital content in home languages of learners restricts full understanding." The absence of localized and culturally embedded digital resources was seen as a barrier to expressive and meaningful learning experiences.

Theme 6: Equity and Ethical Worries

The integration of generative AI in education raises critical concerns about equity and ethics, particularly in under-resourced settings. Mpu2 warned, "We cannot ignore that some students are being left behind, and that raises serious ethical questions about fairness." NW1 added, "If digital education isn't accessible for all, we risk reinforcing existing social inequalities." EC2 raised concerns about data protection, stating, "We must be mindful of protecting students' data and privacy as we integrate more digital tools." Lim1 emphasized the broader ethical implications, noting, "We must address privacy concerns and establish clear policies to protect learners' digital rights."

Discussion

The findings of this study revealed a complex interplay of structural, pedagogical, and socioculturalsociocultural factors that shape rural educators' experiences with generative AI-driven teaching strategies. Six key themes

emerged: inadequate digital infrastructure, limited access to devices, insufficient institutional support, substandard educator training, challenges related to language and cultural relevance, and concerns around equity and ethics. This discussion section grouped issues to align with the problems highlighted in the themes.

Barriers to Digital Infrastructure in Rural Education

One of the most persistent and structurally embedded barriers to equitable generative AI integration in education is the continued inadequacy of digital infrastructure and unreliable internet connectivity in rural provinces. Respondents across the four provinces consistently described broadband access in their schools as either unstable or absent, severely limiting the feasibility of digital learning. These accounts reaffirm longstanding critiques that infrastructure remains a legacy obstacle to technological equity in resource-constrained education systems (Shumba et al., 2025; Van Deursen & Van Dijk, 2019). The inequalities between urban and rural investment trajectories are unambiguous; urban centers continue to benefit from concentrated infrastructure development, while rural communities remain digitally marginalized. This exclusion is technical and deeply systemic, sustained by fragmented policy frameworks and sluggish implementation efforts. As Boerman et al. (2022) argue, the infrastructural gap is perpetuated by institutional inertia and the absence of coordinated public-private investment strategies. The frustration expressed by educators reflects a broader structural failure to prioritize digital equity, revealing a critical fault line in the pursuit of inclusive educational innovation. According to Nuryanti (2025), the insistent lack of digital infrastructure and unreliable internet connectivity in rural provinces can be openly linked to existing theories of technology adoption, educator agency, and rural education development by demonstrating how systemic infrastructural deficits constrain the ability of educators to incorporate generative AI expressively. According to Rogers' Diffusion of Innovations theory, technology adoption requires responsiveness, interest, and accessible and stable infrastructure. Which rural schools lack, impeding the initial and continued use of digital tools (Kim et al., 2025). Moreover, educator agency is weakened when digital access is unreliable or absent, where educator agency is the educators' capacity to make independent instructional decisions (Mouta et al., 2025). This would limit educators' potential professional autonomy and innovation, mainly in resource-inhibited rural situations with deficient support structures. Boillat et al. (2025) enlighten that rural education development theories explain how old urban-rural differences in investment and policy attention generate rooted disparities, both technical shortfalls and displays of broader socio-political downgrading. Hence, the infrastructural gap is a notable barrier to digital inclusion and rural educators' empowerment as change agents. This shows how disjointed policies and institutional disinterest prolong segregation and restrict impartial technological progress in education.

Challenges of Access in Rural Digital Education

Regarding poor access to devices and technology, respondents from the Eastern Cape and Limpopo highlighted this challenge. This reflects the broader structural reality of the first-level digital divide (FLDD), which Paskaleva (2025) defines as unequal access to physical and economic digital tools. King and Gonzales (2023) argue that obsolete or scarce school hardware restricts engagement and actively widens the digital divide. Economic hardship further compounds this divide, as families and institutions struggle to acquire and maintain appropriate technology. In response to such disparities, several African nations, such as Burundi, Congo, Ghana, Kenya,

Libya, Rwanda, Tanzania, and Uganda, have adopted initiatives like the one laptop per child (OLPC) program (Rwigema, 2020), a nonprofit effort aimed at transforming global education through low-cost, durable, and energy-efficient laptops. As Muthukrishna et al. (2025) explain, OLPC was designed to promote early digital literacy and empower children in developing regions. However, despite its ambitious goals, OLPC faced significant implementation challenges, including rapid hardware obsolescence, high maintenance costs, and inadequate technical support (Amiri, 2025). These limitations highlight the need for more sustainable, context-sensitive strategies to bridge the FLDD and ensure that digital transformation in education does not remain a privilege of the urban elite but becomes a reality for all learners. Underprivileged access to technological devices in rural Eastern Cape and Limpopo echoes the first-level digital divide (Ghimire & Mokhtari, 2025). Ragnedda and Ruiu (2025) add that this restricts technology adoption and educator agency. The initiatives that emerged to empower learners apparently faced sustainability issues, which stressed the need for context-sensitive rural education strategies.

Bridging the Digital Education Policy Gap

Several respondents highlighted a disconnect between digital education policy frameworks and their practical implementation, describing policies as "existing only on paper." This disconnect resulted in poorly executed digital initiatives and inadequate resource allocation. Oteyi and Dede (2025) critically examined this gap, revealing that administrative capacities often lag the rapid pace of technological advancement, undermining digital transformation's effectiveness. The lack of stakeholder buy-in further compounds these challenges, impeding digital education's equitable distribution and adoption. Recent studies highlight that effective engagement of stakeholders in educational programs requires strategic approaches focused on knowledge acquisition and competitive advantage alignment (Al-Thani, 2025; Sadovska et al., 2024). Moreover, robust governance and visionary leadership are essential for navigating the complexities of digital integration. Uzorka et al. (2025) argue that educational leaders should be equipped to manage digital inequality, information overload, and pedagogical shifts while nurturing innovation and adaptability. Jing et al. (2025) reinforce this by emphasizing the need for leadership competencies that support strategic planning, policy implementation, and institutional transformation in the digital era. According to Bergsteedt and du Plessis (2025), the obstinate gap between digital education policies and practice reflects institutional theory's emphasis on decoupling. In this theory, formal policies exist without essential execution due to misaligned capacities and interests. Limited stakeholder engagement and weak governance intensify this gap by stressing the necessity of transformational leadership theory. According to Mohamad Rashid and Abdul Wahab (2024), the transformational leadership theory advocates for visionary, adaptive leaders who promote innovation, associate stakeholders, and drive effective digital integration within complexity.

Associating Educator Training and Digital Transformation

The narratives concerning substandard educator training and digital literacy expose a disconnect in the digital transformation of education, i.e., without sustained, context-sensitive professional development, change is unlikely to take root. Respondents consistently highlighted a gap in educators' digital competence that erodes

confidence and constrains the pedagogical use of available technologies. This concern was echoed across recent literature, highlighting that short-term interventions and one-off workshops are insufficient to promote meaningful instructional innovation. Domínguez-González et al. (2025) highlight that digital competence remains low among educators, particularly in secondary education, and that training programs often fail to align with educators' real-world classroom needs. Gallego Joya et al. (2025) argue that effective digital integration demands a multifaceted approach combining technical and pedagogical training, institutional support, and continuous evaluation. Amemasor et al. (2025) support this by demonstrating that transformative professional development should be collaborative, hands-on, and sustained over time to shift educator attitudes and practices meaningfully. These studies highlight that digital reform in education will remain aspirational unless educators are empowered with technical professional skills to navigate the realities of generative AI. These findings underscore a critical theory of change in education technology (Mouza et al., 2022). According to this theory, sustainable digital transformation depends on constant, context-sensitive professional development. Drawing on sociocultural learning theory and situated cognition (Giles et al., 2025), effective digital integration involves technology use within reliable classroom practices. With no incessant collaborative training that aligns with lived experiences, low digital competence educators delay evocative academic innovation and the real-world application of generative AI.

Multilingual Inclusion in Digital Education Strategy

Despite the global surge in digital education, its design remains monolingual and monocultural, an oversight with reflective outcomes in linguistically diverse societies like South Africa. Respondents contend that the dominance of English in digital learning platforms embeds systemic exclusion, marginalizing learners whose identities and epistemologies are rooted in indigenous languages and cultural frameworks. This linguistic and cultural erasure weakens comprehension and isolates learners from the educational process itself. Vann et al. (2025) affirm that when digital content is anchored in local identities, it catalyzes deeper engagement and significantly improves learning outcomes. On the other hand, Emeklioğlu and Bayraktar Balkır (2025) call for a radical reimagined digital education policy that prioritizes localization and linguistic justice as foundational. According to Subandiyah et al. (2025), the findings stress that monolingual digital education perpetuates exclusion, aligning with Rogers' Diffusion of Innovations theory. In this theory, cultural relevance facilitates adoption. Educator agency is vital as educators should facilitate local content to encourage engagement. In rural education development frameworks, embedding indigenous languages promotes inclusivity and empowerment. Kerfoot (2024) echoes the call for policies selecting linguistic justice and localized digital learning.

Dealing with Equity and Ethics in AI Education

Concerns over widening digital divides, inequitable access, and student data privacy surfaced repeatedly, revealing deep systemic vulnerabilities in the integration of generative AI in education. Respondents voiced frustration over the exclusion of marginalized learners and the absence of enforceable policies to safeguard digital rights and privacy. These concerns highlight global anxieties surrounding the ethical deployment of generative AI, which Mukaffan and Siswanto (2025) frame as a critical risk factor for heightening existing educational

inequalities when digital systems are not inclusively designed. The findings highlight a critical need for recalibrating digital education strategies where technological innovations are balanced with principles of social justice and inclusion (Amiri, 2025). Buchanan et al. (2022) and Eynon and Malmberg (2021) argue that educational technologies must serve as equality instruments, not exclusion. Moreover, without intentional design and policy safeguards, generative AI-enhanced education risks entrenching disparities rather than dismantling them. Thus, the ethical architecture of digital education should prioritize the protection of vulnerable populations, ensure equitable access, and uphold the digital rights of all learners in an increasingly digitalized world. The findings align with technology adoption theories emphasizing contextual and equity reflections, highlighting how educator agency and inclusive policy mitigate digital divides in rural education development. Tanksley et al. (2025) warn that without deliberate, justice-centered designs and empowered educators, generative AI risks would reinforce exclusion and not enable equitable learning opportunities.

Implications for Policy and Practice

This study highlights the need for transformative policy frameworks beyond top-down mandates. Policies should institutionalize the co-creation of digital content with active input from local educators and communities to enhance cultural and linguistic relevance. Continuous professional development should be embedded within policy, tailored to the unique challenges of rural education systems. Strategic investment in digital infrastructure supported by public and private partnerships should be prioritized to bridge the urban and rural digital divide. Moreover, robust digital equity policies are essential to guarantee fair access, promote inclusion, and safeguard student data and privacy. Subsidization models for device access and mechanisms for ongoing technical support and maintenance should be considered to ensure long-term sustainability.

Additionally, practitioners must adopt a collaborative and context-aware approach to implementing digital education. Infrastructure deployment should be sensitive to rural schools' logistical and sociocultural realities. Educational institutions and districts should establish and sustain partnerships to facilitate the delivery, maintenance, and renewal of digital devices for educators and learners. Inclusive practices and ethical protocols should guide the distribution of generative AI and digital tools, ensuring they address the needs of marginalized groups while protecting digital rights and privacy. The co-development of digital learning content should be led by local educators and community members, integrating indigenous languages and cultural knowledge to encourage learner engagement and achievement. Finally, ongoing educator training programs could combine digital literacy with curriculum-aligned technology integration and responsive support systems to build pedagogical confidence and competence.

Conclusion

This study identified the multifaceted challenges impeding the equitable and effective integration of generative AI in education, in multilingual and multicultural contexts such as South Africa. The findings revealed systemic gaps in digital literacy among educators, a persistent disconnect between policy and practice, and a critical lack of localized content that resonates with learners' linguistic and cultural identities. These barriers are not merely

operational; they are structural, rooted in governance, leadership, and the undervaluing of sustained professional development of educators. The evidence suggests that digital transformation in education cannot be achieved through fragmented interventions or symbolic policy gestures. Instead, it demands a shift that centres educators as digital change agents in education, embeds cultural relevance into content design, and aligns strategic policy with grassroots implementation. Future research should interrogate the mechanisms of stakeholder buy-in, explore scalable models of educator training, and evaluate the long-term impact of culturally responsive digital pedagogies. Without such reformations, the promise of generative AI in education will remain aspirational rather than transformative.

Recommendations

To overcome the entrenched challenges facing generative AI in education in rural South Africa, a coordinated and sustained effort from all stakeholders, including government bodies, private sector actors, educational institutions, and local communities, is imperative. Strategic collaboration should be underpinned by evidence-informed policymaking and the deployment of technologies sensitive to local contexts. Generative AI-driven educational innovations should be leveraged not to widen existing divides, but to actively close them. This situation requires continuous investment in digital infrastructure, comprehensive and ongoing educator professional development, inclusive and culturally relevant content creation, and the establishment of robust ethical frameworks. These elements should be integrated into a cohesive strategy that prioritizes equity, sustainability, and community empowerment at every stage of digital transformation.

Author(s)' Statements on Ethics and Conflict of Interest

***Ethics Statement*:** We hereby declare that research/publication ethics and citing principles have been considered in all the stages of the study. We take full responsibility for the content of the paper in case of dispute (Ethical review board name: Sefako Makgatho University Research Ethics Committee (SMUREC), Date: 01 December 2024, Reference Number: SMUREC/S/910/2022: IND).

***Statement of Interest*:** We have no conflict of interest to declare.

Data Availability Statement: Data are available on reasonable request from the authors.

Author Contributions: All authors contributed to the study's conception and design. Solly Matshonisa Seeletse was responsible for data collection, formal analysis, and drafting the manuscript. Oratilwe Penwell Mokoena contributed to the methodology, interpretation of results, and critical revision of the manuscript.

***Funding*:** None

***Acknowledgements*:** None

References

Ahmad, M., & Wilkins, S. (2024). Purposive sampling in qualitative research: A framework for the entire journey. *Quality & Quantity*, *59*, 1-19. https://doi.org/10.1007/s11135-024-02022-5

Aisyah, D. N., Lokopessy, A. F., Naman, M., Diva, H., Manikam, L., Adisasmito, W., & Kozlakidis, Z. (2023).

The use of digital technology for COVID-19 detection and response management in Indonesia: mixed methods study. *Interactive Journal of Medical Research, 12*(1), e41308. https://doi.org/10.2196/41308

Al Mulla, A., Alkaraan, F., & Darwish, T. (2025). The influence of COVID-19 on the adoption of disruptive technologies in SMEs practices: UAE context. In *From Digital Disruption to Dominance: Leveraging FinTech Applications for Sustainable Growth* (pp. 299-311). Emerald Publishing Limited. https://doi.org/10.1108/978-1-83549-608-420251015

Albannai, N. A. A., & Raziq, M. M. (2025). Navigating ethical, human-centric leadership in AI-driven organizations: a thematic literature review. *The Service Industries Journal*, 1-28. https://doi.org/10.1080/02642069.2025.2534360

Al-Thani, G. (2025). Beyond consultation: Rethinking stakeholder engagement in Qatar's public education policymaking. *Education Sciences, 15*(6), 769. https://doi.org/10.3390/educsci15060769

Amemasor, S. K., Oppong, S. O., Ghansah, B., Benuwa, B.-B., & Essel, D. D. (2025). A systematic review on the impact of teacher professional development on digital instructional integration and teaching practices. *Frontiers in Education, 10*, 1541031. https://doi.org/10.3389/feduc.2025.1541031

Amiri, S. M. H. (2025). Digital transformations in education: Research insights for 21st-century learning. *International Journal of Innovative Science, Engineering & Technology (IJISET), 12*(03), 1-15. http://dx.doi.org/10.2139/ssrn.5194886

Ashta, A., Stokes, P., & Srisuphaolarn, P. (2025). Trust failure dynamics in developed and developing Asia intercultural communication: perspectives from a Japanese subsidiary in Thailand. *International Journal of Organizational Analysis, 33*(7), 1617-1632. https://doi.org/10.1108/IJOA-05-2024-4516

Awashreh, R. (2025). Omani private universities: Debates between progress in human development but weak education quality. *International Journal of Educational Organization & Leadership, 32*(1). https://doi.org/10.18848/2329-1656/CGP/v32i01/1-15

Bacolod, D. B. (2022). Mobile learning as a solution for restricted learning during the COVID19 pandemic. *Journal of Digital Educational Technology, 2*(1), ep2203. https://doi.org/10.21601/jdet/11584

Bergsteedt, B., & du Plessis, A. (2025). Reimagining transformation through strategic thinking and accountable governance in the South African public university system. *Higher Education*, 1-19. https://doi.org/10.1007/s10734-025-01517-w

Boerman, T. J., Aguilar Umaña, I., & Jones, R. A. (2025). Absent, Repressive, and Criminalized States: Forced Internal Displacement and Irregular Migration in El Salvador, Honduras, and Guatemala. *Latin American Perspectives, 52*(2), 63-86. https://doi.org/10.1177/0094582X231206814

Boillat, S., Gerber, J. D., Oberlack, C., Zaehringer, J. G., Ifejika Speranza, C., & Rist, S. (2018). Distant interactions, power, and environmental justice in protected area governance: A telecoupling perspective. *Sustainability*, *10*(11), 3954. https://doi.org/10.3390/su10113954

Buchanan, R. A., Forster, D. J., Douglas, S., Nakar, S., Boon, H. J., Heath, T., Heyward, P., D'Olimpio, L., Ailwood, J., Eacott, S., Smith, S., & Tesar, M. (2022). Philosophy of education in a new key: Exploring new ways of teaching and doing ethics in education in the 21st century. *Educational Philosophy and Theory*, *54*(8), 1178-1197. https://doi.org/10.1080/00131857.2021.1880387

Canevez, R., Maitland, C., Ettayebi, S., Shaw, J., Everson, C., & Rantanen, M. (2020). *The expression of power in ICT's knowledge enterprise: An empirical illustration of computing's colonial impulse*. Proceedings

of the 2020 International Conference on Information and Communication Technologies and Development (ICTD '20), 26, 1–5. Association for Computing Machinery. https://doi.org/10.1145/3392561.3397580

Castro, A., Díaz, B., Aguilera, C., Prat, M., & Chávez-Herting, D. (2025). Identifying rural elementary teachers' perception challenges and opportunities in integrating artificial intelligence in teaching practices. *Sustainability*, *17*(6), 2748. https://doi.org/10.3390/su17062748

Ciaschi, M., & Barone, M. (2024, September). Exploring the role of Artificial Intelligence in assessing soft skills. In *2024 19th Conference on Computer Science and Intelligence Systems (FedCSIS)* (pp. 573-578). IEEE. https://doi.org/10.15439/2024F2063

Djuraev, I., Baratov, A., Khujayev, S., Yakubova, I., Rakhmonova, M., Mukumov, B., & Abdurakhmanova, N. (2025). The impact of digitization on legal systems in developing countries. *Qubahan Academic Journal*, *5*(1), 81-117. https://doi.org/10.48161/qaj.v5n1a1246

Domínguez-González, M. Á., Luque de la Rosa, A., Hervás-Gómez, C., & Román-Graván, P. (2025). Teacher digital competence: Keys for an educational future through a systematic review. *Contemporary Educational Technology*, *17*(2), ep577. https://doi.org/10.30935/cedtech/16168

Ebrahim, S. S., & Rajab, H. A. (2025). The future of HR: The role of AI-powered recruitment in shaping the modern workforce. *Open Access Library Journal*, *12*(1), 1-22. https://doi.org/10.4236/oalib.1112770

Emeklioğlu, S., & Bayraktar Balkır, N. (2025). Localisation in language learning: a qualitative study on EFL instructors' perspectives on culturally familiar content. Language, *Culture and Curriculum*, *38*(3), 401-418. https://doi.org/10.1080/07908318.2025.2488894

Estrellado, C. J., & Miranda, J. C. (2023). Artificial intelligence in the Philippine educational context: Circumspection and future inquiries. *International Journal of Scientific and Research Publications*, *13*(5), 16-22. http://dx.doi.org/10.29322/IJSRP.13.04.2023.p13704

Eynon, R., & Malmberg, L. E. (2021). Lifelong learning and the Internet: Who benefits most from learning online? *British Journal of Educational Technology*, *52*(2), 569-583. https://doi.org/10.1111/bjet.13041

Fiegler-Rudol, J. (2025). Exploring human–AI dynamics in enhancing workplace health and safety: A narrative review. *International Journal of Environmental Research and Public Health*, *22*(2). 199. https://doi.org/10.3390/ijerph22020199

Gallego Joya, L., Merchán Merchán, M. A., & López Barrera, E. A. (2025). Development and strengthening of teachers' digital competence: Systematic review. *Contemporary Educational Technology*, *17*(1), ep555. https://doi.org/10.30935/cedtech/15744

Ghimire, N., & Mokhtari, K. (2025). Basic ICT access and reading achievement: First-level digital divide patterns among US 15-year-olds in theP ISA 2018. *Forum for Education Studies.* *3*(3), 2937 https://doi.org/10.59400/fes2937

Giles, A. K., Pitonyak, J. S., George-Paschal, L., Piernik-Yoder, B., & Taff, S. D. (2025). Situated learning. In *Routledge Companion to Occupational Therapy* (pp. 663-673). Routledge.

Göçen, A., & Döğer, M. F. (2025). A global perspective on artificial intelligence in educational leadership. The *Journal of Educational Research*, 1-19. https://doi.org/10.1080/00220671.2025.2510397

Gonsalves, C. (2024). Generative AI's impact on critical thinking: Revisiting Bloom's Taxonomy. *Journal of Marketing Education*. Advance online publication. https://doi.org/10.1177/02734753241305980

Hashim, S., Omar, M. K., Ab Jalil, H., & Sharef, N. M. (2022). Trends on technologies and artificial intelligence in education for personalized learning: systematic literature. *Journal of Academic Research in Progressive Education and Development*, *12*(1), 884-903. https://doi.org/10.6007/IJARPED/v11-i1/12230

Heleta, S., & Bagus, T. (2021). Sustainable development goals and higher education: leaving many behind. *Higher Education*, *81*(1), 163-177. https://doi.org/10.1007/s10734-020-00573-8

Indriyani, N. (2025). From policy frameworks to classrooms: EFL challenges in Indonesia. *Acceleration: Multidisciplinary Research Journal*, *3*(2), 73-83. https://doi.org/10.70210/amrj.v3i2.138

Jing, M., Guo, Z., Wu, X., Yang, Z., & Wang, X. (2025). Higher education digital academic leadership: Perceptions and practices from Chinese University Leaders. *Education Sciences*, *15*(5), 606. https://doi.org/10.3390/educsci15050606

Joseph, O. B., & Uzondu, N. C. (2024). Integrating AI and Machine Learning in STEM education: Challenges and opportunities. *Computer Science & IT Research Journal*, *5*(8), 1732-1750. https://doi.org/10.51594/csitrj.v5i8.1379

Judijanto, L., Mudinillah, A., Rahman, R., & Joshi, N. (2025). AI and social equity: Challenges and opportunities in the age of automation. *Journal of Social Science Utilizing Technology*, *3*(1), 42-51. https://doi.org/10.70177/jssut.v3i1.2117

Kayaalp, F., Durnali, M., & Gökbulut, B. (2025). Enhancing competence for a sustainable future: Integrating artificial intelligence–supported educational technologies in pre-service teacher training for sustainable development. *European Journal of Education*, *60*(1), e12865. https://doi.org/10.1111/ejed.12865

Kerfoot, C. (2024). Language, translanguaging, and epistemic justice: Multilingual learning across the curriculum. *South African Journal of Science*, *120*(7-8), 1-4. https://doi.org/10.17159/sajs.2024/18146

Kim, J., & Wargo, E. (2025, April). Empowering educational leaders for AI integration in rural STEM education: challenges and strategies. In *Frontiers in Education* (Vol. 10, p. 1567698). Frontiers Media SA. https://doi.org/10.3389/feduc.2025.1567698

Kim, W.-H., & Kim, J.-H. (2020). Individualized AI tutor based on developmental learning networks. *IEEE Access* 8, 27927–27937. https://doi.org/10.1109/ACCESS.2020.2972167

Kim, Y., Wang, L., Noh, J., & Roh, T. (2025). Exploring the role of innovation diffusion and trust transfer on technology acceptance: intention to use drone delivery service in China. *Asian Business & Management*, 1-28. https://doi.org/10.1057/s41291-025-00302-y

King, J., & Gonzales, A. L. (2023). The influence of digital divide frames on legislative passage and partisan sponsorship: A content analysis of digital equity legislation in the US from 1990 to 2020. *Telecommunications Policy*, *47*(7), 102573. https://doi.org/10.1016/j.telpol.2023.102573

Lim, W. M. (2025). What is qualitative research? An overview and guidelines. *Australasian Marketing Journal*, *33*(2), 199-229. https://doi.org/10.1177/14413582241264619

Liu, J., Li, S., & Dong, Q. (2024). Collaboration with generative artificial intelligence: An exploratory study based on learning analytics. *Journal of Educational Computing Research*, *62*(5), 1234-1266. https://doi.org/10.1177/07356331241242441

Mathinya, E. L. (2024). *What future for small-scale farming in South Africa?* (Publication No. 3070005824) [Doctoral dissertation, Wageningen University and Research]. ProQuest Dissertations Publishing.

Matimolane, S., & Mathivha, F. I. (2025). Tackling rural water scarcity in South Africa: climate change, governance, and sustainability pathways. *Frontiers in Environmental Science*, *13*, 1550738. https://doi.org/10.3389/fenvs.2025.1550738

Mohamad Rashid, S. N. A., & Abdul Wahab, J. L. (2024). Transformational leadership practices of headmasters in forming the quality of teachers transformation schools 2025. *Special Education*, *2*(1), 1-15. https://doi.org/10.59055/se.v2i1.31

Mokone, E. L. (2023). *Assessment of sustainable water security in the Bojanala region in the Northwest Province in South Africa* (Publication No. 3224601655) [Doctoral dissertation, University of South Africa]. ProQuest Dissertations Publishing.

Mouta, A., Torrecilla-Sánchez, E. M., & Pinto-Llorente, A. M. (2025). Comprehensive professional learning for teacher agency in addressing ethical challenges of AIED: Insights from educational design research. *Education and Information Technologies*, *30*(3), 3343-3387. https://doi.org/10.1007/s10639-024-12946-y

Mouza, C., Hartshorne, R., Baumgartner, E., & Kaplan-Rakowski, R. (2022). Special issue editorial: A 2025 vision for technology and teacher education. *Journal of Technology and Teacher Education*, *30*(2), 107-115. https://doi.org/10.70725/835637sxppbi

Mukaffan, & Siswanto, A. H. (2025). Ethical integration of generative AI in Islamic education: Toward inclusive and sustainable human capital development. *AL-ADABIYAH: Jurnal Pendidikan Agama Islam*, *6*(3), 303-325. Retrieved from https://al-adabiyah.uinkhas.ac.id/index.php/adabiyah/article/view/1178

Murphy, R. F. (2019). Artificial intelligence applications to support K-12 teachers and teaching. *Rand Corporation*, *10*(1), 1-20. https://www.jstor.org/stable/resrep19907

Murtiningsih, S., & Sujito, A. (2024). Reimagining the future of education: Inclusive pedagogies, critical intergenerational justice, and technological disruption. *Policy Futures in Education*, 14782103251341406. https://doi.org/10.1177/14782103251341406

Muthukrishna, M., Dai, J., Panizo Madrid, D., Sabherwal, R., Vanoppen, K., & Yao, H. (2025). AI Can Revolutionise Education but Technology Is Not Enough: Human Development Meets Cultural Evolution. *Journal of Human Development and Capabilities*, *26*(3), 482–492. https://doi.org/10.1080/19452829.2025.2517740

Nchabeleng, P. M. (2025). Examining the challenges faced in service delivery by South African rural communities after 28 years of democratic government administration: The case of Sekhukhune Municipal Areas-Limpopo Province. *E-Journal of Humanities Arts and Social Sciences*, *6*(7), 983-996. https://doi.org/10.38159/ehass.2025673

Ncube, C. N., & Tawanda, T. (2025). Critical digital pedagogy for contemporary transformative practices in the Global South: a literature review. *Cogent Education*, *12*(1), 2523133. https://doi.org/10.1080/2331186X.2025.2523133

Ng, D. T. K., Lee, M., Tan, R. J. Y., Hu, X., Downie, J. S., & Chu, S. K. W. (2023). A review of AI teaching and learning from 2000 to 2020. *Education and Information Technologies*, *28*(7), 8445-8501. https://doi.org/10.1007/s10639-022-11491-w

Ngumbela, X. G. (2023). Eastern Cape province's response to the challenge of poverty. *African Renaissance*, *20*(3), 289-312. https://hdl.handle.net/10520/ejc-jemba-v12-n1-a7

Nuryadin, R., & Marlina, M. (2023). The use of Artificial Intelligence in education. *Indonesian Journal of Primary Education, 7*(2), 143-158. https://doi.org/10.17509/ijpe.v7i2.64290

Nuryanti, N. (2025). ESP in the digital age: Mapping tools, platform, and pedagogical shifts in higher education. *Elsya: Journal of English Language Studies*, *7*(2), 158-173. https://doi.org/10.31849/elsya.v7i2.26395

Obuseh, E., Eyenubo, J., Alele, J., Okpare, A., & Oghogho, I. (2025). A systematic review of barriers to renewable energy integration and adoption. *Journal of Asian Energy Studies*, *9*, 26-45. https://doi.org/10.24112/jaes.090002

OECD (2023a). *Equity and inclusion in education: Finding strength through diversity*. OECD Publishing, Paris, https://doi.org/10.1787/e9072e21-en

OECD (2023b). *OECD Digital Education Outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en

OECD. (2024). OECD AI policy observatory: AI courses in English by discipline. Retrieved July 3, 2024, from https://oecd.ai/en/data?selectedArea=ai-education&selectedVisualization=ai-courses-bydiscipline-in-time

Oteyi, T., & Dede, M. (2025). Digital disconnect in education: The administrative challenge of aligning rhetoric and reality in the implementation of AI-powered and non-AI digital tools. *International Journal of Educational Management (IJEDM), 3*(1), 45–62. Retrieved from https://ijedm.com/index.php/ijedm/article/view/18

Paskaleva, M. (2025). Digital divide–the new form of social inequality. *Financial Navigator Journal, 10*(1), 121-131. https://doi.org/10.56065/FNJ2025.1.121

Ragnedda, M., & Ruiu, M. L. (2025). Digital divide. *A Companion to Digital Ethics*, 217-226. https://doi.org/10.1002/9781394240821.ch18

Raimi, L., Abdur-Rauf, I. A., & Ashafa, S. A. (2024). Does Islamic sustainable finance support sustainable development goals to avert financial risk in the management of Islamic finance products? A critical literature review. *Journal of Risk and Financial Management, 17*(6), 236. https://doi.org/10.3390/jrfm17060236

Romaioli, D. (2022). A generative sequential mixed methods approach using quantitative measures to enhance social constructionist inquiry. *Journal of Mixed Methods Research, 16*(2), 207-225. https://doi.org/10.1177/1558689820986273

Rubach, C., & Lazarides, R. (2025). Empowering teacher professionalization with digital competencies. *Education Sciences, 15*(7), 867. https://doi.org/10.3390/educsci15070867

Rusca, M., Savelli, E., Di Baldassarre, G., Biza, A., & Messori, G. (2023). Unprecedented droughts are expected to exacerbate urban inequalities in Southern Africa. *Nature Climate Change*, *13*(1), 98-105. https://doi.org/10.1038/s41558-022-01546-8

Rwigema, P. C. (2020). Digital technology and its relevance to political and social economic transformation. Case study of East African community region. *The Strategic Journal of Business & Change Management, 7*(4), 1402-1436. Retrieved from https://www.strategicjournals.com/index.php/journal/article/view/1870/1789

Sadovska, V., Rastorgueva, N., Migliorini, P., & Melin, M. (2024). Engagement of stakeholders in action-oriented

education for sustainability: a study of motivations and benefits and development of a process model. *The Journal of Agricultural Education and Extension, 31*(4), 575–597. https://doi.org/10.1080/1389224X.2024.2415607

Shumba, T., Munkuli, T., & Saruchera, F. (2025). Remote Learning Access, Readiness, and Support in South African Higher Education Institutions Post-COVID-19. *Progressio*, 1-25. https://doi.org/10.25159/2663-5895/17437

Slimi, Z., & Carballido, B. V. (2023). Navigating the ethical challenges of artificial intelligence in higher education: An analysis of seven global AI ethics policies. *TEM Journal, 12*(2), 590-602. https://doi.org/10.18421/TEM122-02

Strielkowski, W., Grebennikova, V., Lisovskiy, A., Rakhimova, G., & Vasileva, T. (2025). AI-driven adaptive learning for sustainable educational transformation. *Sustainable Development*, *33*(2), 1921-1947. https://doi.org/10.1002/sd.3221

Subandiyah, A. E., Juliyan Jaka Pratama, B., & Miftarani, D. (2025). Analysis of BPD DIY digital marketing implementation with rogers' diffusion of innovation theory approach (DOI). *International Journal of Innovative Science and Research Technology*, *10*(6), 2299-2308. https://doi.org/10.38124/ijisrt/25jun1615

Tanksley, T., Smith, A. D., Sharma, S., & Huff Jr, E. W. (2025, April). "Ethics is not neutral": Understanding ethical and responsible AI design from the lenses of black youth. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (pp. 1-20). https://doi.org/10.1145/3706598.3713510

Temimi, A., Rebai, R., Aldamen, H., Souki, K., & Amiri, K. (2025). Education at a crossroads: will AI fix learning or break it? *Management & Sustainability: An Arab Review*, 1-25. https://doi.org/10.1108/MSAR-04-2025-0118

Thilakarathne, N. N., Bakar, M. S. A., Abas, P. E., & Yassin, H. (2025). Internet of things enabled smart agriculture: Current status, latest advancements, challenges and countermeasures. *Heliyon, 11*(3). https://doi.org/10.1016/j.heliyon.2025.e42136

Thongprasit, J., & Wannapiroon, P. (2022). Framework of artificial intelligence learning platform for education. *International Education Studies*, *15*(1), 76-86. https://doi.org/10.5539/ies.v15n1p76

Tripathi, A., Yadav, V., & Kumar, S. (2025). Leveraging artificial intelligence for rural education: A systematic review of transforming learning opportunities and bridging the urban-rural divide. *Journal of Advances in Artificial Intelligence*, *3*(3), 215-223. https://doi.org/10.18178/JAAI.2025.3.3.215-223

Uzorka, A., Odebiyi, O. A., & Kalabuki, K. (2025). Educational leadership in the digital age: Navigating challenges and embracing opportunities. *International Journal of Technology in Education and Science, 9*(1), 128–141. https://doi.org/10.46328/ijtes.605

Van Deursen, A. J., & Van Dijk, J. A. (2019). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media & Society, 21*(2), 354-375. https://doi.org/10.1177/1461444818797082

Vann, R., Rith, V., & Suyitno, S. (2025). Community-based social education for sustainable development–An Indonesian perspective on collaborative learning models. *Journal Neosantara Hybrid Learning*, *3*(1), 10-19. https://doi.org/10.70177/jnhl.v3i1.2174

Wang, Y., Liu, Z., & Tu, C. (2025). Advancing Sustainable Development Goal 4 through a scholarship of teaching and learning: The development and validation of a student-centered educational quality scale in developing countries. *Sustainability*, *17*(10), 4369. https://doi.org/10.3390/su17104369

White, R., & Fletcher, G. (2025). Navigating inclusive education in mainstream primary schools: a phenomenological study of teachers' perceptions and experiences. *International Journal of Inclusive Education*, 1-29. https://doi.org/10.1080/13603116.2025.2459719

Xiao, J., & Bozkurt, A. (2025). Prophets of progress: How do leading global agencies naturalize enchanted determinism surrounding artificial intelligence for education? *Journal of Applied Learning and Teaching*, *8*(1), 28-40. https://doi.org/10.37074/jalt.2025.8.1.19

Yadav, S. (2025). Reimagining education with advanced technologies: transformative pedagogical shifts driven by artificial intelligence. In *Impacts of Generative AI on the Future of Research and Education* (pp. 1-26). IGI Global. https://doi.org/10.4018/979-8-3693-0884-4.ch001