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# Philosophical and critical perspectives of integrating AI into STEM curriculum design: Opportunities and challenges in African educational contexts

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**Abstract**

The integration of artificial intelligence (AI) into science, technology, engineering, and mathematics (STEM) education is transforming teaching methods worldwide. In Africa, this change presents major opportunities along with notable challenges. This conceptual paper critically explores the philosophical and critical perspectives of how AI can be incorporated into STEM curriculum design within African education systems to enhance teaching and learning outcomes. The paper adopts a dual-theory approach using the artificial intelligence technological pedagogical content knowledge (AI-TPACK) framework and Paulo Freire's critical pedagogy theory. These frameworks guide the analysis of how AI can be aligned with curriculum goals, teaching strategies, and student needs, while ensuring ethical and culturally responsive integration. A conceptual and interpretive research design is foregrounded, supported by a narrative literature review, and is employed to generate theoretical insights rather than empirical findings. AI tools, including intelligent tutoring systems, adaptive learning platforms, automated assessment tools, and generative content applications, can personalize instruction, encourage problem-solving and critical thinking, and provide real-time feedback to both students and teachers. In environments characterized by overcrowded classrooms, limited educational resources, and unequal access to quality learning, AI offers scalable, data-driven approaches to improve STEM education. By integrating AI, education systems can work toward reducing learning gaps and promoting the development of future-ready skills aligned with the needs of the 4th Industrial Revolution. The paper recommends the development of culturally relevant, inclusive, and ethically grounded strategies to guide AI integration in STEM education across Africa. These approaches should address infrastructural gaps, teacher capacity, and contextual diversity to prevent the reinforcement of educational inequities.

**Keywords:** philosophical perspectives, artificial intelligence, STEM education, curriculum design, AI-TPACK

## INTRODUCTION

Artificial intelligence (AI) is rapidly transforming the global educational landscape. Its impact is particularly profound in science, technology, engineering, and mathematics (STEM) disciplines (Xu & Ouyang, 2022). Within the context of the 4th Industrial Revolution (4IR), AI is not merely a technological trend; it catalyzes pedagogical innovation. It enhances learning outcomes, personalizes instruction, and streamlines educational management systems (Castro et al., 2024). In STEM education, data-driven inquiry, computational thinking, and problem-solving are essential. AI enhances these processes through tools such as intelligent tutoring systems, adaptive learning platforms, and predictive analytics, enabling educators and learners to engage more deeply and personally with STEM content.

This paper is guided by two key frameworks: the artificial intelligence technological pedagogical content knowledge (AI-TPACK) and Paulo Freire's critical pedagogy. These frameworks provide a philosophical and practical foundation for understanding how AI can be integrated into STEM curriculum design in African contexts. This combined lens enables a deeper


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**Contribution to the literature**

- The paper introduces a new dual-framework model that combines AI-TPACK with critical pedagogy for ethical and culturally responsive AI integration in STEM education.
- It provides a context-specific analysis of AI opportunities and challenges unique to African educational environments.
- It offers practical, culturally grounded recommendations to guide equitable AI-enhanced STEM curriculum design across Africa.

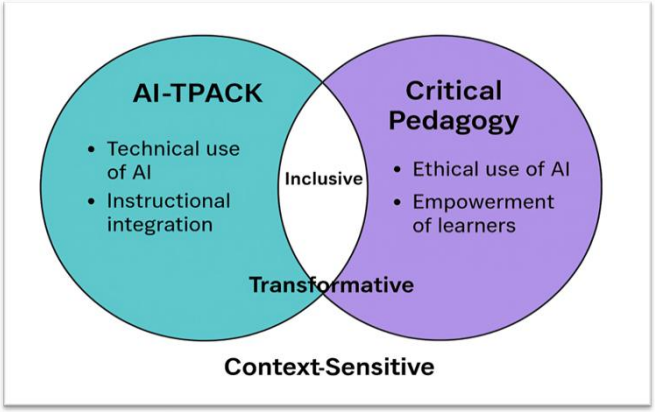


**Figure 1.** Theoretical framework on AI-TPACK and critical pedagogy (Adapted from Freire, 1970; Mishra & Koehler, 2006; Ning et al., 2024)

understanding of both the technical and ethical dimensions of AI integration. It ensures that curriculum design is not only innovative but also culturally responsive and socially just. **Figure 1**, later in the paper, visually illustrates how these two frameworks intersect to support inclusive and transformative STEM education.

Philosophically, the integration of AI into STEM education across Africa presents a dual narrative. On one hand, it provides a way to address challenges such as teacher shortages, limited access to quality resources, and unequal learning outcomes. On the other hand, successful implementation requires a context-sensitive understanding of Africa's diverse educational realities (Dlamini et al., 2025). Local needs, infrastructural constraints, and cultural dynamics must be considered. Africa's socio-economic diversity, linguistic variation, and varied education systems call for AI solutions that are inclusive, equitable, and designed for long-term impact (Falebita & Kok, 2024; Joseph & Uzondu, 2024). AI technologies, including intelligent tutoring systems, virtual laboratories, and generative content tools, are already being used in African universities. These innovations improve instructional delivery, support adaptive learning, and make academic assistance more efficient. Platforms like ChatGPT and AI-driven tutoring systems encourage student engagement and personalized learning. They also help promote data-informed teaching practices.

Importantly, AI has the potential to democratize access to high-quality STEM education. In resource-constrained environments, it offers scalable, interactive, and culturally responsive learning experiences (UNESCO, 2022). Despite these advancements, several barriers impede effective AI integration in African STEM education. A major obstacle is the lack of robust digital infrastructure, particularly in remote and marginalized areas. This limits access to AI-powered tools and platforms (Falebita & Kok, 2024). Widespread digital illiteracy among educators and learners further compounds the issue. Many lack the technical competencies needed to engage meaningfully with AI technologies (Chisom et al., 2023).

Additionally, existing curricula are often outdated and misaligned with emerging technological paradigms. This rigidity poses a significant obstacle to incorporating AI-related content and instructional strategies (Chisom et al., 2024). Ethical concerns also arise in AI integration. Issues such as data privacy, algorithmic bias, and cultural relevance, especially in systems developed outside African contexts, must be addressed. These concerns raise questions about inclusivity, epistemic justice, and the contextual appropriateness of AI technologies (Chisom et al., 2023). Such questions are not only technical but also philosophical, inviting reflection on the nature of knowledge, fairness, and the moral responsibilities of AI developers and educators. The integration of African philosophical perspectives, such as *ubuntu*, communalism, and indigenous epistemologies, can enrich the discourse and guide the development of AI systems that are culturally grounded and ethically sound (Suliman et al., 2024; Yilma, 2025).

Global literature extensively documents the benefits of AI in STEM education. However, research focused specifically on the African context remains limited. Much of the existing scholarship extrapolates findings from high-income countries. This often overlooks the infrastructural, pedagogical, and socio-cultural complexities of African education systems (Xu & Ouyang, 2022). The lack of contextual specificity limits the relevance of global insights. Moreover, the alignment of AI tools with local curricula, languages, and cultural values is underexplored.

This paper addresses these gaps by offering a context-sensitive and philosophically informed analysis of AI integration in African STEM education. It explores both opportunities and constraints, while critically examining ethical and epistemological implications. By

incorporating philosophical inquiry, particularly in ethics and epistemology, it aims to deepen understanding of how AI can support inclusive, just, and culturally relevant education. The goal is to inform policy development, guide curriculum reform, and support the creation of localized AI solutions that are inclusive, sustainable, and impactful.

### Research Questions

The study explores two central research questions:

1. How can AI integration be more philosophically, critically, and practically integrated in STEM curriculum to be guided by AI-TPACK and critical pedagogy, enhance learning outcomes, and promote culturally grounded pedagogy in African education?
2. What challenges and opportunities shape AI adoption in African STEM education, and how can inclusive, philosophically informed strategies ensure equitable implementation?

### Problem Statement

AI is transforming STEM education worldwide by enabling personalized learning, automated assessment, and enhanced student engagement (Holmes et al., 2022). However, its integration into African educational systems remains limited and often poorly aligned with local needs. Key barriers include outdated curricula, inadequate infrastructure, and a shortage of trained educators. Most AI tools developed in Western contexts do not reflect African cultural values, pedagogical traditions, or linguistic diversity. This raises concerns about cultural relevance and the marginalization of indigenous knowledge systems (Bond et al., 2021; Gleason, 2018). In the absence of national strategies, teacher training, and curriculum guidelines, AI adoption tends to be inconsistent and unsustainable (Adedoyin & Soykan, 2020). Furthermore, there are limited studies on the integration of AI in African STEM education. This limits the development of evidence-based policies and context-sensitive curriculum design (UNESCO, 2022). This study addresses these gaps by examining both the opportunities and challenges of AI integration and by proposing inclusive strategies tailored to Africa's diverse educational realities.

## THEORETICAL FRAMEWORK

This conceptual paper is based on two complementary theories: the AI-TPACK framework and Paulo Freire's critical pedagogy theory. These frameworks help analyze how AI tools can be integrated into STEM education in Africa. They focus on curriculum design, teaching practices, and the importance of cultural and ethical relevance.

The AI-TPACK framework is built on the original TPACK model by Mishra and Koehler (2006). It adds AI-specific knowledge to the mix. Ning et al. (2024) describe AI-TPACK as having seven key components: pedagogical knowledge (PK), content knowledge (CK), AI-technological knowledge (AI-TK), pedagogical content knowledge (PCK), AI-technological pedagogical knowledge (AI-TPK), AI-technological content knowledge (AI-TCK), and AI-TPACK. This framework helps teachers align AI tools with subject content and teaching strategies. In African classrooms, where infrastructure and digital skills may be limited, AI-TPACK supports practical and inclusive teaching approaches.

Critical pedagogy theory, developed by Freire (1970), provides an ethical and philosophical foundation. It views education as a tool for liberation. Freire promotes learner agency, cultural relevance, and social justice. Freire's ideas, such as *conscientização* (critical awareness), *praxis* (reflection and action), and rejecting the "banking model" of education, are vital in African contexts. Many AI tools are designed outside Africa, which can lead to cultural mismatches and reinforce inequality (Pietersen, 2024). Critical pedagogy encourages educators to question the fairness and relevance of these tools. Freire's ideas highlight the need for AI systems that empower learners and promote epistemic justice. His philosophy aligns with African indigenous thought, including *ubuntu* and communalism, which advocate for culturally responsive and community-centered education (Freire, 1970; Mbiti, 1969; Venter, 2004).

Together, AI-TPACK and critical pedagogy offer a balanced approach. AI-TPACK guides the technical and instructional use of AI. Critical pedagogy ensures that AI is used ethically and in ways that empower learners. This combined framework supports inclusive, transformative, and context-sensitive STEM education in Africa.

## METHOD

This study adopts a conceptual and interpretive research design to examine the integration of AI into STEM education across African contexts, focusing on pedagogical enhancement and socio-technical challenges. This approach is well-suited for generating theoretical insights and critically engaging with existing literature, rather than collecting new empirical data. Interpretive research allows for a nuanced understanding of how AI technologies intersect with educational practices, cultural contexts, and systemic constraints, emphasizing meaning-making over measurement (Smeyers et al., 2015). Empirical methods were intentionally not employed in this study due to the exploratory and theoretical nature of the research focus. The aim is to develop a conceptual framework and philosophical grounding for AI integration in STEM

education, which requires synthesizing diverse scholarly perspectives rather than collecting primary data. This approach also accommodates the complexity and diversity of African educational contexts, which may not be adequately captured through standardized empirical instruments.

A narrative literature review was conducted to synthesize peer-reviewed journal articles, policy documents, and theoretical contributions related to AI, STEM education, and African educational systems. Sources were purposively sampled from databases such as Scopus, Web of Science, and Google Scholar, with a deliberate emphasis on African and Global South perspectives. This method enabled thematic synthesis across diverse contexts, offering insights into both the transformative potential of AI and the barriers to its equitable implementation. The review also reflects the growing use of narrative approaches in African education research to explore policy, pedagogy, and innovation in digitally evolving environments (Cohen et al., 2017).

## FINDINGS AND DISCUSSION

This section synthesizes key themes from the narrative literature review to address the research questions that guided the study.

### Philosophical Foundations for AI Integration in African STEM Curriculum

Integrating AI into STEM curriculum design in Africa is not merely a technical endeavor. It raises important philosophical and ethical questions, including fairness, epistemic justice, and the responsibilities of AI developers and educators (Chisom et al., 2023). These concerns require thoughtful reflection and culturally grounded responses. Paulo Freire's philosophy offers a valuable lens for addressing these issues. He viewed education as a tool for liberation and emphasized student-centered learning and dialogue (Freire, 1970). Learners, in his view, should be active participants in their education.

> "Ubuntu is not merely a cultural concept but a moral philosophy that emphasizes communal relationships, mutual respect, and the nurturing of human dignity" (Chingombe & Major, 2024, p. 45).

In the context of education, it calls for pedagogical practices that are inclusive, empathetic, and rooted in the lived experiences of learners in Southern Africa. (Chingombe & Major, 2024). In the context of AI, this implies designing tools that foster critical thinking, inquiry, and learner agency, rather than passive content consumption (Holstein et al., 2019; Villegas-Ch et al., 2025). African philosophical traditions also provide essential insights. The concept of *ubuntu* emphasizes community, interconnectedness, and shared humanity. Mbiti (1969) famously stated, "I am because we are, and since we are, therefore I am." This worldview contrasts with the individualism often embedded in Western AI systems. In curriculum design, *Ubuntu* supports collaborative learning, cultural relevance, and collective well-being (Venter, 2004). These values align with inclusive AI practices that respect local knowledge and promote equitable access to technology (Suliman et al., 2024).

Bhuda and Marumo (2022) argue that applying Ubuntu in education significantly helps decolonize AI. By incorporating indigenous African values like communalism, empathy, and respect, Ubuntu makes AI a more meaningful and responsive tool for African learners.

> "Ubuntu serves as a tool to decolonize and indigenize research ... when embodied with the esteem and dignity it deserves, [it] has the potential of restoring indigenous values, heritage and cultures through research" (Bhuda & Marumo, 2022, p. 6).

This ethical framework challenges Western-centric models of AI and promotes culturally relevant learning technologies. Similarly, Kamanzi (2025) emphasizes that the principle of communalism reinforces the idea that individual success is inherently tied to the success of the community. This supports the development of AI tools that encourage peer learning and shared achievement. Zheng et al. (2023) found that AI-generated feedback significantly improved group performance during collaborative learning activities. These findings suggest that Ubuntu-informed AI systems could play a vital role in fostering inclusive and cooperative educational environments.

Philosophy thus plays a critical role in guiding AI integration. It moves curriculum design beyond technical efficiency toward values such as equity, dignity, and cultural relevance. When informed by African thought and ethical frameworks, AI can support inclusive education and contribute to broader goals of social transformation and educational justice (Joseph & Uzondu, 2024; Kamanzi, 2025; Yilma, 2025).

### The Role of AI-TPACK and Critical Pedagogy Frameworks in Shaping AI Integration in STEM Education

AI is widely acknowledged as a transformative force in STEM education. It has significantly influenced instructional design, teaching methods, and assessment practices (Leon et al., 2025). AI is commonly used in STEM fields through tools such as personalized tutoring systems, automated grading software, and platforms that track and analyze student learning. These technologies aim to improve the quality, accessibility,

and personalization of learning environments (Xu & Ouyang, 2022).

> "The use of AI in education is transforming various dimensions of the education system, such as instructional practices, assessment strategies, and administrative processes" (Almasri, 2024).

A major contribution of AI is its support for personalized and adaptive learning. By analyzing student data, AI systems can tailor content delivery, suggest relevant resources, and provide immediate feedback. This fosters student-centered learning environments. It also improves engagement and learning outcomes (Chen et al., 2020). AI supports teacher development by analyzing classroom interactions. It offers feedback on instructional practices, promoting continuous improvement. This is especially valuable in dynamic STEM fields (Xu & Ouyang, 2022). AI tools also enhance inclusivity and accessibility. Features such as adaptive interfaces, speech-to-text functions, and real-time translation services support learners with disabilities and those from multilingual backgrounds (Holstein et al., 2019).

However, successful AI integration requires a holistic approach. Technological solutions must align with pedagogical goals. They must also be tailored to the complexities of educational ecosystems. Global scholarship affirms the pedagogical potential of AI. Castro et al. (2024) describe AI as a catalyst in the 4IR. They emphasize its role in personalizing instruction and streamlining educational management. Villegas-Ch et al. (2025) provide evidence of improved student performance through adaptive tutoring systems. Leon et al. (2025) propose a transdisciplinary framework. They focus on student agency, adaptive assessment, and ethical considerations. Fitria (2021) highlights AI's potential to create personalized and efficient learning experiences. Her work discusses intelligent tutoring, automated grading, and multimedia platforms. However, it remains conceptual and does not fully address infrastructural and ethical barriers. Venkateswaran et al. (2024) explore how AI transforms pedagogical models and institutional operations. They emphasize interactive learning and the development of 21st century skills. They also call for systemic support and ethical oversight. Algahtani (2024) bridges technical and pedagogical dimensions. He evaluates AI tools in higher education, focusing on usability and learner experience. His findings show that intuitive interfaces enhance engagement. Poorly designed tools hinder learning. The study's limited scope and lack of longitudinal data restrict its generalizability.

AI contributes significantly to academic workflows and assessment. Studies by Owan et al. (2023) and Pinzolits (2024) show improvements in efficiency and accuracy. However, they also raise concerns about fairness, transparency, and data security. Kwid et al. (2024) categorize AI tools into instructional, administrative, and analytical functions. They emphasize differentiated instruction and early warning systems. Stanković et al. (2024) examine AI's dual impact. They highlight their potential for innovation and the risks of digital inequality and institutional unpreparedness.

In the African context, scholars are grounding AI in local educational realities. Falebita and Kok (2024) explore generative AI adoption in African universities. They find that digital infrastructure and perceived behavioral control strongly influence usage. Joseph and Uzondu (2024) examine AI's role in addressing teacher shortages and unequal access. They also discuss challenges related to data privacy and educator training. Funda and Mbangeleli (2024) focus on South African higher education. They argue that AI can reduce dropout rates and improve instructional quality. Mosoa and van der Westhuizen (2025) explore AI's role in personalized learning in physical science classrooms. They emphasize the need for teacher training and curriculum alignment. Murungu (2024) highlights the potential of prompt engineering in African education. He calls for AI tools that reflect cultural and linguistic diversity. Ijiga et al. (2021) advocate for inclusive STEM pedagogies. They promote indigenous knowledge integration and multilingual instruction. Tarisayi (2024) uses a socio-technical lens to examine ChatGPT in South African universities. He argues that successful AI integration requires alignment between technology and human actors. Chasokela (2025) examines AI's role in developing 21st century skills in Zimbabwean universities. Falebita and Kok (2024) provide a continental overview. They advocate for increased AI literacy and alignment with the sustainable development goals (SDGs).

A conceptual paper using the AI-TPACK and critical pedagogy frameworks adds a theoretical dimension. The AI-TPACK framework extends the traditional TPACK model. It emphasizes the integration of AI tools with PK and CK. AI-TPACK encourages educators to assess how AI mediates learning. It supports differentiated instruction and adapts to diverse learner needs (Aboderin et al., 2025). This is especially useful in African contexts, where resources are limited and learning environments vary widely. Studies by Mosoa and van der Westhuizen (2025) and Ijiga et al. (2021) show how AI supports personalized learning and integrates indigenous knowledge. These align well with AI-TPACK principles. The critical pedagogy framework complements AI-TPACK. It foregrounds issues of power, equity, and social justice in AI integration. It challenges educators to interrogate assumptions embedded in AI systems. It promotes inclusive practices and ensures technology serves marginalized communities. Critical pedagogy emphasizes learner agency, ethical awareness, and co-construction of

knowledge. In African education systems, this means designing AI tools that reflect cultural and linguistic diversity. It also means supporting multilingual instruction and empowering both teachers and students. Studies by Murungu (2024) and Ijiga et al. (2021) support these principles. They advocate for culturally responsive AI and participatory design processes.

Collectively, these studies present a nuanced and comprehensive view of AI in education. They highlight its transformative potential. They also stress the need for context-sensitive, ethically grounded, and pedagogically sound implementation. Key themes include personalization, efficiency, ethical and technical challenges, usability, institutional readiness, and equity. Despite its promise, the success of AI depends on thoughtful integration. This must consider infrastructure, training, user experience, and inclusion. Future research should focus on empirical validation, longitudinal studies, and diverse perspectives. These will guide responsible AI adoption

## Opportunities and Challenges of Integrating AI into STEM Education in Resource-Constrained African Contexts

The integration of AI into STEM education across Africa is increasingly recognized as both a transformative opportunity and a multifaceted challenge. A growing body of scholarship emphasizes the importance of embedding AI within culturally responsive pedagogies that reflect African epistemologies, local languages, and contextual learning needs. Musundire (2025) argues that meaningful AI integration must extend beyond technological access. He advocates for curriculum adaptation and inclusive design that centers indigenous knowledge systems. However, he also highlights the epistemological limitations of Western-centric AI models, which often fail to align with African ways of knowing. While Musundire (2025) foregrounds cultural sensitivity, his work does not propose a structured framework for embedding these perspectives into national curricula. Similarly, Oladejo et al. (2025) introduce the culturo-techno-contextual approach, which integrates cultural relevance, technological tools, and contextual realities to enhance STEM learning. This model reinforces the imperative of grounding educational innovation in local pedagogical traditions. Additionally, Isangula (2025) calls for epistemic justice and methodological clarity, particularly in low-income African contexts where dominant knowledge systems marginalize local perspectives.

The global pedagogical shift from STEM to science, technology, engineering, arts, and mathematics (STEAM) and eventually to STREAM education reflects a movement toward holistic and interdisciplinary learning. Badmus and Omosewo (2020) observe that although STEM-to-STREAM models are gaining international traction, their adoption in African education systems remains limited. This is due to persistent barriers such as inadequate teacher training, infrastructural deficits, and gaps in PK. Abanikannda and Falade (2024) (2025) reveal widespread enthusiasm among educators and learners for the integration of AI into STEM education. However, their findings also highlight a lack of preparedness, underscoring the urgent need for curriculum reforms and scalable, context-aware training models. In the South African context, Dlamini et al. (2025) argue that without deliberate policy interventions and inclusive curriculum design, AI could exacerbate existing educational inequalities. Their work underscores the importance of equity, access, and teacher preparedness in ensuring that AI serves as a tool for inclusion rather than exclusion.

Ethical considerations play a key role in discussions about AI in education. Lodhi (2025) highlights several significant risks related to AI use in K-12 STEM education, such as algorithmic bias, surveillance, and systemic inequality. She suggests a three-phase implementation plan and a tiered professional development model that focuses on ethical reasoning, equity, and fostering student agency. Joseph and Uzondu (2024) stress the importance of strong instructional design and ethical frameworks when deploying AI and mobile learning tools. They warn that, without careful planning and ethical oversight, these technologies could reinforce existing educational inequalities instead of reducing them.

At the strategic level, Falebita and Kok (2024) argue that integrating AI into African higher education should be approached as a systemic initiative aligned with national development goals, institutional priorities, and long-term educational strategies. Their macro-level analysis reveals common challenges across the continent, such as gaps in digital infrastructure and faculty resistance, while also identifying opportunities for curriculum innovation and institutional transformation. However, their work lacks detailed case studies and does not sufficiently engage with the cultural and ethical dimensions of AI integration.

Fiqri et al. (2025) examine the integration of AI and virtual reality in STEM-based mathematics education across urban and rural high schools. The study revealed a significant digital divide. Urban schools demonstrate greater readiness and access to infrastructure, while rural schools face constraints in connectivity, teacher training, and device availability. The authors argue that the successful implementation of immersive technologies requires targeted investments and differentiated strategies tailored to diverse educational settings.

Tshibangu and Thembane (2025) provide a comprehensive synthesis of 46 studies on AI in African STEM education. They applied thematic and PESTEL

analysis to uncover regional disparities, ethical concerns, and the need for decolonized, context-sensitive AI integration strategies. These were aligned with the SDGs. Scholars such as Chasokela (2025), Ajayi (2023), Salisu (2025), and Samuel and Salisu (2025) further advocate for AI adoption strategies that are aligned with local realities, inclusive practices, and the SDGs. Their contributions emphasize the importance of context-aware curriculum design, ethical AI use, and the empowerment of educators and learners.

Collectively, these studies converge on the view that AI holds significant promise for transforming STEM education in Africa. However, realizing this potential requires a multifaceted approach that integrates cultural sensitivity, ethical responsibility, strategic alignment, and systemic capacity building. The path forward lies in developing inclusive, contextually grounded frameworks that not only harness the power of AI but also reflect the diverse educational landscapes of the African continent.

The literature underscores that meaningful AI integration demands more than technological access; it requires inclusive design, cultural relevance, ethical foresight, and a commitment to epistemic justice. From personalized learning and mobile classrooms to culturally responsive pedagogy and immersive technologies, the reviewed scholarship offers a roadmap for transforming African STEM education into a space where innovation is both inclusive and transformative. In summary, while AI presents transformative possibilities for STEM education in Africa, its success depends on culturally responsive design, ethical oversight, and strategic investment. Addressing infrastructural and pedagogical gaps is essential to ensure inclusive and sustainable implementation.

### Strategic Recommendations for Effective Integration of AI in African STEM Education

Scholars across the African continent increasingly argue that transforming education and communication systems requires approaches that are culturally grounded, inclusive, and technologically adaptive. Murungu (2024) highlights the transformative potential of AI, particularly prompt engineering, in reshaping African education. He emphasizes the need for AI-generated content that reflects Africa's linguistic and cultural diversity. Murungu (2024) also calls for collaboration among governments, educators, and technology developers to ensure equitable and context-sensitive AI integration. In the same vein, Ijiga et al. (2021) underscore the need for inclusive STEM education in sub-Saharan Africa's multilingual classrooms. They argue that conventional STEM models often marginalize learners by neglecting their linguistic and cultural realities. Their work advocates for culturally responsive teaching, the integration of indigenous knowledge systems, and comprehensive teacher training as essential strategies for bridging the gap between global STEM standards and local educational needs.

Sangwa et al. (2025) extended this discourse into the business and communication domain by exploring how AI and cultural intelligence can enhance communication between African and European business actors. They identify persistent cultural misalignments and propose a framework that combines digital fluency with cultural awareness to foster more effective and equitable cross-continental collaboration. Their findings underscore the importance of context-sensitive communication strategies in an increasingly AI-mediated global economy. From a community-centered perspective, Sunzuma et al. (2025) advocate for a STEAM approach that prioritizes equity, justice, and innovation. Their research promotes participatory education models that empower learners as community change agents. Integrating arts and social justice into STEM education, they argue, fosters critical thinking, creativity, and civic responsibility.

Chasokela (2025) reinforces the role of AI in African higher education by examining its integration in Zimbabwean universities. Her study demonstrates how AI tools are enhancing 21st century skills such as collaboration, problem-solving, and critical thinking. She also addresses challenges such as limited infrastructure and the need for faculty training, emphasizing that successful AI adoption must align with local institutional capacities and educational goals. Falebita and Kok (2024) provide a broader continental perspective through a systematic review of AI integration in STEM education across African higher education institutions. They identify strategic uses of AI for teaching, research, content generation, and administration. Their findings show that tools like ChatGPT are widely used for paraphrasing, grammar checking, and self-directed learning. They advocate for increased AI literacy and targeted research to close existing gaps and ensure that AI adoption supports Africa's SDGs.

Finally, Abisoye (2023) contributes to this growing body of knowledge by examining the intersection of AI, education, and African development. His work emphasizes the ethical and policy dimensions of AI integration, urging African institutions to develop frameworks that ensure the responsible and inclusive use of emerging technologies in education.

Together, these scholars present a unified vision: that Africa's educational and communicative transformation must be rooted in cultural relevance, technological innovation, and social equity. They call for reimagined systems that not only prepare learners for global competitiveness but also empower them to lead meaningful change within their own communities.

Collectively, these scholars advocate for an educational transformation that is culturally relevant,

technologically innovative, and socially equitable. Their insights offer a roadmap for integrating AI in ways that empower learners and align with Africa's developmental priorities.

## IMPLICATIONS FOR THE STUDY

These implications are grounded in the AI-TPACK and UTAUT frameworks. These models emphasize the integration of technology with PK and CK. They also highlight behavioral factors that influence technology adoption. The study highlights the importance of collaborative efforts among educators, policymakers, and institutional leaders. These efforts are crucial to ensure that AI integration in STEM education is both pedagogically sound and contextually relevant across African education systems. Educators need ongoing professional development. This training should help them use AI tools effectively. It must support differentiated instruction and culturally responsive pedagogy. Key areas of focus include AI literacy, instructional design, and ethical use of technology (Mfikoyi & Rabotapi, 2025; Nkwo et al., 2025). Policymakers should prioritize inclusive digital reforms. These reforms must expand broadband infrastructure, develop ethical governance frameworks, and safeguard data privacy.

Such measures are crucial for reducing digital inequality and promoting equitable access to AI-enhanced learning environments (Umoke et al., 2025; Eden et al., 2024).

## RECOMMENDATIONS

Based on this study, two recommendations are proposed. First, educational institutions in Africa should adopt curriculum design models informed by the AI-TPACK and UTAUT frameworks to guide the integration of AI in STEM education. This approach ensures that technological tools are aligned with pedagogical strategies and CK, promoting personalized, adaptive, and inclusive learning experiences (Ijiga et al., 2021; Mosoa & van der Westhuizen, 2025). Second, successful AI adoption requires investment in digital infrastructure, teacher training, and strategic collaboration with industry stakeholders. These efforts will enhance user confidence, address barriers to technology acceptance, and ensure that AI-enhanced curricula remain relevant to evolving workforce demands and educational goals (Falebita & Kok, 2024). These recommendations provide a strategic foundation for advancing AI integration in African STEM education, ensuring that technological innovation is both pedagogically sound and socially equitable.

## CONCLUSION

This paper explored how AI can be integrated into STEM curriculum design in Africa. The analysis was both critical and context-sensitive. AI offers many benefits: it can personalize learning, improve assessments, and support inclusive education. The study was guided by the AI-TPACK and UTAUT frameworks. These helped explain how AI tools can align with teaching goals and user behavior. However, successful integration requires more than just technology. It demands strong infrastructure, comprehensive teacher training, and ethical planning. Philosophy plays a key role in guiding this integration. Paulo Freire's ideas remind us that education should empower learners. African philosophies like *ubuntu* emphasize community, fairness, and shared growth. These values must inform the design and use of AI tools. A framework-based approach can help build AI-enhanced curricula that are both ethical and relevant. Future research should focus on real-world applications, long-term impact, and equitable access across diverse African educational settings.

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