Bibliometric Analysis of AI-Enhanced Education and Its Potential to Close Africa's Skills Gap: Towards an African AI Integration Model

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ABSTRACT

The paper offers a comprehensive literature review and bibliometric analysis of research on how AI-enhanced education can help close the skills gap in Africa. The review included 45 articles published between 2020 and 2026 and retrieved from Google Scholar, ERIC, SAGE, and Scopus. To identify important patterns, trends, and recurring themes in the literature, the selected papers were examined and analysed thematically, taking into account their publication year, country, title, and authors. The main findings show that many existing AI integration models originate from the Global North and may not sufficiently account for the educational requirements and contextual realities of the Global South. The paper also examines the extent to which AI-enhanced education is being adopted in Africa, highlighting the main obstacles to its successful implementation. These findings emphasise the need to develop AI integration models that account for Africa's distinct educational, technological, and economic circumstances. The findings confirm that Africa's journey requires a shift from theory-heavy frameworks towards a skills-based, AI-enhanced ecosystem. The study concludes by proposing an Africa-sensitive AI-enhanced education model, the AI-Enhanced Education Model for Africa, designed to help address the continent's skills gap. This model calls for a consultative approach and collaboration among governments, educators, learners, and industry.

INTRODUCTION

Artificial intelligence (AI) is creating new opportunities for education systems to improve teaching and learning, develop relevant competencies, and prepare learners for changing labour markets. AI integration in African education requires curriculum reform, teacher training, university–industry collaboration, and attention to ethical and contextual challenges (Ahmed et al., 2025). Thus, AI is not only digitalising the existing education system but also transforming what is learned, how it is learned, who can learn, and what learning leads to. It is changing graduate skills, employability, and forms of innovation.

The purpose of this analysis is to examine the available literature on AI-enhanced education, identify the main research trends and knowledge and skills gaps, and establish how AI can contribute to closing Africa's skills gap. The discussion concludes by proposing an African AI integration model that responds to the continent's educational, technological, economic, and social realities. African countries should avoid simply adopting or importing AI integration frameworks developed in the Global North. These frameworks should be critically evaluated, contextually adapted, and validated against Africa's diverse educational, cultural, linguistic, technological, and socioeconomic realities (Maina & Kuria, 2024).

The analysis brings together literature on AI adoption in African lower and higher education, AI readiness, digital and employability skills, personalised learning, teacher development, entrepreneurship, curriculum reform, infrastructure, and responsible AI. It also considers international policy literature where this helps explain the relationship between AI-enhanced education and workforce preparation. Therefore, the conceptualisation of the proposed framework was influenced by international frameworks and principles, particularly those developed under UNESCO's auspices. This approach is consistent with Martini et al. (2022), who demonstrate how global development priorities and international guidelines can inform the development of a roadmap while allowing for adaptation to specific contextual circumstances.

Bibliometric analysis systematically examines the quantitative characteristics and intellectual structure of a defined body of literature, including publication trends, author productivity, citation patterns, collaboration networks, and keyword co-occurrence (Donthu et al., 2021). It typically examines publication years, authors, countries, journals, citations, keywords, co-authorship, and thematic relationships. A thematic synthesis, by contrast, interprets what the studies report about educational practices, challenges, and solutions. Both approaches are valuable for this topic, but their findings should be reported separately.

The available article-extraction material contains useful study-level information and some review-level statistics. Some of these are presented in tables to show themes, publication years, and, in some cases, frequencies.

1.1. Background

Education plays a pivotal role in bringing about change, serving as a foundation for both national and individual empowerment. It plays a crucial role in enabling individuals to participate fully in economic growth and contribute to meaningful societal progress (Global Gender Gap Report, 2024). Beyond personal growth, education strengthens the quality of the workforce by equipping citizens with skills relevant to the global labour market. Nations with higher levels of literacy and educational attainment consistently demonstrate greater economic prosperity, innovation, and social development, highlighting the central role that education plays in shaping a country's future (Yulia et al., 2025). By developing critical thinking, technical competence, and informed citizenship, education acts not only as a tool for learning but also as a catalyst for economic development and scientific enquiry.

Education is widely recognised as a central driver of skills development and economic growth. Thus, education can help address unemployment if it is well aligned with technological changes (Sharma et al., 2024). Higher education institutions in Africa have a critical role in equipping students with work-ready skills, knowledge, and constructive attitudes that enhance their employability and contribute to economic development (Adewolu, 2024). When graduates possess relevant competencies, including technical, entrepreneurial, and cognitive skills, they are better able to fill workforce gaps, innovate, and support industries that are essential for sustainable development (Syafruddin et al., 2025). In this way, effective education not only enhances individual employability but also strengthens the quality of the workforce, which, in turn, boosts productivity and competitiveness in the global market, including in Africa.

Moreover, Mbithi et al. (2021) argue that education must not be static but responsive to evolving economic and societal demands if it is to remain relevant in the modern world. Static curricula often fail to match the evolving demands of industries, especially during a period characterised by digital transformation, climate change, and the needs of the Fourth Industrial Revolution (4IR). The authors suggest that higher education institutions should continually adapt their programmes, collaborate with industry, and create learning environments that encourage lifelong learning, innovation, and resilience among students. Such adaptability ensures that education remains a force for positive change, capable of closing skills gaps and driving long-term economic growth across Africa (Mbithi et al., 2021).

Africa's current education systems are not fully aligned with the skills demanded by rapidly changing labour markets, especially those influenced by the 4IR. Musuva (2026) argues that intermediate digital skills, alongside soft skills such as communication and problem-solving, are important for improving graduate employability in Africa. AI is reshaping nearly every sector, creating new opportunities as well as new skills requirements, ranging from data literacy to advanced analytical thinking (Babashahi et al., 2024). What remains unknown is how quickly African countries can adapt to new technologies and how best to integrate these technologies in ways that are affordable, inclusive, and context-appropriate. These uncertainties point to an urgent need to understand not only the types of skills that will matter in the next decade but also the most effective methods for integrating AI into education (Rane et al., 2023).

Chivige and Magidi (2026) highlight that workforce development in Africa requires education aligned with labour-market needs and emphasising digital technology and problem-solving competencies. To meet these new demands, education in Africa must be restructured into a more flexible, technology-aware, and future-focused

system (Foster et al., 2023). The type of graduate that Africa now needs is one who is adaptable, digitally fluent, entrepreneurial, and capable of critical and ethical decision-making. Such a graduate should not only possess technical knowledge but also demonstrate curiosity, collaboration, and the confidence to solve complex local and global challenges. Kayyali (2024) stresses that education must prioritise innovation, digital competence, and resilience, ensuring that learners are prepared for jobs that may not yet exist. This reimagined graduate profile is essential for Africa to thrive in a world defined by automation, innovation, and continuous transformation.

Although many studies show that AI can improve learning, there remains a major gap in understanding how African education systems can use AI in practical and effective ways to help close the continent's growing skills gap (Hlongwane et al., 2024). This gap matters because it affects science, academia, industry, and society as a whole. The integration of emerging technologies in education and university–industry collaboration can improve learning outcomes and increase graduate employability (Ahmed et al., 2025).

This study aims to identify a practical and context-appropriate framework for African schools and universities to use AI to improve learning and develop future-ready graduates. This is because Africa has been importing AI-enhanced education models from the Global North. Although these models may have produced positive results in the Global North, they may not be suitable for African contexts (Hultgren et al., 2025). This study focuses on identifying effective AI tools for low-resource settings, reforming curricula and redesigning teaching practices, and understanding how teachers can be trained to use AI confidently and effectively. The ultimate goal is to produce graduates who are employable in the 4IR, capable of innovating to help Africa move from being a consumer of AI to becoming a producer, and able to turn AI into enterprises.

1.2. Definition of key terms

- **Artificial Intelligence (AI)**
  AI refers to computer systems or machines that can perform tasks that normally require human intelligence, such as problem-solving, learning, decision-making, and pattern recognition.

- **AI-Enhanced Education**
  This refers to the use of AI tools and technologies to support teaching and learning.

- **Fourth Industrial Revolution (4IR)**
  4IR is the current period of technological change driven by innovations such as AI, robotics, automation, and big data. It is reshaping how people work, learn, and live.

- **Skills Gap**
  The skills gap is the mismatch between the skills that employers need and the skills that graduates or workers currently have.

- **Curriculum Reform**
  Curriculum reform refers to the process of updating or redesigning what is taught and how it is taught in schools and universities.

- **Adaptive Learning Tools**
  These are digital or AI-driven systems that adjust learning content and pace based on a student's performance, needs, or learning style.

- **Literature Review**
  A literature review is a structured examination of previous studies, books, reports, and academic articles on a particular topic. It helps identify trends, gaps, and insights from existing research.

- **Digital Skills**
  Digital skills include the ability to use digital tools, software, and technologies confidently and safely.

- **Problem-Solving Skills**
  These are abilities that help learners analyse situations, think critically, and find effective solutions. They are essential for success in modern workplaces.

- **African Context-Appropriate Model**
  This refers to a practical framework or approach that fits the unique needs, challenges, and realities of African education systems.

METHODOLOGICAL APPROACH TO THE BIBLIOMETRIC ANALYSIS

2.1 Aim and research questions

The bibliometric analysis should establish how research on AI-enhanced education and skills development has developed, which countries and research themes receive attention, and how the evidence can inform an African model for AI integration.

2.1.1. Objectives

1. To assess how AI tools can enhance teaching and learning processes within African education systems.

2. To identify AI-enhanced teaching and learning methods that develop the digital and problem-solving competencies required for the Fourth Industrial Revolution (4IR)

3. To identify the contextual factors and barriers influencing the integration of AI-enhanced education in Africa.

4. To develop a contextualised framework for integrating AI-enhanced education into African education systems to address 4IR skills.

2.2 Data sources and period

The information for this study was obtained from four academic databases and search platforms: Scopus, Google Scholar, ERIC (Education Resources Information Center), and SAGE Journals. These sources were selected because they provide access to scholarly literature on artificial intelligence (AI), education, skills development, and employability. Using multiple sources helped identify relevant studies examining the role of AI-enhanced education in addressing Africa's skills gap.

The literature search used combinations of the following keywords: "artificial intelligence" OR "AI-enhanced" AND "education" OR "higher education" AND "skills development" OR "skills gap". These terms were selected to identify studies focusing on AI applications in education, skills development, and the relationship between education and labour-market needs. The search focused on literature published between 2020 and 2026.

A systematic search method was used to identify relevant publications. The search terms were applied across the selected databases and platforms, and the retrieved records were screened for relevance to the study's objectives. Duplicate records were identified and removed, after which titles and abstracts were assessed against the inclusion criteria. The full texts of potentially relevant studies were then examined to determine their eligibility for inclusion in the review. This process helped ensure that the final selection of literature was relevant to understanding the opportunities and challenges of AI-enhanced education in addressing Africa's skills gap.

2.3. Eligibility criteria

The eligibility criteria for selecting studies were established based on their relevance to the systematic literature review, which examines how AI-enhanced education can help close Africa's skills gap for the Fourth Industrial Revolution (4IR). The inclusion criteria covered peer-reviewed journal and conference articles, official policy documents, published systematic reviews, and peer-reviewed doctoral theses relevant to AI in skills development.

These publications had to be published between 2020 and 2026, written in English, and focus on artificial intelligence in education, digital skills development, 4IR competencies, employability, and workforce preparedness in Africa. Studies examining AI-supported teaching and learning, personalised learning, technical and vocational education, curriculum innovation, and the alignment of educational outcomes with emerging labour-market demands were also considered. Research addressing the opportunities and challenges of adopting AI-enhanced education in African educational institutions was included.

The exclusion criteria comprised duplicate publications, studies for which full texts were inaccessible, non-academic sources lacking credible evidence, and publications unrelated to AI-enhanced education or skills development for the 4IR. Studies focusing exclusively on contexts outside Africa, without providing relevant comparative insights applicable to African countries, were excluded. Publications that lacked sufficient methodological detail, clear findings, or relevance to the research objectives were also omitted. These criteria were applied to maintain the relevance, credibility, and quality of the evidence included in the review while ensuring that the selected literature provided meaningful insights into the potential of AI-enhanced education to address Africa's 4IR skills gap.

Criterion	Inclusion	Exclusion
Geographic focus	Studies addressing African countries or Africa or global	Studies with no African relevance
Topic	AI-enhanced education and skills	AI studies not related to education or skills
Publication	Peer reviewed research articles	Editorial, opinions pieces and non-scholarly materials
Period	2016-2026	Outside the specified period
Language	English or translated into English	Languages not understood by the researcher.
Evidence	Empirical, theoretical or review studies	Studies lacking sufficient information for analysis.

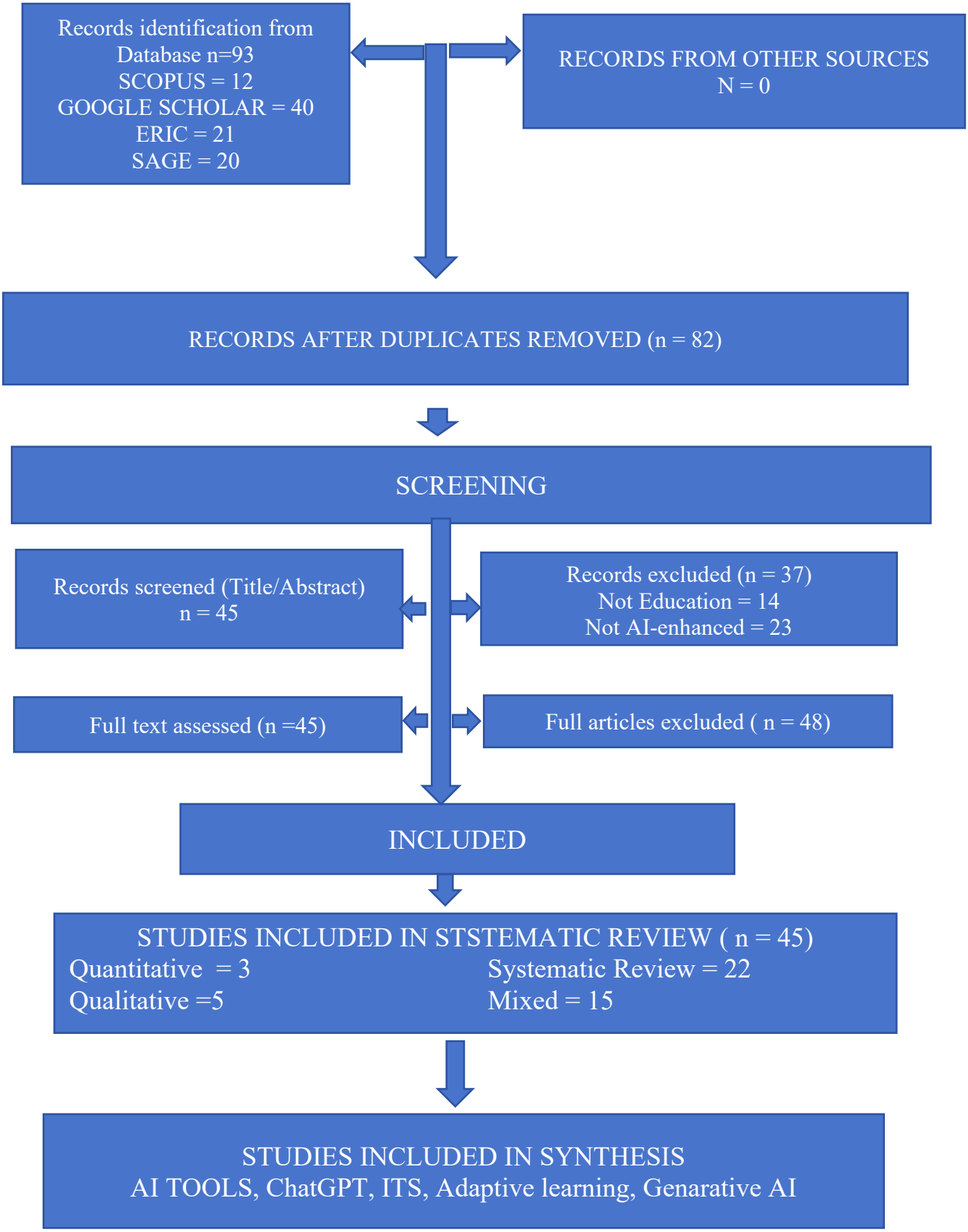
2.4. Overall Characteristics of the Evidence Base

The evidence base for this systematic literature review comprises peer-reviewed journal articles, peer reviewed conference papers and official policy documents retrieved from Scopus, Google Scholar, ERIC, and SAGE Journals. The literature focuses on the role of AI-enhanced education in developing the skills required for the 4IR in Africa. Key themes include AI integration in teaching and learning, digital literacy, critical thinking, problem-solving, technical and vocational skills, personalised learning, and the alignment of educational programmes with evolving labour-market demands. The evidence also explores the opportunities presented by AI technologies to widen access to education, improve learning outcomes, and support the development of a skilled workforce capable of participating in Africa's digital economy.

Overall, the evidence suggests that AI-enhanced education has the potential to contribute to closing Africa's 4IR skills gap by facilitating personalised learning, strengthening digital competencies, and improving access to relevant, industry-oriented training (Mutambara, 2024). However, the extent to which these benefits can be realised depends on factors such as digital infrastructure, internet connectivity, access to AI tools, educator preparedness, curriculum relevance, and institutional capacity (Mhlanga, 2024). The literature also highlights challenges relating to inequalities in access to technology, affordability, ethical AI use, and the digital divide between and within African countries (UNESCO, 2025). Nevertheless, the strength and applicability of the evidence may vary according to the research designs, geographical coverage, and contexts of the studies reviewed. This systematic review therefore examines both the potential contributions and limitations of AI-enhanced education to identify evidence-based strategies for addressing Africa's 4IR skills gap.

2.5. Study selection process

The diagram below shows the identification procedures that were followed in this study.



A total of 93 articles were identified through systematic searches of 4 major electronic databases such as Google Scholar (40 articles), SAGE (20 articles), ERIC (21 articles), and Scopus (12 articles). The selection process was guided by pre-defined search criteria designed to identify literature relevant to the intersection of AI, education, skills development, and employability within the African context. The search terms included combinations of

the following concepts: AI in education or AI-enhanced education; education models; skills gap, skills, or employability; and Africa, African countries, or African regions. These terms were used to capture studies examining the role of AI in educational settings and its potential contribution to addressing skills gaps and improving employability in Africa.

The articles considered for inclusion were assessed against the established search criteria to determine their relevance to the study's research objectives. Studies were considered eligible if they addressed AI in education or AI-enhanced education, particularly in relation to educational models, skills development, skills gaps, or employability, and had a relevant geographical focus on Africa, an African country, or an African region. Articles that aligned with these thematic and geographical criteria were selected for further consideration in the review. This approach ensured that the literature selection remained focused on the relationship between AI, education, and labour-market skills within the African context.

2.6. Data collection process

Data extraction was conducted systematically for each of the 45 articles included in the review by the creation of extracted tables. Two reviewers extract information using extraction tables to create uniformity. Two reviewers were used to eliminate bias. Disagreements were resolved through discussions and in some complicated situations, a third part was requested to verify on the point of disagreement.. Key information was recorded, including authors, publication year, study objectives, geographical context, research methodology, and major findings. Particular attention was given to evidence on AI-enhanced education, 4IR skills development, employability, and workforce preparedness in Africa.

The information extracted from each article was entered into a structured data extraction table to ensure consistency and facilitate comparison. Relevant findings on the benefits, challenges, and recommendations associated with AI-enhanced education were recorded for each study. The methodological quality and relevance of the articles were also considered during the extraction process.

After data had been extracted from all 45 articles, the information was combined and compared to identify recurring patterns, similarities, differences, and gaps in the literature. The findings were then grouped into common themes, such as digital skills development, personalised learning, teacher preparedness, technological infrastructure, and employability. This thematic synthesis provided an overall understanding of how AI-enhanced education can contribute to closing Africa's 4IR skills gap.

2.7. Data Items

The data items extracted from the 45 articles included in the systematic review, titled *AI in Education for Addressing the 4IR Skills Gap in Africa: A Systematic Review and Contextualised Framework*, were organised into key categories to ensure comprehensive and consistent analysis. The first category captured the bibliographic characteristics of each article, including author names, publication year, article title, journal, country of study, and source database. These details helped establish publication trends, geographical distribution, and the development of research on AI-enhanced education and 4IR skills development in Africa.

The second category focused on study characteristics and methodological information. Data were collected on the objectives, research questions, study design, data collection methods, sample characteristics, and analytical approaches used in the selected articles. This information supported an assessment of the methodological quality and reliability of the evidence and helped identify whether the findings were based on empirical research, theoretical analysis, or literature reviews.

The third category examined the types and applications of artificial intelligence in education. Information was extracted on AI technologies, including generative AI, intelligent tutoring systems, adaptive learning platforms, automated assessment, and learning analytics, where reported. The review also recorded how these technologies were applied in educational settings, including universities, technical and vocational education and training institutions, schools, and professional development programmes. The outcomes of interest included improved access to learning, personalised instruction, student engagement, and the development of practical competencies.

The fourth category addressed 4IR skills and educational outcomes. Data were extracted on the specific competencies discussed in each article, including digital literacy, data analysis, coding, robotics, artificial intelligence literacy, critical thinking, creativity, problem-solving, and adaptability. Particular attention was given to reported outcomes relating to skills acquisition, learner performance, graduate employability, entrepreneurship, and preparedness for technology-driven workplaces. Where available, evidence of measurable improvements was distinguished from authors' perceptions, expectations, or proposed benefits.

The fifth category captured the contextual factors, barriers, and enabling conditions influencing the adoption of AI-enhanced education in Africa. These included digital infrastructure, internet connectivity, electricity access, the affordability of AI tools, educator preparedness, curriculum relevance, institutional capacity, government policies, and partnerships between educational institutions and industry. Ethical considerations, data privacy, algorithmic bias, language diversity, and inequalities in access to technology were also recorded. These data items helped establish the contextual challenges that may influence the effectiveness and equitable implementation of AI-enhanced education across different African countries.

The sixth category focused on implementation strategies, recommendations, and framework components relevant to addressing the 4IR skills gap. Information was extracted on proposed interventions, policy recommendations, curriculum reforms, teacher training, industry collaboration, and strategies for improving access to AI-enabled learning. Findings from all 45 articles were compared and synthesised to identify recurring themes, convergent findings, contradictory evidence, and research gaps. The resulting synthesis informed the development of a contextualised framework outlining how AI-enhanced education could contribute to closing Africa's 4IR skills gap while accounting for the continent's diverse educational, technological, economic, and institutional conditions.

2.8. Risk Management

Several risks were encountered during data collection for the systematic literature review on AI in education and the 4IR skills gap in Africa. The first was inconsistency and missing data, as some articles did not clearly report essential information, such as authors' names, sample sizes, research methodologies, or AI tools used. This risk was addressed by using a standardised data extraction form to ensure consistent recording of information across all 45 articles. The second risk was reviewer bias, which could arise from misinterpreting study findings or applying inclusion criteria inconsistently. To minimise this risk, two reviewers independently assessed and extracted data, while a third reviewer helped resolve disagreements. Inter-rater reliability was assessed using Cohen's kappa to measure the level of agreement between reviewers.

The third risk was publication bias and the over-representation of certain sources, as some databases or research contexts may be more heavily represented than others, potentially limiting the diversity of the evidence. This was addressed by searching multiple databases and platforms, including Scopus, Google Scholar, ERIC, and SAGE Journals. The fourth risk was the loss of contextual meaning during synthesis, whereby combining findings from different African countries could obscure country-specific differences in infrastructure, educational systems, policy environments, and access to AI technologies. To address this, the country and institutional context of each study was retained throughout data extraction and thematic analysis, allowing the findings to be interpreted within their specific settings.

The fifth risk was duplication and double counting, which could occur when the same study appeared in multiple databases or was published in different journals, potentially inflating the evidence supporting particular findings. This risk was managed by checking article titles, author names, and Digital Object Identifiers (DOIs) to identify and remove duplicate records before finalising the included studies. Collectively, these measures strengthened the consistency, transparency, and credibility of the review process. They also helped ensure that the synthesis of the 45 articles provided a more balanced and context-sensitive understanding of how AI-enhanced education could contribute to addressing Africa's 4IR skills gap.

2.9. Synthesis Methods and Development of the Contextualised Framework

The systematic literature review employed a thematic synthesis approach to organise, compare, and interpret findings from the 45 selected articles on artificial intelligence in education for addressing the 4IR skills gap in

Africa. Thematic synthesis is a method for identifying and synthesising recurrent themes across primary studies to develop higher-order analytical themes that inform new conceptual models (Lui & Jerosch-Herold, 2024). The extracted data were organised into a standardised table covering study characteristics, AI technologies, educational applications, 4IR skills, reported outcomes, implementation barriers, and recommendations.

The findings were coded to identify recurring concepts, and similar codes were grouped into broader themes, such as personalised learning, digital skills development, teacher preparedness, employability, and educational technology infrastructure. This process enabled the identification of common patterns, emerging issues, and gaps in the existing literature.

The second stage involved descriptive and comparative analysis to examine similarities and differences across the included studies. Findings were compared according to geographical context, educational level, AI application, and the types of 4IR skills addressed. Where sufficient data were available, descriptive summaries were used to establish the distribution of studies by publication year, country, and research topic. The analysis also examined reported benefits, limitations, and contextual differences affecting the implementation of AI-enhanced education across African countries. Contradictory findings and variations in the strength of the evidence were documented to ensure that the conclusions reflected the diversity of the reviewed studies (Higgins et al., 2023).

Finally, the findings were integrated to develop a contextualised conceptual framework explaining how AI-enhanced education could contribute to closing Africa's 4IR skills gap. Framework development followed a structured process. First, the major themes emerging from the synthesis were identified. Second, relationships between AI technologies, educational interventions, enabling conditions, and skills outcomes were examined. Third, relevant contextual factors, including digital infrastructure, educator competencies, curriculum relevance, institutional capacity, government policy, and industry partnerships, were incorporated. These elements were then organised into interconnected framework components linking AI-enhanced educational inputs and interventions to skills development outcomes, with contextual factors influencing the effectiveness of implementation. Finally, the proposed framework was refined by checking its components against the evidence from the 45 articles to ensure that its relationships and recommendations were grounded in the reviewed literature. The resulting framework is intended to guide policymakers, educational institutions, and industry stakeholders in designing context-sensitive strategies for strengthening digital competencies, employability, and workforce readiness for the Fourth Industrial Revolution in Africa.

DESCRIPTIVE BIBLIOMETRIC FINDINGS

3.1 Publication growth and research development

The available literature indicates increasing research attention to AI in African education, particularly in publications from 2024 onwards. Recent studies examine AI adoption, institutional preparedness, personalised learning, educator competencies, entrepreneurship, and the relationship between education and employment.

This is shown in the table below:

Table 4.1. Publications mentioned in the document

Original No.	Authors	Research title	Year	Country or geographical scope
1	Ahmed et al.	Half a decade of artificial intelligence in education in Africa: Trends, opportunities, challenges and future directions	2025	Africa
2	Hlongwane et al.	Towards the integration of artificial intelligence in higher education, challenges and opportunities: The African context, a case of Zimbabwe	2024	Zimbabwe
3	Maina & Kuria	Building an AI future: Research and policy directions for Africa's higher education	2024	Africa

4	Opesemowo & Adekomaya	Harnessing artificial intelligence for advancing sustainable development goals in South Africa's higher education system: A qualitative study	2024	South Africa
5	Sey & Mudongo	Case studies on AI skills capacity-building and AI in workforce development in Africa	2021	Ghana and South Africa
6	Mukandayisenga et al.	Artificial intelligence in medical imaging: Utilization, challenges, and practitioner perceptions in Rwanda	2026	Rwanda
7	Naphiyo et al.	From awareness to readiness: A systematic review of AI readiness in Sub-Saharan African higher education and its implications for entrepreneurship	2026	Sub-Saharan Africa
8	Soko et al.	Gender differences in awareness and preparedness for the use of artificial intelligence (AI) in higher education institutions across Sub-Saharan Africa: A comparative analysis	2026	Kenya, Malawi, Nigeria and Uganda
9	Chasokela	Integrating artificial intelligence in STEM education: Enhancing 21st century skills in Zimbabwean universities	2025	Zimbabwe
10	Dumbuya	Decolonizing African curricula through AI-enhanced pedagogy: Reclaiming indigenous knowledge and future skills in postcolonial education systems	2025	Africa; Sierra Leone associated with the article
11	Jaya et al.	Bridging educational gaps in low-resource classrooms: AI-enhanced project-based learning for STEM educators in Africa	2026	Nigeria, Botswana, Ghana, Namibia and Sierra Leone
12	Shaban et al.	Potential of AI-driven virtual learning environments in African higher education institutions	2025	Africa
13	Mthethwa et al.	The nexus of artificial intelligence (AI) and entrepreneurship in higher education skills development: A review	2025	South Africa; broader literature
14	Khoza & Van Der Walt	A systematic review on AI-enhanced pedagogies in higher education in the Global South	2025	Global South
15	Falebita & Kok	Strategic goals for artificial intelligence integration among STEM academics and undergraduates in African higher education: A systematic review	2024	Africa
16	Maluleke	AI adoption in African higher education: A systematic review of benefits and ethical implications	2025	Africa
17	Oguntona & Emere	Mapping the landscape of artificial intelligence in teaching and learning across African higher education	2025	Africa
18	Pasipamire et al.	Exploring the use and impact of artificial intelligence in higher education in Africa	2025	Africa
19	Nzama & Nkomo	A bibliometric analysis of artificial intelligence in personalised learning: Global trends, research gaps, and implications for African education	2026	Global literature; implications for Africa
20	Mutambara	Artificial Intelligence: A Driver of Inclusive Development and Shared Prosperity for the Global South	2025	Global South

21	Mutambara	How to Make Africa Ready for Artificial Intelligence	2024	Africa
22	Mutambara	Can Artificial Intelligence Be the Solution to Challenges Bedeviling the Global South? Yes, and Here is How	2025	Global South
23	Mutambara	Deploying Artificial Intelligence to Achieve the UN Sustainable Development Goals: Enablers, Drivers and Strategic Framework	2025	Global/international
24	Sangwa & Mutabazi	Artificial Intelligence and Rwanda's Economic Transformation: A Strategic Policy Review of Sectoral Readiness, Challenges, and Opportunities	2025	Rwanda
25	Abbasi et al.	Exploring the impact of artificial intelligence on curriculum development in global higher education institutions	2025	Global/international
26	Acquah et al.	Preservice teachers' artificial intelligence competence: A network and latent profile analyses	2026	Ghana
27	Goto & Ramnarain	Does culture matter in AI adoption? A predictive analysis of cultural dimensions, social influence, and personal innovativeness in the modified UTAUT model	2026	South Africa
28	Kafilongo & Zuva	Teacher-AI-student relationships in student-centered learning: A systematic review	2026	Global; emphasis on Africa
29	Mnguni	A qualitative analysis of South African pre-service life sciences teachers' behavioral intentions for integrating AI in teaching	2025	South Africa
30	Morgado et al.	Technology-mediated education: Impact of AI on the main distance learning modalities	2025	Portugal, Brazil and Angola
31	Olaifa et al.	Bridging the AI divide in high school STEM education in developing countries to advance equity and innovation	2026	Developing countries in Africa and Asia; examples include South Africa, Kenya, Cameroon, Benin, DRC, Ghana and Nigeria
32	Chaturvedi & Biswas	Workforce transformation in the age of AI: A review of AI receptionist systems and organizational impacts in SMEs	2026	Global/international
33	Linda & Li	The impact of AI technology on the green development of manufacturing enterprises in Ghana	2025	Ghana
34	Geberetsadike	Comprehensive talent development framework for a future-ready workforce in the age of AI: Upskilling and reskilling as strategy	2026	Country not specified; government organization case study
35	Tang et al.	"Chinese + vocational skills" education in East Africa: Evolution of pathways, challenge insights and future outlook	2025	East Africa: Kenya, Ethiopia, Tanzania, Rwanda, Uganda and Djibouti
36	Mukhatayeva	The impact of AI exposure on job insecurity, employee morale, and the moderating role of emotional intelligence	2025	Country not specified; international scope unverified
37	Bamia & Bamia	Sustainable digital exports from China to Africa based on innovation and predictive analytic to improve supply chain efficiency	2025	China and Africa; AI relevance needs full-text confirmation
38	OECD	OECD Digital Education Outlook 2026: Exploring Effective Uses of Generative AI in Education	2026	global
39	Magadza, I.	Integrating curriculum reform, faculty	2026	South Africa

		development, and graduate employability in South Africa's higher education: A qualitative study in the Fourth Industrial Revolution		
40	Mateko, F. M	Opportunities in emerging technologies for Southern Africa: How the Global South should adopt to take advantage?	2024	Southern Africa
41	Miao, F., & Cukurova, M.	AI competency framework for teachers	2024	Global
42	Musuva, P.	Digital skills for youth employment in Africa: A systematic review	2026	Sub-Saharan Africa
43	Ngao, A. I., Boreka, A. B., & Peters, M. A.	A systematic scoping review of transformative potential and contextual challenges of integrating AI and collective intelligence in African higher education	2026	Africa
44	Fraiese, S.	Strategic horizons of AI in education: A comparative analysis of Morocco and Egypt	2025	Morocco and Egypt
45	Abellaoui, S. & Nait, B, Y.	Teachers' training in the age of AI: Moral, social and educational dimensions in using artificial intelligence in training in the Moroccan context.	2026	Morocco and North Africa

Several publications are particularly relevant to the development of AI-enhanced skills for the 4IR. Ahmed et al. (2025) examined trends, opportunities, challenges, and future directions in AI in African education by reviewing 22 articles published between 2017 and 2022. Hlongwane et al. (2024) investigated the challenges and opportunities associated with AI integration in higher education, focusing empirically on Zimbabwe. Maluleke (2025) reviewed AI adoption in African higher education using 113 articles from Web of Science and Scopus covering the period from 2020 to 2024. Pasipamire et al. (2025) examined AI use and its impact on African higher education, reporting that 1,521 records were identified across four sources and 63 studies were retained for review. Naphiyo et al. (2026) synthesised 63 peer-reviewed studies on AI readiness in sub-Saharan African higher education, covering the period from 2020 to 2025.

The evidence suggests a developing research agenda that moves beyond general discussions of AI adoption towards questions of readiness, competencies, curriculum integration, governance, and employment outcomes. Thus, there is a drive toward producing graduates who possess both AI skills embedded in real time competencies. These are the skills needed to drive African economies through the 4IR. Only one article was published outside the 2024–2026 period, indicating that 97.8% of the publications appeared between 2024 and 2026. This recent concentration suggests that the literature reflects current developments in AI-enhanced education and provides timely insights into the opportunities and challenges facing African education systems.

3.2 Geographical distribution of the articles

Table 3.1.2. Distribution of articles by region/geographical scope

Region / geographical scope	**Article number(s)**	**Article frequency**	**Percentage frequency**
Southern Africa	2, 4, 5, 9, 11, 13, 27, 29, 30, 31, 33, 39, 40	13	28.90%
East Africa	6, 8, 24, 31, 35	5	11.10%
West Africa	5, 8, 10, 11, 26, 31, 33	7	15.60%
North Africa	44, 45	2	4.40%
Central Africa	31	1	2.20%

Africa-wide / continental scope	1, 3, 10, 12, 15, 16, 17, 18, 21, 43	10	22.20%
Sub-Saharan Africa (regional scope not further specified)	7, 42	2	4.40%
Global / Global South / international or other scope	14, 19, 20, 22, 23, 25, 28, 32, 34, 36, 38, 41	12	26.70%

The findings show that Southern Africa had the highest representation, with 13 articles (28.9%), followed by West Africa, with 7 articles (15.6%), and East Africa, with 5 articles (11.1%). North Africa accounted for 2 articles (4.4%), while Central Africa had the lowest representation, with 1 article (2.2%).

These findings indicate an uneven geographical distribution of research on AI-enhanced education and skills development across Africa. Southern and West Africa received greater research attention, while Central and North Africa were less represented. This highlights the need for further research in underrepresented regions to support the development of context-specific AI-enhanced education models across the continent.

Table 3.1.3. Country entries across the articles

Country	Entries of article	Total
Angola	30	1
Benin	31	1
Botswana	11	1
Brazil	30	1
Cameroon	31	1
China	37	1
Democratic Republic of the Congo (DRC)	31	1
Djibouti	35	1
Egypt	44	1
Ethiopia	35	1
Ghana	5, 11, 26, 31, 33	5
Kenya	8, 31, 35	3
Malawi	8	1
Morocco	44, 45	2
Namibia	11	1
Nigeria	8, 11, 31	3
Portugal	30	1
Rwanda	6, 24, 35	3
Sierra Leone	10, 11	2
South Africa	4, 5, 13, 27, 29, 31, 33, 39	8
Tanzania	35	1
Uganda	8, 35	2
Zimbabwe	2, 9	2

The country-level distribution shows that South Africa had the highest representation, appearing in eight article entries. Ghana followed with five entries, while Kenya, Nigeria, and Rwanda each appeared in three entries. Morocco, Sierra Leone, Tanzania, and Zimbabwe were also represented, although to varying degrees. Uganda appeared in two entries, while several other countries, including Angola, Benin, Botswana, Cameroon, the Democratic Republic of the Congo, Djibouti, Egypt, Ethiopia, Malawi, Namibia, and Portugal, appeared once each. These findings suggest that the selected literature covers a range of African countries, but representation is uneven. South Africa and Ghana are particularly prominent in the dataset, whereas many other countries appear less frequently.

The country-level findings suggest that the literature provides insights into AI-enhanced education, digital skills, and workforce development across diverse African settings, but the evidence is not distributed equally across countries. The relatively high representation of South Africa and Ghana may indicate greater visibility of research from these contexts within the selected articles. However, the counts should not be interpreted as a direct measure of the actual level of AI adoption or research activity in each country, as they reflect only the articles included in this review. Furthermore, some articles cover several countries, meaning that a single article may contribute entries for more than one country. The findings therefore point to the need for further context-specific research, particularly in countries that appear less frequently, to support the development of an AI-enhanced education model that responds to the diverse infrastructural, educational, linguistic, and labour-market conditions across Africa.

3.3 Publication outlets and disciplinary coverage

Publication characteristic	Number of records
Total records listed	45
Records published in 2021	1
Records published in 2024	6
Records published in 2025	22
Records published in 2026	16
Total	45

Of the published articles, eight are systematic literature reviews, while one is a bibliometric analysis. This means that, among the 45 articles included in the review, eight (17.8%) are systematic literature reviews and one (2.2%) is a bibliometric analysis. Together, these account for nine articles (20%) of the sample, while the remaining 36 articles (80%) use other research approaches or document types that need to be classified.

The identified literature spans educational technology, higher education, STEM education, educational policy, entrepreneurship, digital development, and workforce preparation. These articles were published in outlets including Discover Education, Interdisciplinary Journal of Education Research, Journal of Engineering Education Transformations, Journal of Pedagogical Sociology and Psychology, International Journal of Learning, Teaching and Educational Research, Cogent Education, and Asian Journal of Distance Education.

The diversity of publication outlets reflects the interdisciplinary nature of the topic. AI-enhanced education is not simply a matter of introducing software into classrooms. It concerns how learners develop competencies, how educators redesign pedagogical practices, how institutions prepare for technological change, and how educational qualifications align with employment needs (UNESCO, 2024).

1. Thematic bibliometric synthesis: What does the literature say?

The substantial topics that link AI-enhanced education to reducing Africa's skills gap are examined in the next phase. The suggested model is based on these themes.

1.1 Major research themes

Theme No.	Theme	Article number	Frequency	Percentage
1	AI literacy and future-ready digital skills	5, 9, 15, 31, 34, 41, 42	7	15.6%
2	Curriculum transformation and pedagogical innovation	9, 10, 11, 14, 15, 25, 39	7	15.6%
3	Teacher capacity-building and AI readiness	2, 7, 15, 26, 29, 41, 45	7	15.6%
4	Graduate employability and labor-market alignment	5, 13, 32, 34, 35, 39, 42	7	15.6%
5	Personalized, flexible, and technology-enabled learning	1, 11, 12, 17, 18, 19, 30	7	15.6%

6	Equity, inclusion, and bridging the digital divide	8, 11, 16, 20, 22, 31, 43	7	15.6%
7	Entrepreneurship, innovation, and job creation	5, 7, 13, 20, 24, 40	6	13.3%
8	Policy, infrastructure, and institutional readiness	1, 2, 3, 7, 21, 24, 43, 44	8	17.8%
9	Ethical, culturally responsive, and context-sensitive AI	10, 16, 20, 27, 28, 38, 43	7	15.6%

Theme 1: AI Literacy and Future-Ready Digital Skills

The first theme concerns the development of AI literacy, digital competencies, and future-ready skills among African learners. The reviewed articles suggest that AI-enhanced education provides opportunities to prepare students for a labour market increasingly influenced by emerging technologies. Chasokela (2025), in the study Integrating *Artificial Intelligence in STEM Education: Enhancing 21st Century Skills in Zimbabwean Universities,* focuses on the relationship between AI integration and the development of twenty-first-century skills in higher education. Similarly, Musuva (2026) examines digital skills development in relation to youth employment in Sub-Saharan Africa. These studies identify the importance of equipping learners with relevant technological competencies. Therefore, AI literacy should extend beyond the ability to use AI tools. It should also include critical thinking, problem-solving, digital communication, and responsible technology use (Chasokela, 2025).. Such competencies are important for preparing African graduates to participate in these ever-changing employment opportunities.

Theme 2: Curriculum Transformation and Pedagogical Innovation

AI literacy should encompass critical thinking, problem-solving, digital communication, and the responsible use of AI technologies (Miao & Cukurova, 2024). Abbasi et al. (2025), in their study on the impact of AI technology on curriculum development in global higher education institutions, provide a relevant framework for examining how AI may influence curriculum design. Jaya et al. (2026) also focus on AI-enhanced project-based learning for STEM educators in African countries. These studies point to the potential of integrating emerging technologies such as AI into teaching and learning. Curriculum transformation is particularly relevant to Africa's skills gap because learners need competencies that reflect changing workplace demands. Integrating AI into curricula could enhance practical learning, foster innovation, and bridge the gap between theoretical knowledge and real-world problem-solving (Abbasi et al., 2025). However, the extent to which these approaches improve learning outcomes must be established from the studies' reported findings.

Theme 3: Teacher Capacity-Building and AI Readiness

The third theme addresses the preparedness of instructors and lecturers to integrate AI into educational practice. Educators play a pivotal role in translating technological innovations into meaningful learning experiences. Miao and Cukurova (2024), in their *AI Competency Framework for Teachers,* provide a relevant reference for understanding the competencies educators require to use AI effectively. AI proficiency among Ghanaian preservice teachers is also examined by Acquah et al. (2026). The significance of teacher preparation in AI-enhanced education is highlighted by these studies. Teachers require more than just technical proficiency with digital technologies. They also call for critical thinking, educational expertise, and an awareness of the moral ramifications of using AI. Increasing teacher capacity could help students in Africa develop their professional and digital skills.Without adequate teacher training and professional development, AI integration in education may remain limited and fail to improve learners' competencies and employability (UNESCO, 2024).

Theme 4: Graduate Employability and Labour-Market Alignment

The fourth theme focuses on the relationship between educational outcomes, graduate employability, and labor-market requirements. Africa's skills gap partly reflects the problem of ensuring that graduates possess abilities appropriate to present and emerging career opportunities. In the study on curriculum change, faculty development, and graduate employability in South Africa's higher education system, Magadza (2026) makes a clear connection between graduate employment and educational reform. Sey and Mudongo (2021) also examine AI skills capacity-building and workforce development in Ghana and South Africa. These studies provide a basis

for examining how AI-related training can strengthen the relationship between education and work. AI-integrated education can help address this challenge by aligning curricula with industry needs, providing hands-on learning experiences, and equipping learners with transferable competencies that respond to evolving labour-market requirements (OECD, 2026). Greater alignment between educational programmes and employer requirements could help reduce skills mismatches. Nevertheless, the contribution of AI to actual employment outcomes requires evidence beyond the adoption of AI technologies in educational institutions.

Theme 5: Personalised, Flexible, and Technology-Enabled Learning

The fifth theme highlights the importance of ensuring that AI-enhanced education benefits learners from different social, economic, and geographical backgrounds. Although AI can create new learning opportunities, unequal access to technology may widen existing educational inequalities. Olaifa et al. (2026) examine the AI divide in high-school STEM education in developing countries, linking AI integration with equity and innovation. Similarly, Soko et al. (2026) investigate gender differences in AI awareness and preparedness in higher education institutions in Kenya, Malawi, Nigeria, and Uganda.

These studies highlight the need to consider equity when using AI to support skills development. AI-enhanced education should promote equity and inclusion by addressing unequal access to technology and ensuring that learners from different social, economic, and geographical backgrounds can benefit from AI-supported learning (UNESCO, 2024). Addressing these barriers is essential to ensure that AI-enhanced education helps reduce rather than widen Africa's skills gap. Inclusive implementation should therefore consider gender, socioeconomic background, geographical location, and differences in institutional resources.

Theme 6: Entrepreneurship, Innovation, and Job Creation

The sixth theme highlights the potential relationship between AI-enhanced education, entrepreneurship, and economic opportunity. Beyond preparing students for existing jobs, education can help learners develop the competencies required to establish businesses and create employment. Mthethwa et al. (2025), in their review of the relationship between AI and entrepreneurship in higher education skills development, establish a direct connection between these areas. Naphiyo et al. (2026) also examine AI readiness in Sub-Saharan African higher education and its implications for entrepreneurship. These studies suggest that AI-related competencies are relevant to entrepreneurial learning and innovation.

Through appropriate educational approaches, learners may develop skills in identifying business opportunities, solving problems, and applying technology to products and services. This is particularly important in African economies where formal employment opportunities may not meet the needs of a growing workforce. However, turning entrepreneurial skills into viable businesses also requires access to finance, mentorship, infrastructure, and a supportive business environment (World Bank, 2025).

Theme 7: Entrepreneurship, innovation, and job creation

Mutambara (2024) argues that while AI may displace some existing jobs, strategic investment in AI, education, innovation, entrepreneurship, and reskilling can generate new employment opportunities and promote inclusive economic growth. Conversely, failure to adopt AI may hinder Africa's competitiveness and participation in emerging digital economies. Graduates who possess the abilities necessary to use and develop with AI don't have to wait for employment; instead, they can start their own businesses. Universities must include AI into their curricula as applied AI rather than merely as an informational tool.

Theme 8: Policy, Infrastructure, and Institutional Readiness

The eighth theme concerns the institutional and policy conditions required for successful AI integration in African education. AI-enhanced education requires more than access to software. It also depends on reliable digital infrastructure, institutional leadership, adequate funding, relevant policies, and the capacity to implement AI effectively (OECD, 2026). Ahmed et al. (2025), in their study Half a Decade of Artificial Intelligence in

Education in Africa: Trends, Opportunities, Challenges and Future Directions, provide a continent-wide perspective on the development of AI in education and the challenges associated with its integration.

Maina and Kuria (2024) also address research and policy directions for AI in Africa's higher education sector. These studies are relevant to understanding the conditions under which AI-related educational initiatives can be implemented and sustained. Limited infrastructure and inconsistent institutional preparedness may restrict the adoption of AI tools, particularly in under-resourced institutions. Effective policies should therefore support infrastructure development, educator training, responsible AI use, and collaboration among educational institutions, governments, and industry (UNESCO, 2024). Such measures could create a stronger foundation for skills development at scale.

Theme 9: Ethical, Culturally Responsive, and Context-Sensitive AI

The ninth and final theme focuses on the ethical and contextual dimensions of AI-enhanced education. AI integration raises questions about data privacy, bias, academic integrity, accountability, and the relevance of educational technologies to local contexts (Maleki, 2026). Dumbuya (2025), in the study Decolonizing African Curricula Through AI-Enhanced Pedagogy: Reclaiming Indigenous Knowledge and Future Skills in Postcolonial Education Systems, foregrounds the relationship between AI-enhanced pedagogy, indigenous knowledge, and future skills. Maluleke (2025) also examines the benefits and ethical implications of AI adoption in African higher education.

These studies provide a basis for considering how AI can be integrated without overlooking African knowledge systems, cultural diversity, and local educational priorities. Ethical and context-sensitive implementation is important because technologies developed elsewhere may not automatically address Africa's diverse learning needs (Ondiba & Kprop, 2026). Educational institutions should therefore promote responsible AI use while ensuring that AI-supported curricula remain culturally relevant and inclusive (UNESCO, 2023). UNESCO emphasises ethical and human-centred AI use, inclusion, equity, and respect for cultural and linguistic diversity in education. This approach could help develop graduates who possess both technological competencies and the critical judgement needed to use AI responsibly.

Overall Finding

The nine themes suggest that AI-enhanced education may contribute to closing Africa's skills gap through the combined development of digital competencies, improved teaching practices, stronger teacher preparedness, better alignment with employment needs, and more inclusive access to learning. This means that educational institutions should collaborate with governments and industry to ensure that education meets policy priorities and labour-market needs. Such collaboration can support relevant curriculum development, skills training, resource provision, and improved employment opportunities (UNESCO, 2024). However, these benefits depend on supportive policies, adequate infrastructure, and ethical, context-sensitive implementation.

4.2 Research themes and the solutions they imply

Table: Challenges of AI Integration in African Education, Proposed Solutions and Expected Contributions to Skills Development

Challenges to AI Integration	**Proposed Solutions**	**Expected Contribution to Skills Development**
1. Inadequate ICT infrastructure, electricity and internet access.	Invest in affordable internet, digital devices and reliable electricity.	Improves access to AI learning and digital skills development.
2. Limited AI competencies among educators.	Provide continuous AI training and professional development.	Strengthens teaching capacity and prepares learners for digital workplaces.

3. Low AI literacy among learners.	Integrate AI and data literacy into educational programmes.	Develops AI competence and responsible technology use.
4. Outdated curricula and limited AI integration.	Update curricula to include AI, coding, data science and STEM.	Aligns learners' competencies with emerging labour-market needs.
5. Weak education–industry collaboration.	Establish partnerships for internships, practical training and curriculum development.	Improves graduate employability and workplace readiness.
6. Limited institutional preparedness and funding.	Develop institutional AI strategies and sustainable funding mechanisms.	Supports effective AI adoption and continuous skills development.
7. Ethical concerns and data-privacy risks.	Establish AI policies, data-protection measures and ethical guidelines.	Promotes critical thinking and responsible AI use.
8. Unequal access to AI-enhanced education.	Provide inclusive, affordable and accessible AI learning resources.	Expands equitable access to digital and technical skills.
9. Limited African context models of AI tools.	Adapt AI tools to African languages, cultures and educational needs.	Develops locally relevant skills/ for solving African challenges.
10. Limited practical learning and problem-solving.	Integrate AI-supported projects, simulations and practical activities.	Strengthens creativity, critical thinking and applied skills.
11. Skills mismatch and limited entrepreneurship.	Align AI education with industry needs and entrepreneurship training.	Improves employability, innovation and self-employment opportunities.
12. Weak monitoring and stakeholder coordination.	Strengthen collaboration and evaluate AI-integration initiatives.	Promotes sustainable skills development aligned with economic priorities.

The findings identify inadequate ICT infrastructure, unreliable electricity, and limited internet access as major challenges to AI integration in African education (Mutambara, 2024). These barriers restrict learners' and educators' access to AI-enhanced learning opportunities. Investment in affordable digital devices, reliable electricity, and internet connectivity could improve access to AI technologies and support the development of digital skills.

A second challenge is the limited AI competence of educators and learners, alongside outdated curricula and inadequate institutional preparedness. Continuous professional development, AI literacy programmes, and curriculum reform are therefore important for strengthening the effective use of AI in education. These measures could improve educators' capacity to integrate AI into teaching and prepare learners with relevant digital, technical, and problem-solving skills.

The findings also highlight weak collaboration between educational institutions and industry, skills mismatches, and limited opportunities for practical learning and entrepreneurship (Hlongwane et al., 2024). Strengthening partnerships among governments, educational institutions, and industry could promote work-based learning, internships, and curricula aligned with labour-market needs. In addition, AI-supported projects and practical activities could develop critical thinking, creativity, and innovation, as well as improve workplace readiness, thereby enhancing opportunities for employment and self-employment (Kayyali, 2025).

According to Mutambara (2024), the sustainable deployment of AI requires strong governance frameworks, investment in digital infrastructure and human capacity, locally applicable AI solutions, and cooperation among governments, academia, businesses, and international partners. Without these foundations, AI could worsen inequality and restrict meaningful engagement in the digital economy. The findings suggest the need for clear AI policies, data-protection measures, inclusive learning resources, and tools adapted to African languages and educational contexts (Hlongwane et al., 2024). Regular monitoring and collaboration among stakeholders could help ensure that AI-enhanced education remains responsible, accessible, and relevant to local needs (Miao &

Cukurova, 2024). Collectively, these measures have the potential to strengthen skills development and contribute to closing Africa's skills gap.

HOW AI-ENHANCED EDUCATION CAN CLOSE AFRICA'S SKILLS GAP

There are various ways in which Africa can address the skills gap. In an era in which the Fourth Industrial Revolution (4IR) is transforming the world of work through artificial intelligence (AI), robotics, and data-driven systems, Africa faces a critical turning point. Its rapidly growing youthful population presents significant opportunities for economic development. However, slow educational reform and limited alignment between education and labour-market demands risk widening the skills gap and marginalising the continent in the global digital economy (World Bank, 2024). Traditional teaching and learning approaches, rote learning, and theory-heavy curricula across Africa are ill-equipped to develop the adaptive, digital, and complex problem-solving competencies demanded by the 4IR.

This section discusses how AI-enhanced education can contribute positively to closing the 4IR skills gap in Africa.

5.1 Develop Foundational and Advanced Competencies

Digital skills development requires foundational competencies in AI literacy, numeracy, and digital literacy. AI-enhanced education can support the development of these competencies through targeted explanations, adaptive practice, and formative assessment (Atherton et al., 2026). Once these foundations are established, learners can progress towards more advanced competencies, including data analysis, programming, AI development, systems thinking, and interdisciplinary problem-solving (UNESCO, 2024).

This progression is important because learners need a sound foundation of knowledge and skills before they can effectively develop advanced technical competencies. Without strengthening foundational learning, Africa risks perpetuating gaps in educational quality and limiting learners' ability to benefit from technological advances. Strengthening these foundations could help prepare graduates for employment by developing communication, teamwork, and problem-solving skills. Building on this foundation, advanced competencies in data analytics, coding, and robotics could enhance innovation, workforce readiness, and the competitiveness of African economies in the global market (World Economic Forum, 2025).

5.2 Move from passive AI awareness to active AI application

The review by Naphiyo et al. (2026) provides a useful distinction between AI awareness and readiness to use AI effectively. The 63 studies included in the review indicate that familiarity with basic generative AI applications does not necessarily mean that learners or institutions possess the skills required for more advanced applications. Africa cannot close the 4IR skills gap merely by teaching about AI; it must also teach with and through AI. AI application should be the ultimate goal.

Africa should move beyond consuming foreign AI technologies towards developing locally relevant AI solutions. While AI awareness enables learners to use existing tools, developing advanced AI competencies can empower them to design, adapt, and create solutions that address African challenges and reflect the continent's cultural, linguistic, and educational contexts (UNESCO, 2025). The continent must use AI-enhanced education to progress from AI literacy to AI competency and, ultimately, to AI innovation and entrepreneurship. A suitable educational progression should move from understanding AI and its limitations to applying tools, evaluating outputs, and creating AI-supported solutions to real-world problems (Miao et al., 2024). Learners should then demonstrate these competencies through practical assignments, internships, portfolios, or entrepreneurship. Assessment should focus on demonstrated skills rather than AI-use frequency or self-reported confidence alone.

5.3 Strengthen educator capacity

Teachers determine whether AI merely automates activities or facilitates meaningful learning. Therefore, teacher development should include AI literacy, pedagogical design, subject-specific applications, evaluation, data

protection, and the ability to assess AI-generated outputs (Miao & Cukurova, 2024). This means that, rather than allowing AI to replace pedagogical decision-making or meaningful teacher-student interaction, educators must embrace technology as a tool to improve professional judgement, learner engagement, and subject understanding.

Teaching strategies that take recent technological advancements into account are necessary to prepare students for the 4IR. Although some teachers at African universities are aware of AI, they might not have the practical skills needed to incorporate it successfully into their lessons. Continuous, hands-on professional development is therefore vital to prevent educators' skills from becoming outdated (Hlongwane et al., 2024). With appropriate training, lecturers should be able to develop lesson plans, differentiated exercises, and AI-supported learning activities; assess student progress; and establish standards for the responsible use of AI (Miao & Cukurova, 2024).

Teachers who lack the necessary skills should participate in brief, competency-based upskilling sessions rather than lengthy theoretical seminars. To accelerate the programme, governments should establish train-the-trainer initiatives and peer-learning groups. AI-enhanced education will fall short without AI-enhanced educators.

5.4 Align educational programmes with labour-market demands.

Universities and colleges need to collaborate with employers, professional bodies, governments, and entrepreneurs to identify the competencies required in emerging and existing occupations. This consultative approach will foster a continuous consultative ecosystem and help prevent the continent from lagging behind in developing the skills required for the 4IR.

These partnerships can support curriculum design, workplace activities, internships, apprenticeships, and competency-based evaluation. Additionally, they can assist businesses in determining when AI competencies should be incorporated into existing disciplines and when specialised AI training is required (OECD, 2026).

AI-enhanced education should prepare students for careers in which AI is used as a supporting tool, as well as for employment involving AI. AI-related skills can boost productivity, creativity, and problem-solving across a variety of African contexts, including manufacturing, agriculture, education, healthcare, finance, logistics, public administration, and small-business development (World Economic Forum, 2025).

5.5 Design with sustainability, affordability, and inclusivity in mind

Where digital devices are expensive, internet connectivity is limited, and the electricity supply is unstable, the benefits of AI-enhanced education may remain unevenly distributed. Therefore, affordable devices, reliable electricity, accessible internet, support for local languages, and open educational resources should be given top priority throughout implementation (Falebita & Kok, 2024).

Institutions should also evaluate the total cost of implementation, including maintenance, connectivity, staff training, data security, and software subscriptions. Before being widely implemented, affordable pilot programmes should be assessed to determine their efficacy, sustainability, and suitability for local educational environments (African Union Commission, 2024; UNESCO, 2025).

True 4IR in Africa must be affordable enough for a rural school to adopt, inclusive enough for a girl learner to benefit from, and sustainable enough to continue beyond a pilot project.

5.6 Results, not just technology adoption

Africa does not need AI adoption theatre, but there is a need for AI-enabled transformation measured by jobs created, problems solved, and lives improved, rather than just tools installed (World Economic Forum, 2025). The success of AI-enhanced education should be assessed through measurable improvements in learners' knowledge and competencies. Key indicators include subject-specific assessment results, AI and digital literacy, critical thinking, problem-solving, practical project completion, and educators' competence in AI-supported teaching (UNESCO, 2024). Evaluation should also consider equitable participation across gender, geographical

location, and socioeconomic groups, alongside learners' completion of internships, professional certifications, and workplace tasks.

Further evidence of the impact of AI-enhanced education on skills development can be seen in graduate employment, self-employment, and employer-reported competencies (World Economic Forum, 2025). However, employment outcomes are influenced by factors beyond education, including economic growth and job availability. AI-enhanced education should therefore be evaluated as a potential contributor to closing the skills gap, rather than assuming that increased AI use automatically leads to employment.

RESEARCH GAPS IDENTIFIED BY THE ANALYSIS

The literature points to four major gaps that should inform the development of an African AI integration model.

6.1 Geographic and contextual gap

The available literature includes research from different regions of Africa. Although existing literature discusses AI integration across several African countries, region-specific research is needed to establish contextually appropriate models. Such research should systematically assess the representation of different countries and educational levels and identify under-researched contexts (Olaifa et al., 2026).

Adopting a one-size-fits-all strategy across Africa would be inappropriate because countries such as South Africa, Egypt, and Rwanda operate at varying levels of AI integration in education. A rural school or a technical and vocational education institution with poor connectivity might not be able to adopt a model developed for a well-resourced university. Therefore, models of AI integration in Africa should take into consideration variations in infrastructure, languages, institutional capacity, curricula, and labour market demands (Hlongwane et al., 2024).

6.2 Competency gap

Despite increased investment in education and training across Africa, a gap persists between graduates' competencies and the skills required in the 4IR economy. Olaitan and Mavuso (2022) highlight the need to skill and reskill students for economic relevance, suggesting that traditional curricula and theory-based instruction may be insufficient to meet evolving industry demands. Consequently, education systems need to strengthen practical, digital, and technological competencies to prepare graduates for the changing world of work.

Mutambara (2024) asserts that sophisticated analytical capabilities, digital literacy, educator preparedness, and AI awareness are crucial elements of AI readiness. He argues that successful AI adoption requires investment in education, skills development, reskilling, and institutional capacity so that individuals can become active creators and informed users of AI technologies rather than passive consumers. A key question is how to move from awareness and basic AI use towards demonstrated competence in problem-solving, innovation, and workplace application.

Future research should distinguish between knowing about AI, using AI, evaluating AI outputs, and creating AI-enabled solutions. Additionally, there is a need for an AI-enhanced education model that systematically develops both foundational and advanced competencies to effectively reduce the 4IR skills gap (Mthethwa et al., 2025).

6.3 Curriculum–employment gap

AI can improve teaching and learning, but how much it contributes to the development of skills relies on how well educational activities match business prospects and labour market demands. Olaitan and Mavuso (2022) stress the significance of reskilling and upskilling learners to be relevant in the Fourth Industrial Revolution. In a similar vein, Awosejo et al. (2024) emphasise how e-skills empower graduates, highlighting the necessity for educational systems to shift from theoretical knowledge to practical, career-oriented competencies.

Therefore, greater cooperation between academic institutions and business is necessary to guarantee that curriculum design takes into account the demands of the modern and developing workplace. In their analysis of

the prospects and difficulties of integrating AI in African higher education, Hlongwane et al. (2024) emphasise the necessity of addressing contextual impediments to successful implementation. In this sense, integrating industry consulting, hands-on projects, work-based learning, and competency-based assessment could help students apply AI-related knowledge to real-world issues, cultivate entrepreneurial skills, and improve their job readiness.

6.4. Evidence and measurement gap

Systematic reviews, conceptual articles, and policy analyses make up a significant component of the reviewed literature on AI-enhanced education. There is still less empirical data showing how AI-enhanced education directly affects employment outcomes, despite the fact that these articles provide insightful information on new practices, implementation issues, and policy goals. For example, Hlongwane et al. (2024) examine the challenges and opportunities associated with AI integration in African higher education, while Olaitan and Mavuso (2022) emphasise the importance of skilling and reskilling students for relevance in the 4IR economy. Similarly, Awosejo et al. (2024) discuss the role of e-skills in empowering graduates. However, recognising the potential of AI and digital skills does not prove that employability, workplace performance, or entrepreneurship are improved by AI-enhanced educational interventions (OECD, 2026).

Future research should therefore move beyond conceptual discussions towards rigorous empirical evaluations of AI-supported educational interventions. Where feasible, studies should employ baseline and follow-up assessments, comparison groups and qualitative feedback to measure changes in learners' competencies, assess intervention effectiveness and gain a deeper understanding of learners' experiences (Han et al., 2025) Cost-effectiveness analysis could further determine whether the benefits of AI integration justify the financial and infrastructural investments required, particularly in resource-constrained African educational settings (Adefolalu, 2026).

In addition, longitudinal studies should track graduates' employment status, career progression, workplace performance and entrepreneurial activities over time (Adefolalu, 2026). By strengthening the data on AI-enhanced education and employability, these methods would help develop solutions that are appropriate for the African context and help close the skills gap.

PROPOSED AI INTEGRATION MODEL FOR AFRICAN EDUCATION

The proposed model is called the AI-Enhanced Education Model for Africa (AI-EEMA). It synthesises recurring issues in the available literature into a context-sensitive pathway for developing the skills needed for employment, entrepreneurship and wider economic participation. The model is a proposed conceptual framework derived from the literature and is not yet a validated model. Its effectiveness would need to be tested in different African educational settings.

7.1 Proposed Conceptual Model (AI-EEMA)

The proposed model functions as an integrated ecosystem rather than a linear intervention, supported by continuous stakeholder interaction and feedback. Its implementation begins with a comprehensive assessment of African contexts and labour-market demands. This process identifies local skills gaps, employer requirements, community priorities and entrepreneurial opportunities, ensuring that educational provision and AI integration respond to relevant socio-economic needs. The foundation phase should prioritise inclusive stakeholder engagement, involving learners, traditional leaders, employers, informal-sector representatives and labour-market analysts.

Their participation would help identify community priorities, local skills gaps and emerging employment opportunities, ensuring that the model responds to Africa's diverse socio-economic contexts (Allieu et al., 2026). This approach would help address the uncritical adoption of externally developed educational models in Africa by ensuring that the AI-EEMA model is validated and adapted to local contexts before implementation. It would also promote infrastructure development and equitable access through the provision of appropriate digital

devices, reliable electricity, affordable internet connectivity, accessible digital platforms and resources in local languages. Governments should play a central role in facilitating these provisions through policy development, public investment, infrastructure expansion and collaboration with educational institutions, industry and development partners.

The pedagogical foundation of the model lies in an AI-responsive curriculum and pedagogy, supported by the systematic development of teachers' and learners' competencies. Zhai and Krajcik (2024) emphasise the importance of integrating AI into STEM teaching, learning and assessment. Building on this perspective, the model proposes that AI should be integrated into relevant curriculum areas and applied to real-world problems rather than being confined to a stand-alone subject. It prioritises the development of AI literacy, digital skills, critical thinking, data literacy, pedagogical competence and responsible AI use. These competencies can be developed through collaborative workshops involving educators, curriculum designers, industry experts and learners. This approach aims to move AI use beyond basic awareness towards practical competence, and from passive consumption towards innovation and creation.

The model also emphasises applied AI, innovation and entrepreneurship. Learners should progress from classroom-based projects to developing practical solutions to challenges in agriculture, education, manufacturing, finance and transport. This process is supported by education–industry–government partnerships, which form the backbone of the ecosystem (Nzeyimana et al., 2026). Through this collaboration, stakeholders can co-design curricula, provide work-based learning opportunities, support innovation hubs and connect learning with employment prospects. The model establishes a continuous feedback loop in which the education sector develops skilled graduates and conducts applied research, industry contributes real-world problems, relevant data and work-placement opportunities, and governments provide policy direction and infrastructure.

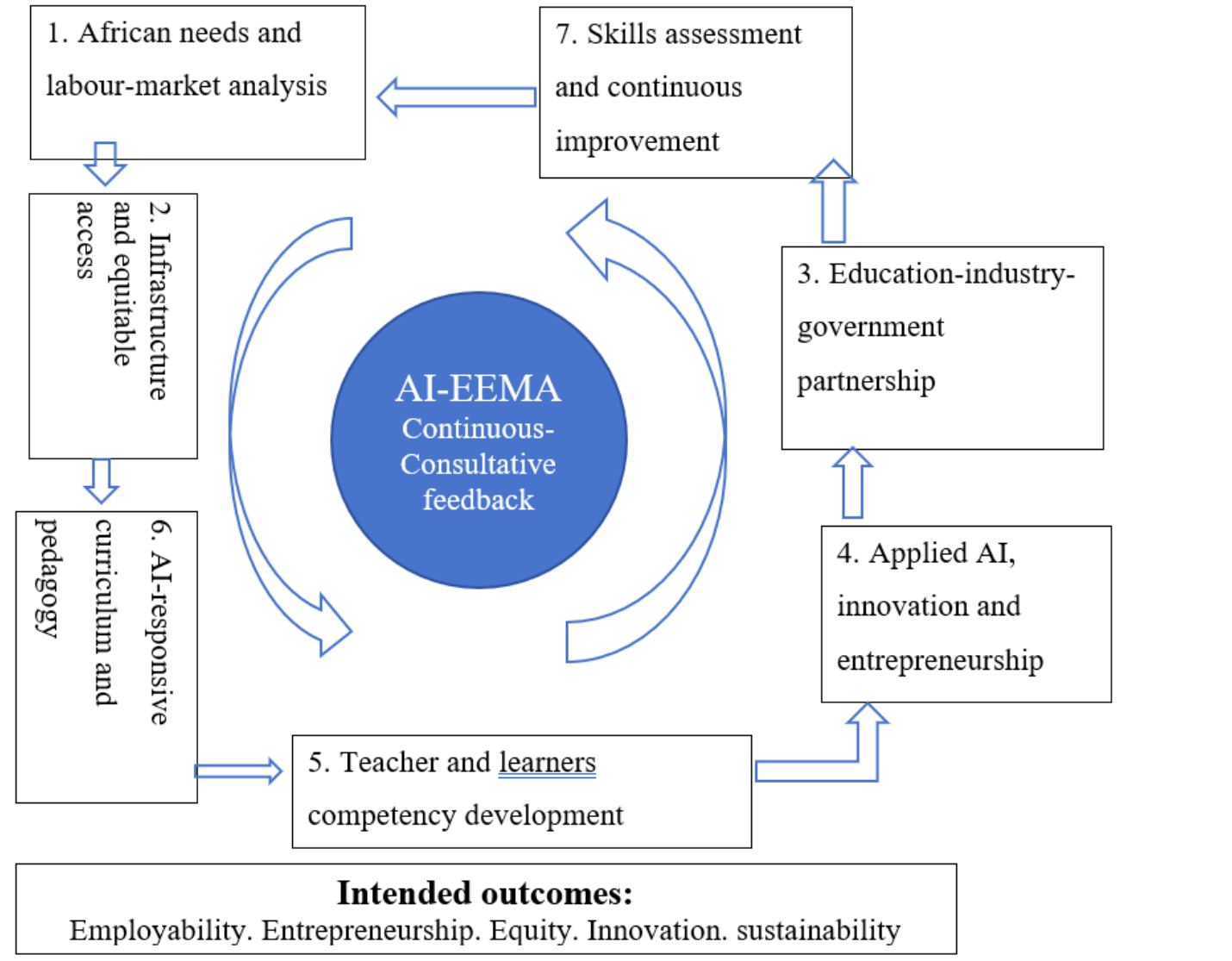
The model is underpinned by a robust mechanism for skills assessment and continuous improvement. Success should be measured not simply by the number of AI tools installed, but by the competencies developed, equity achieved, employability enhanced and enterprises created (Adewolu, 2024). Feedback from communities, industry representatives and labour-market experts should inform regular curriculum reviews and improvements to implementation. Quarterly reviews could help ensure that the model remains responsive, adaptive and accountable. Through this continuous process of assessment and refinement, AI-enhanced education can contribute to improved employability, entrepreneurship and job creation across diverse African contexts.

7.2 Intended outcomes

The intended outcome of the AI-enhanced Education Model for Africa (AI-EEMA) is to provide a contextually relevant framework for integrating artificial intelligence into African education systems in ways that address local educational needs and skills gaps. The model aims to align AI-enhanced teaching and learning with national development priorities, curriculum requirements and labour-market demands (Mthethwa et al., 2025). It is intended to strengthen teachers' and learners' AI literacy, digital competencies, critical thinking, creativity and problem-solving skills. By considering contextual factors such as infrastructure, internet connectivity, electricity, affordability, language diversity and institutional readiness, the model seeks to promote equitable, inclusive and sustainable AI integration across different educational settings.

By ensuring that AI-enhanced learning develops competencies pertinent to the evolving workplace, another goal is to improve the interaction between education, industry, and employment (Olaitan & Mavuso, 2022). The model seeks to encourage practical, competency-based learning, industry partnerships, entrepreneurship and the application of AI to African challenges, including those in agriculture, healthcare, education and other productive sectors. It also aims to promote responsible AI use through appropriate policies, ethical guidelines and data-protection measures. Ultimately, the model aims to promote meaningful AI integration that enhances learning, strengthens workforce readiness, and supports employment, innovation and sustainable socioeconomic development across Africa (Hlongwane et al., 2024).

AI-EEMA diuagram



The model does not work linearly. It is circular ecosystem where skills assessment feedback into African needs analysis. At every stage, stakeholders consult. The centre holds it together and continuous feedback promotes the models' refinement. This guarantees that the model is affordable, inclusive and sustainable because it is owned by all, not imposed from the top.

7.1 Explanation of the model's components

Component	Recommended implementation	Indicator of progress
Labour-market analysis	Consult employers, communities, educators, learners and professional bodies	Identified and prioritised competency gaps
Infrastructure and access	Assess connectivity, electricity, devices, software costs and accessibility	Reliable access across participating institutions
AI-responsive curriculum and pedagogy	Integrate AI into learning areas, STEM, vocational education and authentic assessment	Curriculum outcomes and adaptive pedagogy
Teacher and learner competencies	Provide differentiated training for teachers and learners	Demonstrated AI, digital and disciplinary competence

Applied AI and entrepreneurship	Use local problems as the basis for projects and innovation	Completed projects, portfolios and prototypes
Partnerships	Develop joint programmes with employers and public institutions	Workplace placements, joint courses and employer participation
Monitoring and improvement	Evaluate learning, inclusion, costs and employment-related outcomes	Evidence of improvement and documented model revisions

- **Labour-market analysis:** Identifies the knowledge and skills required by employers, communities and emerging industries to ensure that education responds to real employment needs.
- **Infrastructure and access:** Ensures that institutions and learners have access to reliable electricity, internet connectivity, appropriate devices and affordable AI tools.
- **AI-responsive curriculum and pedagogy**: Integrates AI into curriculum content, teaching methods and assessment to improve learning, problem-solving and the development of relevant competencies.
- **Teacher and learner competencies:** Develops the digital, AI-related, ethical and subject-specific knowledge and skills that teachers and learners need to use AI effectively and responsibly.
- **Applied AI and entrepreneurship:** Encourages learners to apply AI to real-world problems, develop innovative solutions and create opportunities for employment and self-employment.
- **Partnerships:** Promotes collaboration among governments, educational institutions, industry, employers and communities to align education with skills needs and provide practical learning opportunities
- **Monitoring and improvement:** Systematically evaluates the effectiveness, accessibility, affordability and employment relevance of AI-enhanced education to guide continuous improvement.

7.3 What makes AI-EEMA appropriate for Africa?

First, the model is needs-driven rather than technology-driven. Educational institutions should begin by identifying learners' competency needs and the educational challenges they seek to address before selecting appropriate AI tools to support these objectives. The problem is identified first before the solution is prescribed.

Secondly, the model recognises infrastructure as a fundamental condition for successful implementation. Where electricity and internet connectivity are unreliable, institutions may need to adopt offline-capable tools, shared devices and low-bandwidth applications, supported by phased investment in digital infrastructure. These units should be supplied by the government and other non-governmental organisations such as churches and donors.

Thirdly, the model promotes the development of both general and specialised competencies. All learners should acquire appropriate digital and AI literacy, while those pursuing specialised fields may require advanced skills in areas such as data science, AI development, robotics, agricultural technology and health technology.

Fourth, the model emphasises the connection between learning and productive activity. Learners should have opportunities to apply their knowledge and skills to authentic African challenges rather than engage with AI concepts without meaningful practical experience. This may open Africa to innovation and entrepreneurship.

Fifth, the model integrates equity and responsible AI governance. AI integration should protect personal data, maintain appropriate human oversight, address algorithmic bias and minimise barriers affecting learners disadvantaged by economic circumstances, language, disability or geographical location.

Finally, the model incorporates continuous monitoring and evaluation. Rather than assuming that AI adoption automatically improves educational or employment outcomes, institutions should use evidence on learner achievement, implementation costs, teacher preparedness, equitable access and workplace outcomes to evaluate effectiveness and guide ongoing improvements.

HOW THE MODEL SHOULD BE TESTED?

a. Expert validation

The AI-EEMA model should undergo expert validation to assess its relevance, feasibility, and suitability for diverse African educational and socio-economic contexts. A panel of approximately 20 experts from 12 African countries could be selected, ensuring representation from all African regions. Ase et al. (2025) demonstrate the importance of comparing AI-generated outputs with expert judgements to identify discrepancies and improve reliability, highlighting the need for human oversight when evaluating AI applications in real-world settings. The panel should include TVET policymakers, AI-in-education researchers, industry representatives, and development planners with relevant expertise.

The proposed AI-EEMA model diagram and a detailed explanation of its intended operation would be provided to the experts. The model could be subjected to expert validation using a modified Delphi technique. Mac Earchen (2025) describes this approach as a structured process in which experts evaluate a predefined set of items over successive rounds, providing a basis for assessing and refining an existing model. Feedback from the first round would inform revisions to the model before the second round, allowing experts to reassess the revised components and recommendations. The results would provide evidence to support further refinement of the model before pilot implementation.

b. Multi-Country pilot implementation

Following expert validation, the revised AI-EEMA model should be piloted in selected African countries to assess its feasibility, adaptability, and effectiveness under different institutional and resource conditions (Sun et al., 2024). Subject to funding availability, three or four countries could be selected to represent diverse economic, technological, and educational contexts. Rwanda could represent a context characterised by relatively limited economic resources but strong digital policy ambitions; Kenya or Nigeria could represent contexts with active technology ecosystems; and South Africa or Egypt could provide contrasting settings with comparatively developed infrastructure and industry linkages. The final selection should be based on transparent criteria, including infrastructure, educational priorities, institutional readiness, and labour-market characteristics, rather than income classification alone.

Two TVET institutions in each participating country could implement the model over one academic semester. Data would be collected on implementation feasibility, costs, teacher and learner competencies, industry engagement, inclusion, and employment-related learning outcomes. Cross-country comparisons would identify which components work consistently across settings and which require contextual adaptation. Evidence from the pilot would inform further revisions before wider implementation (UNESCO, 2023). However, successful implementation in a small number of countries would provide preliminary evidence of transferability rather than establish that the model is universally applicable across Africa.

c. Alignment with Continental Frameworks and Indicators

The AI-EEMA model should be reviewed against relevant African Union (AU) policy frameworks and UNESCO guidance to strengthen its strategic relevance and policy coherence. This process would involve mapping the model's components and intended outcomes against applicable continental priorities for digital transformation, education and skills development, employment, equity, and innovation. Relevant reference points could include the AU Digital Transformation Strategy for Africa (2020–2030), the AU Digital Education Strategy and Implementation Plan (2023–2028), Agenda 2063, and UNESCO's AI competency frameworks for teachers and students. These frameworks emphasise digital infrastructure, digital skills, technology-enabled education, employability, and inclusive development.

A framework-alignment matrix could be developed to connect each AI-EEMA component with relevant policy objectives, expected outcomes, and measurable indicators. For example, employability could be assessed through demonstrated competencies and participation in work-based learning; equity through access across geographical and socio-economic groups; and innovation through locally developed AI-supported projects,

prototypes, and entrepreneurial initiatives. This alignment would help ensure that the model supports continental development priorities while remaining adaptable to national policies, institutional capacities, and local needs (UNESCO, 2024).

CONCLUSION

If education systems continue to deliver content-focused and theory-heavy instruction, Africa will remain a consumer of AI and will lag behind in closing the 4IR skills gap. The need to close the 4IR skills gap is no longer merely academic; it is now an economic and survival imperative.

This concept paper proposes a seven-component AI-Enhanced Education Ecosystem that is inclusive, affordable, and anchored in African realities. It operates as an ecosystem of continuous consultation and feedback involving governments, industry, educators, learners, communities, and development partners. It moves Africa beyond AI awareness towards AI capability. It strongly supports applied AI, innovation, and entrepreneurship, thereby linking learning to employability and enterprise creation.

The AI-EEMA model is not simply about adopting technology; it is about transforming Africa's graduates into innovators and creators of the 4IR. By piloting this model in representative contexts and validating it through pan-African expertise, Africa can develop a sustainable pathway to the future.

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