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PERSONALISED LEARNING WITH ARTIFICIAL INTELLIGENCE IN SOUTH AFRICA: A QUALITATIVE SYNTHESIS OF OPPORTUNITIES AND BARRIERS

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ABSTRACT

In South Africa, a developing nation marked by deep inequalities, educational disparities remain one of the country's most urgent challenges. Although digital access has expanded, with approximately 50.8 million internet users (79% penetration) recorded in early 2025, the rural–urban gap persists: only 10% of rural households have internet access compared to 66% in urban areas. This digital divide is compounded by infrastructural shortcomings, limited digital literacy, and systemic inequalities that affect marginalised learners. Artificial intelligence and adaptive learning technologies offer promising pathways towards more personalised, inclusive, and effective education. This paper adopts a qualitative, secondary data analysis of policy reports, government statistics, and scholarly literature to examine how AI-enabled adaptive learning systems might address South Africa's entrenched inequities, particularly in low-income and rural areas. Guided by critical pedagogy and connectivism, the analysis explores both opportunities and risks, including algorithmic bias, surveillance, affordability, and cultural exclusion. Findings reveal four key patterns. First, adaptive learning systems show potential to individualise instruction and support multilingual learning, which is crucial in South Africa's linguistically diverse education system. Second, these technologies could reduce lecturer workload in ODeL settings and enhance student retention if integrated responsibly. Third, risks persist where commercial AI tools are unaffordable, poorly contextualised, or reliant on urban infrastructure, which excludes rural learners. Fourth, without deliberate policy safeguards, AI may reinforce existing biases, widen class and gender inequalities, and undermine local pedagogical traditions. The study recommends targeted infrastructure investment in rural provinces such as the Eastern Cape and Limpopo; embedding digital literacy and AI awareness into school and community curricula; developing locally trained AI models that integrate South African languages; and fostering partnerships between government, universities, and private technology firms. Crucially, recommendations call for aligning AI adoption with South Africa's constitutional commitments to equity, inclusion, and social justice, ensuring that adaptive learning is not just technologically efficient but socially transformative. The paper contributes by situating technological innovation within the lived educational and cultural realities of the Global South.

KEYWORDS: Adaptive Learning, Artificial Intelligence, Digital Divide, South Africa, Educational Equity, Personalised Learning.

1. INTRODUCTION

South Africa, located at the southernmost tip of the African continent, is often described as one of Africa's most industrialised economies, yet also one of its most unequal societies (World Bank, 2022). The country has a population of approximately 62 million people and is classified as a middle-income economy, but persistent structural inequalities rooted in its apartheid history have resulted in significant socio-economic divisions (Statistics South Africa [Stats SA], 2023). Nowhere are these divisions more evident than in the education sector. Despite the government's substantial investment, approximately 6.4 per cent of gross domestic product (GDP) and one of the highest education budget allocations in sub-Saharan Africa, educational outcomes remain uneven (Department of Basic Education, 2022).

The digital access reflects these inequalities. By early 2025, South Africa recorded around 50.8 million internet users, accounting for 79 per cent penetration nationally (DataReportal, 2025). However, beneath this aggregate figure lies a rural-urban digital divide. In rural areas, only 10 per cent of households have reliable internet access, compared to 66 per cent in urban areas, a disparity that systematically excludes rural learners from participating fully in digital education (Invigilator, 2024). Further obstacles include persistent load shedding, high data costs, and infrastructural gaps, which disrupt educational continuity and limit the integration of emerging technologies into classrooms and universities (Maringe & Ojo, 2021).

Globally, artificial intelligence (AI) and adaptive learning technologies are increasingly being deployed in educational contexts to deliver personalised learning pathways and data-driven support for students (Luckin, 2022). These innovations promise to transform education by tailoring instruction to individual learner needs, predicting academic risks, and enhancing learner engagement. In South Africa, policy frameworks such as the White Paper on Science, Technology and Innovation (Department of Science and Innovation, 2019) and the Department of Higher Education and Training's Fourth Industrial Revolution (4IR) initiatives highlight the urgency of adopting digital innovations to prepare graduates for a changing labour market. Yet, despite these policy ambitions, systemic challenges such as limited infrastructure in rural schools and linguistic diversity across eleven official languages raise questions about the feasibility of adopting AI-driven adaptive learning in a way that promotes inclusivity (Mhlanga & Moloi, 2020).

The importance of this study lies in situating South Africa within the broader context of developing countries that face similar structural barriers while striving to harness the benefits of technological innovation. If introduced without sensitivity to cultural, economic, and linguistic realities, AI-based education may deepen inequalities rather than resolve them (Raimi & Oluwafemi, 2022). Conversely, when grounded in critical pedagogy and culturally responsive approaches, AI has the potential to democratise access to knowledge and support marginalised learners. By interrogating both the opportunities and risks of adaptive learning in South Africa, this study contributes to the broader debate on how education in the Global South can be transformed in ways that are just, equitable, and future-oriented.

Although AI and adaptive learning technologies hold significant potential to mitigate educational inequalities in South Africa, their deployment is hindered by systemic challenges, particularly for rural and low-income learners. Without careful attention to local cultural, linguistic, and infrastructural realities, these innovations risk reinforcing the very inequalities they seek to overcome.

In order to respond to these challenges, it is necessary to frame the study around questions that explore both the opportunities and the risks of AI-driven education in South Africa. The research, therefore, aims to investigate how adaptive learning systems can be used to promote inclusivity, while also critically examining the socio-cultural, policy, and infrastructural contexts in which these technologies are deployed. This focus provides a foundation for analysing whether AI can realistically contribute to reducing educational inequalities in a developing country context.

1.1. Research Questions

- **RQ1:** How can AI-enabled adaptive learning systems contribute to addressing systemic educational inequalities in South Africa, particularly among rural and low-income learners?
- **RQ2:** What cultural, linguistic, and ethical considerations should inform the design and implementation of personalised learning technologies in developing contexts?
- **RQ3:** How can South African policy, infrastructure, and institutional practices be aligned to support equitable and inclusive AI-driven education?

2. LITERATURE REVIEW

The education system in South Africa has long been shaped by the legacies of colonialism and apartheid, which entrenched structural inequalities across race, geography and class. The democratic transition of 1994 established education as a constitutional right, and significant state investment has been directed towards redressing historical imbalances (South African Constitution, 1996; Department of Basic Education, 2022). The country allocates approximately 6.4 % of its GDP to education, one of the highest proportions in Africa (World Bank, 2022). Yet despite this investment, South Africa continues to struggle with uneven educational quality, as reflected in low literacy and numeracy outcomes at the primary level and persistent gaps in tertiary participation (Spaull, 2019).

The post-apartheid period saw the gradual expansion of digital technologies in schools and universities, especially within the higher education sector. However, the adoption of technology was uneven. While wealthier schools integrated computers and online platforms early on, many township and rural schools remained under-resourced, lacking basic infrastructure (Maringe & Ojo, 2021). The COVID-19 pandemic starkly revealed these inequalities. Emergency remote teaching demonstrated both the promise of digital education and the fragility of South Africa's digital infrastructure, particularly in disadvantaged communities (Mhlanga & Moloi, 2020).

2.1. Education In South Africa

The South African education system is divided into basic and higher education, overseen by the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET), respectively. The DBE administers schooling up to Grade 12, culminating in the National Senior Certificate (NSC), while the DHET is responsible for universities and Technical and Vocational Education and Training (TVET) colleges (DBE, 2022).

The system remains characterised by a duality: a small proportion of well-resourced schools producing strong academic outcomes and a majority of under-resourced schools that struggle to provide quality teaching (Spaull & Jansen, 2019). The Progress in International Reading Literacy Study (PIRLS) 2021 revealed that 81 % of South African Grade 4 learners could not read for meaning in any language (Howie et al., 2022). This alarming statistic underscores the urgency of innovative solutions to bridge learning gaps.

A higher education sector of 26 public universities serves over 1.1 million students (Council on Higher Education, 2022). While access has expanded since 1994, participation rates remain skewed in favour of urban and middle-class students. The country's open distance e-learning model, particularly through the University of South Africa (UNISA), has played a pivotal role in widening access to disadvantaged populations (Czerniewicz et al., 2020). Yet the efficacy of this model is constrained by uneven digital access and limited learner support in rural and correctional settings.

2.2. Artificial Intelligence and Adaptive Learning

Artificial intelligence has become a prominent feature of global debates on the future of education. The integration of AI-powered adaptive learning platforms has been shown to personalise learning experiences, enhance student engagement, and provide real-time feedback (Luckin, 2022; Holmes et al., 2021). A review by Chen et al. (2020) found that adaptive systems improve learner outcomes by adjusting pace and content based on student performance.

A growing body of work situates AI as both a potential equaliser and a source of exclusion. Williamson and Eynon (2020) caution that AI systems can reproduce social inequalities if algorithms are not transparent or culturally sensitive. In low-resource contexts, the challenge is compounded by limited connectivity, inadequate teacher training, and financial constraints (Ndung'u & Signé, 2020).

In Africa, AI in education remains at an experimental stage. Studies in Kenya and Ghana show that adaptive systems can improve mathematics outcomes when tailored to local curricula and supported by teacher facilitation (Banerjee et al., 2021). In South Africa, research is emerging on the use of AI for both administration and instruction. Khoalenyane (2023) notes that universities are beginning to experiment with AI-based systems, but infrastructural and ethical challenges persist. Raimi and Oluwafemi (2022) similarly argue that while AI holds promise for expanding access, it must be critically assessed for risks of bias and surveillance.

2.3. The Digital Divide and Language in Education

The digital divide is a central theme in discussions of AI adoption in South Africa. While approximately

79 % of South Africans were online in 2025, rural–urban disparities remain stark: only 10 % of rural households had reliable internet access, compared to 66 % in urban areas (DataReportal, 2025; Invigilator, 2024). Access is largely mobile based, but high data costs and electricity shortages limit consistent participation in digital learning (ICASA, 2025).

A significant dimension of inequality in South Africa is language. With eleven official languages, education has historically privileged English and Afrikaans, often marginalising African languages (Madiba, 2014). The 2020 Language Policy Framework for Higher Education mandates institutions to strengthen the use of indigenous languages for teaching, learning and research (DHET, 2020). Jantjies (2020) argues that without localisation, digital learning tools will reproduce linguistic exclusion. The Masakhane project, a pan-African initiative in natural language processing, has demonstrated that AI can support African language inclusion, opening possibilities for personalised learning in isiZulu, isiXhosa, Sesotho and beyond (Adelani et al., 2022).

3. THEORETICAL FRAMEWORK

This study is underpinned by Critical Pedagogy and Connectivism, two theoretical frameworks that offer valuable insights into the intersections of education, technology, and social context. While originating from different intellectual traditions, both frameworks engage with the question of how knowledge is produced, accessed, and transformed in ways that either reproduce or challenge inequalities.

3.1. Critical Pedagogy

The critical pedagogy is most closely associated with the work of Paulo Freire, whose seminal text Pedagogy of the Oppressed (1970/2005) advanced a radical rethinking of the purpose and practice of education. Writing in the context of Brazil's socio-political struggles, Freire argued that education is never a neutral enterprise: it either functions to reproduce systems of oppression or to liberate the oppressed through the cultivation of critical consciousness. At the centre of his critique is the so-called "banking model" of education, in which learners are treated as passive recipients of knowledge deposited by teachers. In contrast, Freire proposed a problem-posing model, which treats learners as co-creators of knowledge and situates learning in dialogue, praxis, and reflection (Freire, 2005; Freire, 1994).

The intellectual trajectory of critical pedagogy has been enriched by subsequent scholars. Henry Giroux (2011, 2020) positioned it as a form of cultural politics that interrogates how power operates in curricula, media, and everyday schooling. Peter McLaren (2015) similarly extended Freire's work, emphasising education as a revolutionary act requiring teachers to confront neoliberal, capitalist, and colonial logics embedded within institutions. Joe Kincheloe (2008) advanced the field by connecting critical pedagogy with critical literacy and critical race theory, insisting on its relevance for analysing structural inequalities in increasingly globalised classrooms.

The key principles of critical pedagogy include dialogical engagement, which values reciprocal teacher-student relationships; the development of critical consciousness, through which learners interrogate social, political, and cultural realities; and the integration of lived experience into the learning process (Giroux, 2020; Darder, 2017). Education is seen not as a transmission of content but as a political and ethical project aimed at empowerment and social justice (Freire, 2005; McLaren, 2015).

The applications of critical pedagogy have been wide-ranging. In Latin America, it underpinned adult literacy campaigns and community education initiatives that sought to empower disenfranchised populations (Freire, 1994; Darder, 2017). In North America and Europe, it has been mobilised to critique neoliberal reforms such as high stakes testing and the standardisation of curricula (Giroux, 2011; Kincheloe, 2008). More recently, scholars have applied critical pedagogy to the digital age, exploring how technology can both liberate and constrain learners depending on its design and deployment (Selwyn, 2019; Smyth & Wrigley, 2013).

In Africa, critical pedagogy has shaped debates on decolonisation of education, particularly the call to dismantle Eurocentric epistemologies and foreground indigenous knowledge systems (Shizha & Kariwo, 2011; Jansen, 2019). It has been particularly influential in South Africa, where scholars argue that critical pedagogy provides a framework for addressing persistent inequalities inherited from apartheid (Leibowitz, 2017). Madiba (2014) has highlighted its potential to support multilingual education, ensuring that African languages are valued in curricula and digital learning environments. Moreover, critical pedagogy resonates with movements to challenge structural racism, gender inequality, and class divisions in South African universities (Leibowitz & Bozalek, 2016).

Despite its widespread adoption, critical pedagogy has also faced critique. Ellsworth (1989) argued that its rhetoric of empowerment can

sometimes obscure structural barriers and reproduce hierarchies in the classroom. Gore (1993) noted that Freire's ideas are often too abstract, providing little practical guidance for educators in constrained contexts. Others contend that critical pedagogy risks romanticising resistance without adequately addressing the complexities of institutional reform (Apple, 2013). Nonetheless, its enduring appeal lies in its insistence that education is a site of struggle, possibility, and transformation, making it highly relevant in societies grappling with inequality and the politics of knowledge.

3.2. Connectivism

Connectivism, coined by Siemens (2005) and later expanded by Downes (2008, 2012), emerged in response to the growing role of digital technologies in learning and knowledge creation. It is often described as a "theory for the digital age," distinguishing itself from behaviourism, cognitivism, and constructivism by focusing on the external networks of information that shape learning (Siemens, 2005). At its core, connectivism posits that knowledge resides across networks of people, digital tools, and databases and that learning occurs when individuals create, navigate, and reconfigure these connections. The ability to recognise patterns across disparate information sources is seen as more important than the memorisation of static content (Downes, 2008).

Applications of connectivism have been most visible in digital education, particularly in the design of Massive Open Online Courses (MOOCs) and online communities of practice. Anderson and Dron (2011) showed how connectivist principles informed online learning environments that emphasise collaboration and distributed knowledge construction. In African higher education, Nkuyubwatsi (2021) applied connectivism to open and distance learning, highlighting its relevance in contexts where learners rely on networks of peers and digital tools to compensate for institutional limitations.

Despite its appeal, connectivism has faced considerable critique. Verhagen (2006) dismissed it as "pedagogical jargon," arguing that it lacked empirical validation and failed to meet the criteria of a fully developed learning theory. Kop and Hill (2008) added that connectivism ignores the cognitive and psychological processes underpinning learning, presenting instead a macro-level description of information flow. Bell (2011) noted that its heavy emphasis on technology risks marginalising the role of teachers, cultural contexts, and offline learning practices. In low-resource settings, Nkuyubwatsi (2021) warned that connectivism presupposes digital access, which remains highly uneven in many African contexts, thereby limiting its universal applicability.

Many proponents counter that connectivism should not be judged by the standards of traditional learning theories. Siemens (2005) and Downes (2012) argue that its value lies in describing learning in networked environments, rather than explaining internal cognition. Bell (2011) suggests that connectivism complements rather than replaces older theories, addressing the networked and digital dimensions of learning overlooked by behaviourism, cognitivism, and constructivism. Furthermore, empirical studies have begun to test connectivist principles. For example, Cormier and Siemens (2010) illustrated how connectivist principles informed the design of cMOOCs (connectivist Massive Open Online Courses), in which knowledge was collaboratively constructed through learner networks rather than transmitted in a traditional top-down manner. These innovations suggest that connectivism, though still developing, offers an important conceptual lens for analysing how digital technologies shape and mediate contemporary learning processes.

The critical Pedagogy and Connectivism together provide a robust conceptual foundation for interrogating the promises and limitations of artificial intelligence and adaptive learning in education. By situating this study within these two frameworks, it becomes possible to critically explore how adaptive technologies may both reinforce and potentially transform the dynamics of education in developing contexts such as South Africa.

4. RESEARCH METHODOLOGY

This study employs a qualitative research approach, which is suitable for examining complex social and educational phenomena within their broader cultural, political, and technological contexts (Creswell & Poth, 2018). A qualitative orientation enables a nuanced understanding of how artificial intelligence and adaptive learning are situated within the South African education system, with a particular focus on issues of equity, access, and cultural relevance. By privileging interpretive analysis, the study aims to provide depth rather than breadth, aligning with the journal's emphasis on cultural and social dimensions of scientific inquiry.

4.1. Research Design

The research design is a qualitative desktop study,

grounded in interpretivist traditions. Desktop studies draw on existing documentary and secondary sources to generate insights, making them particularly suited to contexts where direct fieldwork may be limited or where the research focus is on synthesising existing bodies of evidence (Bowen, 2009). This design is justified on two grounds: first, the wealth of existing data on digital transformation, AI adoption, and educational inequality in South Africa; and second, the opportunity to situate South African developments within global and continental debates.

4.2. Data Collection: Secondary Sources

Data for this study were collected exclusively from secondary sources, including:

- **Government and policy documents** – such as the White Paper on Science, Technology and Innovation (Department of Science and Innovation, 2019), the Language Policy Framework for Higher Education (DHET, 2020), and the State of ICT Sector Report (ICASA, 2025).
- **National and international statistics** – including datasets from Statistics South Africa (2023), Datar portal (2025), and UNESCO's Global Education Monitoring reports.
- Peer-reviewed academic literature – studies examining AI in education, adaptive learning, and digital transformation in South Africa and the Global South (e.g., Mhlanga & Moloi, 2020; Raimi & Oluwafemi, 2022; Nkuyubwatsi, 2021).
- **Grey literature and institutional reports** – including research by non-governmental organisations, universities, and industry actors such as GSMA and Universities South Africa.

The selection of sources followed two principles: relevance (documents directly addressing AI, adaptive learning, and education in developing contexts) and recency (priority given to sources published within the last five years, except for foundational theoretical texts).

4.3. Data Analysis

The collected data were subjected to qualitative content analysis, a method suitable for interpreting the meaning of textual data through systematic classification and coding (Schreier, 2012). The thematic content analysis proceeds through three stages to ensure rigour and clarity.

Stage 1: Initial Immersion

All sources were read and re-read to develop familiarity with the material. During this stage, open coding was applied. Segments of text were labelled with descriptive codes, such as digital inequality, infrastructure, personalization, predictive analytics, and bias. These codes represented repeated ideas or concepts across documents.

Stage 2: Thematic Coding

The initial codes were then systematically organised into broader categories. For example:

- **Opportunities** include personalisation of learning, predictive analytics for student support, multilingual inclusion, and lecturer workload reduction.
- **Challenges** include infrastructure gaps, connectivity costs, algorithmic bias, cultural exclusion, and surveillance concerns.

At this stage, codes were constantly compared, refined, and collapsed into higher-order themes. Six major themes emerged;

- **Theme 1:** Ubuntu and Community-Centred Learning
- **Theme 2:** Teacher Readiness and Capacity
- **Theme 3:** Policy and Institutional Readiness
- **Theme 4:** Opportunities for AI in Education
- **Theme 5:** Digital Inequalities
- **Theme 6:** Ethical and Cultural Risks

Stage 3: Synthesis And Interpretation

The identified themes were then synthesised and compared across global, continental, and South African contexts. This allowed the study to highlight both convergences (e.g., affordability challenges common across the Global South) and divergences (e.g., South Africa's acute rural–urban digital divide). Finally, the themes were interpreted through the frameworks of critical pedagogy and connectivism, which emphasise the role of equity, cultural relevance, and knowledge networks in shaping effective AI adoption in education

To enhance trustworthiness, triangulation was achieved by drawing on multiple types of secondary data (policy documents, statistics, peer-reviewed articles, and grey literature). In addition, emphasis was placed on identifying both supportive and critical perspectives in the literature, thereby ensuring a balanced analysis. Moreover, through a qualitative, desktop-based design and systematic analysis of secondary sources, this study establishes a solid empirical foundation for examining the role of AI and adaptive learning in South Africa.

4.4. Ethical Considerations

This study is based exclusively on the analysis of

secondary data, including peer-reviewed literature, publicly available policy documents, statistical reports, and grey literature. As such, no direct interaction with human participants was undertaken, and formal ethical clearance was not required. Nevertheless, the research adhered to rigorous ethical standards in line with international scholarly practice. All sources were properly acknowledged through accurate citation and referencing, thereby ensuring academic integrity and preventing plagiarism. Care was taken to represent the authors' arguments faithfully and to avoid the selective use of evidence that could misrepresent the findings. Sensitive data, such as government statistics or institutional reports, were interpreted in context to prevent misapplication or overgeneralisation.

By adhering to these principles of transparency, accountability, and responsible scholarship, the study upholds the ethical standards expected in educational and social research while contributing to ongoing debates on the cultural and technological dimensions of learning

5. RESEARCH FINDINGS AND DISCUSSION

This paper aims to explore the intersection of artificial intelligence and adaptive learning within the South African education context, while also considering global developments for comparison. The findings are organised thematically to highlight opportunities, challenges, risks, and policy implications. These themes provide a structured lens for analysis and are later interpreted through the theoretical perspectives of Critical Pedagogy and Connectivism.

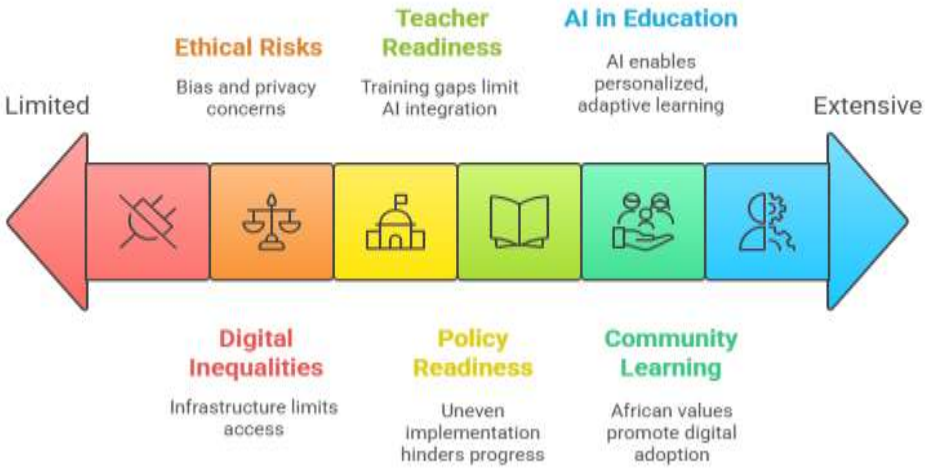

Figure 1: Key Themes Emerging from the Study.

Theme 1: Ubuntu And Community-Centred Learning

In the South African context, Ubuntu is not merely a cultural value but a philosophy that informs how people understand humanity, relationships, and learning. The expression umuntu ngumuntu ngabantu — "a person is a person through other people" — encapsulates the belief that individuals realise their humanity through interdependence, solidarity, and mutual care (Letseka, 2013). Within education, Ubuntu implies that learning is not a solitary act but a communal practice that affirms dignity, empathy, and responsibility towards others (Waghid, 2018).

The findings reveal that any adoption of AI in South African education must be interpreted through this relational lens. While AI systems can personalise content and deliver adaptive pathways, they cannot replicate the ethical and human qualities of Ubuntu. AI is not a person; it does not embody compassion, empathy, or communal responsibility. Instead, it is a tool that processes data and generates outcomes based on algorithms. For example, an AI tutor may adjust the pace of lessons for a learner, but it cannot show understanding when a student feels excluded or demoralised. Ubuntu reminds us that the essence

of education lies not only in efficiency or performance but in nurturing human relationships that affirm dignity and belonging.

Globally, similar insights can be found in critiques of technology-driven education that warn against reducing learning to data flows and algorithmic outputs (Selwyn, 2019; Williamson & Eynon, 2020). In Latin American and Indigenous contexts, Community-Based pedagogies highlight the centrality of cultural values, social ties, and collective knowledge qualities that AI cannot reproduce but can be designed to support (Darder, 2017).

Integrating Ubuntu into discussions of AI does not mean rejecting technology, but rather ensuring that AI is positioned as a supportive tool within a human-centred system. Teachers, peers, and communities remain central to the learning process. Adaptive systems can provide valuable assistance, but they must never replace the ethical and relational dimensions of teaching and learning. Ubuntu thus serves as a reminder that technology must always remain subordinate to human values, ensuring that education promotes solidarity, justice, and humanity.

From a theoretical standpoint, Ubuntu resonates strongly with Critical Pedagogy's call for education to be a practice of freedom and justice (Freire, 2005; Giroux, 2020). It also enriches Connectivism by emphasising that networks of knowledge are not purely technical but deeply human and cultural. Together, these insights show that while AI may extend learning opportunities, it must be carefully integrated in ways that respect the communal and relational foundations of South African education.

Theme 2: Teacher Readiness and Capacity

In South Africa, the successful adoption of AI in education depends heavily on teachers' readiness and capacity to integrate digital tools into pedagogy. The findings indicate that many teachers feel unprepared for this task, with limited training opportunities and uneven access to technological resources (Maringe & Ojo, 2021). Rural teachers often lack both infrastructure and professional development support, leaving them at risk of being further marginalised in a system already marked by inequality (Spaull & Jansen, 2019). Without teachers who are confident and skilled in using adaptive learning systems, AI risks becoming a superficial add-on rather than a transformative tool.

Internationally, research reinforces this challenge. Studies in OECD countries highlight that teacher training is the single most important factor in successful digital adoption (OECD, 2021). For instance, Singapore's national strategy for AI in education has prioritised continuous professional development and teacher empowerment, ensuring that educators are not only trained to use technology but also supported to adapt it to their own pedagogical contexts (Holmes, Bialik, & Fadel, 2021). In African countries such as Kenya and Rwanda, targeted teacher capacity-building programmes have shown that with adequate support, teachers can integrate mobile and AI tools to improve learner engagement and outcomes (UNESCO, 2022).

From a South African perspective, teachers are not simply implementers of technology but mediators who shape how AI is understood and used in classrooms. Here, the philosophy of Ubuntu is vital: teachers embody the human and relational values that AI cannot replicate. While AI may personalise content, it cannot nurture empathy, solidarity, or the moral growth of learners. Teachers must therefore anchor the use of AI in ways that affirm learners' humanity and dignity, ensuring that adaptive systems support, rather than replace, the communal ethos of education.

The critical Pedagogy reinforces this view by positioning teachers as facilitators who encourage learners to question, dialogue, and critically engage with knowledge (Freire, 2005). In the South African classroom, this means that teachers must go beyond using AI as a technical tool and instead integrate it in ways that promote justice and inclusion. Similarly, Connectivism positions teachers as "network navigators" who help students connect to meaningful sources of knowledge across digital platforms and social contexts (Siemens, 2005; Downes, 2008). Teachers thus play a dual role: guiding learners through complex information networks while safeguarding them against bias, exclusion, or alienation.

The findings, therefore, underline that AI adoption is not only a question of infrastructure and policy but also of human capacity. Teachers must be central in this transformation, receiving sustained professional development, institutional support, and resources. Without their readiness, adaptive technologies risk reinforcing the very inequalities they are meant to address.

Theme 3: Policy And Institutional Readiness

South Africa has articulated ambitious and progressive policy goals for digital transformation in education. The White Paper on Science, Technology and Innovation (Department of Science and Innovation [DSI], 2019) places technology and innovation at the centre of the country's

development strategy, highlighting the role of artificial intelligence and other Fourth Industrial Revolution (4IR) tools in shaping future education systems. Similarly, the Language Policy Framework for Higher Education (Department of Higher Education and Training [DHET], 2020) reflects an official commitment to advancing inclusivity and multilingualism in digital and higher education spaces. These policies suggest that government and institutions recognise the potential of technology to address inequalities and expand access.

However, the findings reveal a persistent gap between policy ambition and practice. Many schools, particularly in rural provinces, still lack reliable internet, stable electricity, and functional ICT infrastructure. Teachers remain underprepared for integrating digital technologies into pedagogy, with professional development opportunities limited in scope and reach (Mhlanga & Moloi, 2020). Budgetary constraints, combined with competing priorities such as addressing learning backlogs and infrastructure deficits, limit systemic reform. These weaknesses mean that policies often remain aspirational documents rather than instruments of tangible transformation.

By contrast, examples from other global contexts demonstrate what is possible when policy, infrastructure, and teacher development are aligned. In Singapore, national digital education strategies have been underpinned by heavy investment in infrastructure, compulsory digital literacy training for teachers, and the integration of AI into classroom assessment and administration (Holmes, Bialik, & Fadel, 2021). China has similarly pursued large-scale AI adoption in education, supported by state-led investment in digital platforms, cloud-based systems, and teacher retraining programmes (Zawacki-Richter et al., 2019). These comparisons highlight that South Africa's challenge lies not in the absence of progressive policies, but in the capacity for implementation across deeply unequal socio-economic contexts.

From a theoretical standpoint, Connectivism reinforces the point that networks of learning require a minimum foundation of reliable infrastructure, sustained access, and institutional support in order to function effectively (Siemens, 2005; Downes, 2008). Without connectivity and the institutional scaffolding to support it, the promise of adaptive learning remains out of reach for large segments of the population. Critical Pedagogy, on the other hand, calls for policies that move beyond technical integration to address deeper questions of equity and empowerment (Freire, 2005; Giroux, 2020). For South Africa, this means ensuring that reforms are not only about modernisation but also about dismantling historical exclusions in education. Jansen (2019) reminds us that policies often fail when they do not account for the lived realities of disadvantaged learners, and that true reform requires attention to both systemic structures and community-level needs.

Thus, the evidence suggests that South Africa's success in embedding AI in education will depend on bridging the policy–practice divide by coupling visionary frameworks with practical investments in infrastructure, teacher development, and community engagement. Without this alignment, ambitious goals risk remaining rhetorical commitments rather than meaningful change on the ground

Theme 4: Opportunities For AI In Education

In South Africa, the introduction of AI-enabled adaptive learning systems has the potential to respond to pressing challenges in both basic and higher education. Many schools are overcrowded and under-resourced, with large class sizes limiting individual attention (Spaull & Jansen, 2019). Adaptive systems could assist by providing personalised feedback, remedial support in literacy and numeracy, and targeted pathways for struggling learners. In higher education, particularly within open and distance learning institutions such as UNISA, adaptive systems could enhance support for students balancing academic study with work or incarceration (Czerniewicz et al., 2020).

Internationally, adaptive platforms have been shown to increase learning outcomes. In India, technology-assisted instruction significantly improved mathematics performance, especially for low-achieving learners (Muralidharan, Singh, & Ganimian, 2019). In Kenya and Ghana, low-data adaptive tools delivered via SMS and WhatsApp have expanded access to personalised learning in rural contexts (Jordan, 2024; Henkel, Boateng, & Owusu, 2024).

From a theoretical perspective, Connectivism helps explain how adaptive learning expands learner access to distributed networks of knowledge beyond the physical classroom (Siemens, 2005; Downes, 2008). Critical Pedagogy emphasises that the success of such systems depends on whether they are designed to empower marginalised learners through inclusive content and language integration (Freire, 2005; Giroux, 2020)

Theme 5: Digital Inequalities

South Africa continues to face severe digital inequalities. Although 79 % of the population was

reported to be online in 2025, only 10 % of rural households had reliable internet compared to 66 % of urban households (DataReportal, 2025; Invigilator, 2024). Access remains largely mobile-based, yet data prices are among the highest in Africa relative to income (ICASA, 2025). In addition, persistent load shedding disrupts connectivity, creating a fragile digital environment for learning. These inequalities mean that the very students who could benefit most from adaptive learning are often the least able to access it.

Globally, UNESCO (2022) highlights that similar patterns occur in other developing contexts, where digital transformation disproportionately benefits already privileged groups. For example, rural learners in Ethiopia and Nigeria face infrastructural deficits that limit the reach of adaptive technologies (Ogunode, 2021; UNESCO, 2022).

The critical Pedagogy makes clear that technologies are not neutral but shaped by social and economic realities (Ellsworth, 1989; Giroux, 2020). Unless adaptive systems deliberately address issues of affordability, infrastructure, and linguistic inclusion, they risk reproducing existing inequalities rather than resolving them. Connectivism also highlights that while networks expand opportunities, unequal access to connectivity can exclude entire groups from participating in digital learning (Nkuyubwatsi, 2021).

Theme 6: Ethical And Cultural Risks

In South Africa, concerns about AI in education include issues of surveillance, privacy, and cultural exclusion. Many digital systems in use are designed outside Africa and do not adequately reflect the socio-economic or linguistic realities of South African learners (Raimi & Oluwafemi, 2022). The dominance of English in digital learning platforms marginalises learners whose primary languages are African languages, despite policy commitments to multilingualism (DHET, 2020; Jantjies, 2020).

Globally, similar issues have been observed. Studies in Europe and North America show that algorithms can reproduce social biases and exacerbate inequities in access to opportunities (Williamson & Eynon, 2020). In developing regions, imported platforms have often failed to adapt to local contexts, raising concerns about cultural misalignment (Selwyn, 2019).

Connectivism emphasises the importance of critical digital literacy, enabling learners to evaluate the reliability and biases embedded in digital systems (Bell, 2011). Critical Pedagogy pushes this further, arguing that learners should be empowered to question whose knowledge and values are embedded in technologies and whose perspectives are excluded (Freire, 2005; Shizha, 2013).

6. CONCLUSION

This study set out to explore the opportunities and challenges of artificial intelligence and adaptive learning in South Africa, with reference to global experiences and theoretical perspectives. The findings revealed six central themes: opportunities for AI in education, digital inequalities, ethical and cultural risks, policy and institutional readiness, Ubuntu and community-centred learning, and teacher readiness and capacity.

The analysis shows that while adaptive technologies hold real promise for personalising learning and expanding access, these benefits are constrained by entrenched socio-economic inequalities, infrastructural deficits, and ethical risks. The South African policy landscape is ambitious and forward-looking, but implementation remains uneven, particularly in rural and disadvantaged communities. Ubuntu reminds us that AI must remain subordinate to human values of dignity and solidarity, while teacher readiness highlights the irreplaceable role of educators in mediating between technology and humanity.

Through the lenses of Critical Pedagogy and Connectivism, it is clear that technology cannot be separated from questions of justice, power, and access. AI may connect learners to vast networks of knowledge, but without equity-focused policies and critical engagement, it risks reproducing existing exclusions. For South Africa, the central challenge is not whether AI can be integrated into education, but whether it can be implemented in a way that advances equity, multilingualism, and social justice

6.1. Recommendations

Building on the findings of this study, a number of recommendations are proposed to strengthen the integration of artificial intelligence and adaptive learning in South Africa. These recommendations are framed with attention to the socio-economic inequalities that continue to shape education, as well as the theoretical insights of Critical Pedagogy and Connectivism, which emphasise justice, inclusivity, and connectivity.

- First, there is a pressing need to align policy ambition with implementation capacity. South Africa has developed progressive frameworks such as the White Paper on Science, Technology and Innovation and the Language Policy Framework for Higher

Education, but the gap between vision and practice remains wide. Government must prioritise investment in infrastructure, especially in rural and under-resourced schools, and establish monitoring mechanisms to ensure that policy commitments are realised at classroom level. Without bridging this gap, the benefits of adaptive learning will remain largely aspirational.

- Second, infrastructure and access are essential for any networked learning to succeed. Affordable connectivity should be treated as a right, not a privilege, and measures such as zero-rating of educational websites, community Wi-Fi hubs, and reductions in data costs can help to level the playing field. In addition, persistent energy shortages caused by load shedding undermine digital adoption. Exploring sustainable alternatives such as solar-powered school networks can provide greater stability, particularly in rural areas.
- Third, teacher readiness and professional development must be central to the adoption of AI in education. Teachers are not passive implementers of technology but active mediators who interpret, adapt, and humanise digital systems for learners. Continuous professional development programmes should be introduced to build teachers' digital literacy and pedagogical capacity. Creating communities of practice where teachers can share experiences of blending AI with learner-centred and Ubuntu-inspired pedagogy will further enhance effectiveness and sustainability.
- Fourth, cultural and linguistic inclusivity must be embedded in AI design. While English remains dominant in digital platforms, South Africa's multilingual reality demands that adaptive learning systems integrate indigenous languages. Partnerships with linguists, communities, and initiatives such as the Masakhane project can ensure that AI systems reflect South African linguistic diversity and contribute to equity rather than exclusion.
- Fifth, ethical safeguards are vital. As AI systems raise concerns of bias, surveillance, and privacy, South Africa should develop national guidelines for the ethical use of AI in education. Transparency in algorithm design, clear rules on data protection, and participatory dialogue involving educators, parents, and learners will help ensure that AI serves human development rather than undermines it.

Finally, the adoption of AI must be guided by the relational principles of Ubuntu. Technology can never replace human empathy, solidarity, and care, but it can be used to support them. AI should be positioned as a tool within a human-centred education system, ensuring that learners experience both the efficiency of adaptive technologies and the compassion of teachers and communities. To achieve this balance, participatory design processes that involve local communities are crucial, as they ensure that technology reflects social values and cultural realities.

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