Framework for Integrating Artificial Intelligence in Agricultural Science Teacher Education in Africa

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ABSTRACT

The paper discussed framework for integrating artificial intelligence in agricultural science teacher education in Africa. Attempt was made to review: current state of AI integration in agricultural science teacher education programme; AI tools and components needed in agricultural science teacher education programme; challenges of integrating AI in agricultural science teacher education programme; benefits of integrating AI in agricultural science teacher education programme; and framework for AI integration in education. The authors presented the 'PIECE' framework for AI integration in agricultural science teacher education programme. PIECE encapsulates five key pillars: Professional training, Institutional readiness, Ethical considerations, Curriculum integration, and Evaluation of outcomes. The paper recommended starting with professional training, which will ensure the teachers and other stakeholders that will implement the blended curriculum are well trained and equipped to drive the AI revolution process. This training could be mounted by consultants contracted by the institutions. The end of such intensive training will culminate into identifying institutional gaps and needs for AI integration. These requirements should therefore be met, thereafter ethical issues would be considered prior to identifying and including the needed AI courses in the curriculum. When the blended curriculum is implemented, evaluation of impact is done after few years of implementation. Gaps identified from the evaluation will lead to modification at each stage for a continuous AI integration in agricultural science education curriculum.

Keywords: AI integration, Agricultural science education, teacher education, AI tools

INTRODUCTION

Teacher education remains the formal training programme aimed at developing, preparing and equipping individuals with the required skills, competencies, capabilities to teach. National Council for Teacher Education has defined teacher education as – A programme of education, research and training of persons to teach from pre-primary to higher education level. Teacher education is a programme that is related to the development of teacher proficiency and competence that would enable and empower the teacher to meet the requirements of the profession and face the challenges therein (Dori Lal, 2016). Each teacher education programmes should however be tailored towards imparting the required competencies for effective delivery in that area. Hence the need for well thought out agricultural science teacher education programme.

From a programmatic perspective, the American Association for Agricultural Education (AAAE) (2001) developed the National Standards for Teacher Education to describe what a teacher education programme in agricultural science education should look like. The standards provide an input-side framework for assessing the quality of a preservice agricultural science teacher programme. For example, Standard 2 indicates that a preservice agricultural science programme should consist of a balanced curriculum that includes general education, technical agriculture content, and pedagogy professional skills. (Roberts, et al 2006). The above-mentioned characteristics begin to establish the competencies and traits needed by agricultural science teachers, particularly related to those in the formal setting of the classroom. However, teaching agricultural science extends beyond the classroom. Agricultural science teachers are expected to facilitate student projects, advise student organizations, administer adult groups, as well as plan and operate the agricultural science programme (Roberts, et al 2006). Hence the need to equip agricultural science teachers with relevant modern approaches and competencies such as artificial intelligence (AI).

Integrating artificial intelligence in agricultural science teacher education involves using AI to enhance agricultural science teacher training through personalized professional development, virtual reality classroom simulations, and AI-powered assessment tools. It also requires preparing future agricultural science teachers to use AI effectively in their own classrooms by teaching them pedagogical strategies, AI literacy, and how to critically evaluate AI-generated content, alongside preparing them to guide students in understanding AI's capabilities, limitations, and societal impact

AI has been described by Nwosu, Eko-Nweke and Zion-Ngoka (2024) and Nie (2020) as technical and scientific field devoted to the engineered system that generates outputs like forecast, content, and decisions for a given set of human-defined objectives. AI is a useful counterpart to people in everyday life as it has the capability to interpret and sort data at scale; solve complex problems and automate varied tasks simultaneously thereby filling operational gaps missed by humans (Ukala and Iheukwumere 2025). AI has been applied in various sectors, promoting transformation effects on education, finance, agriculture, transportation, healthcare, entertainment, etc. (Shuaibu, 2024). Integrating AI in agricultural science teacher education might be the needed catalyst reinvigorate agricultural science delivery at all levels of learning in Africa.

Current State of AI Integration in Agricultural Science Teacher Education Programme

Despite the growing importance of AI in various industries, African institutions are yet to fully incorporate AI-related curricula and tools into their programs. This has led to a widening gap between the skills taught in schools and the competencies required by employers in the technology-driven economy. If this gap persists, Nigerian and indeed African youth may face increasing difficulty in securing jobs in the AI-powered industries of the future (Ukala and Iheukwumere 2025). While the discussions about AI in education are expanding in developed countries, empirical research in African region, particularly in Nigeria, remains limited. Schmidt, et al (2025) observed that Kuwait, one of the Gulf countries, is increasingly investing in digital transformation across different sectors as part of its national development goals. In alignment with the new Kuwait 2035 vision, the country is investing in AI capabilities to enhance the educational system. Daher (2025) cited other Notable examples which include the U.S. E-rate program, which addresses resource constraints, and India's "AI for All" initiative, which focuses on equitable AI access. This investments in AI technology is currently ongoing in other developed countries and regions of the world.

However in Africa, literature on AI in the context of higher education, specifically teacher education, is emerging. Teacher educators face similar issues. It is important that college faculty establish close connections with what teacher candidates are experiencing in their school placements and what they will encounter in their future classrooms regarding AI (Alexandrowicz, 2024). Langreo (2023) emphasized: It is critical that schools of education act quickly to ensure that prospective teachers have a foundational understanding of AI, know how to use it effectively for instruction, and can infuse AI literacy into every subject, so they are ready when they enter the classroom. However, preservice programs, especially in teacher education, have not adequately kept up with integrating AI concepts into their curricula for preservice teachers (Grover, 2024). This is basically same with agricultural science teachers.

Daher, (2025) asserted that many educators currently grapple with substantial obstacles in incorporating AI literacy into their teaching practices, primarily due to insufficient professional preparation and training. A recent global survey, which included over 450 schools and universities, revealed that fewer than 10% of them have established institutional policies or formal guidance regarding the use of generative AI applications (UNESCO, 2023). For educators, AI literacy is not just about integrating cutting-edge tools into lesson plans. It's about equipping the next generation with the skills to thrive in an AI-dominated world. The stakes are high: without a robust foundation in AI literacy, educators risk becoming obsolete, potentially exacerbating the digital divide. The latter refers to the gap between those who have access to technology and internet connectivity—such as teachers and students—and those who do not (Daher, 2025). It is therefore evident that most African agricultural science teacher education programmes are yet to formally integrate AI into Agricultural Science teacher's curricula at all levels. Institutional policies to this effect are important to drive this new down in the world-AI. However literatures reveals that both teachers and trainee teachers are embracing the use of AI on individual levels to assist them in various tasks. Coordinated national and regional policies, efforts and investments in AI

with regards to educational transformation, particularly agricultural science teacher education is yet to commence.

AI Tools and Components Needed in Agricultural Science Teacher Education Programme

Artificial Intelligence (AI) is increasingly being recognized as a powerful tool with the potential to revolutionize education (Chen, et al., 2020; Pedro, et al., 2019; Alam, 2021; Eden et al 2024). By leveraging AI technologies, educators can unlock a plethora of opportunities to enhance learning experiences, improve student outcomes, streamline administrative tasks, and create immersive learning environments (Eden et al 2024). Several AI tools/technologies that can be deployed for effective teaching of agricultural science are available. Such tools should be integrated in agricultural science teacher education programme to enable teachers become conversant with such tools.

In education, core AI technologies such as Machine Learning (ML), Natural Language Processing (NLP), MagicSchool.ai, Eduaide and Generative AI such as ChatGPT, are increasingly utilized to enhance teaching, learning, and administrative processes. Tools like personalized learning platforms, intelligent tutoring systems, automated assessment tools, and generative content creators are being integrated into classrooms and institutions to boost student engagement and academic performance (Alexandrowicz, 2024; Schmidt, et al 2025). Others are Automated Grading and Assessment Tools, AI-powered proctoring systems, Virtual 3D Classrooms, Digital Learning tools like Nearpod, and Interdisciplinary Learning like Wolfram Alpha.

Machine learning (ML), a subset of artificial intelligence (AI), plays a pivotal role in delivering personalized learning experiences. By analyzing vast datasets, ML identifies patterns, predicts outcomes, and customizes educational pathways (Gligorea et al 2023; Daher, 2025). AI and ML play a vital role in collecting and interpreting learner data to enhance personalized learning. AI-driven learning platforms offer several benefits, such as an improved educational environment, adaptable scheduling, instant feedback, greater autonomy in managing learning experiences, and faster student progress (Moreno-Guerrero et al 2020; Daher, 2025). These systems efficiently process extensive datasets, recognize patterns, and generate predictions or tailored recommendations. By considering individual strengths, abilities, and academic challenges, AI enables the application of diverse instructional approaches (Tapalova and Zhiyenbayeva, 2022; Daher, 2025). As AI technologies, such as intelligent agents, chatbots, and recommendation systems, become more prevalent in education, the urgency to address these gaps grows. Teachers also face challenges in adopting AI tools, ranging from technical difficulties to communication barriers.

Challenges of Integrating AI in Agricultural Science Teacher Education Programme

Essentially, integrating AI in agricultural teacher education in Africa is faced with multiple challenges ranging from existence of strong Institutional policies, availability of needed IT equipment/facilities, strong network availability, and Ethical consideration among others. Daher (2025) asserted that in today's rapidly evolving educational landscape, the integration of Artificial Intelligence (AI) presents both unprecedented opportunities and significant challenges. Many educators currently grapple with substantial obstacles in incorporating AI literacy into their teaching practices, primarily due to insufficient professional preparation and training. A recent global survey, which included over 450 schools and universities, revealed that fewer than 10% of them have established institutional policies or formal guidance regarding the use of generative AI applications (UNESCO 2023).

Integrating AI literacy into teacher education programs is essential for promoting educational equity. However, implementing such programs requires substantial investments in technology infrastructure, including hardware (computers, servers, networking equipment and software (AI tools and platforms). Technology has always been a central component of education, but the tools and platforms used today have evolved significantly, now playing a critical role in accessing digital learning resources and facilitating collaboration among students on online platforms. Ensuring equitable access to technology is essential for reducing disparities in education. Research indicates that access to the Internet, information and communication technologies, the quality and location of that access, as well as the types of devices available and the means to maintain them, significantly influence what individuals in well-connected countries, like the United States, are

able or unable to do (Daher, 2025). Therefore, students without access to devices such as laptops, tablets, or smartphones, as well as those lacking reliable internet, face significant challenges and substantial disadvantages. This gap impacts marginalized communities, further widening inequalities in academic success and future prospects, exacerbating the consequences of digital exclusion, and limiting the potential for all individuals to benefit from the opportunities AI provides (Daher, 2025).

Another critical challenge in integrating AI in education is the potential for biases to be present in AI algorithms, which can perpetuate inequalities and undermine the fairness and effectiveness of AI-driven educational systems (Eden et al 2024). Biases in AI algorithms may arise from various sources, including biased training data, algorithmic design choices, and societal prejudices encoded in the data used to train AI models.

For example, if AI algorithms are trained on historical data that reflects existing disparities in educational achievement or access to resources, they may inadvertently perpetuate these biases by reinforcing existing patterns of inequality. Moreover, algorithmic decision-making processes that are not transparent or accountable may obscure the presence of biases and make it difficult to identify and address algorithmic discrimination (Akgun, and Greenhow, 2022; Borenstein, and Howard, 2021).

To mitigate biases in AI algorithms, educators and technology developers must adopt principles of fairness, accountability, and transparency in AI design and implementation. This includes critically examining training data to identify and mitigate biases, implementing algorithmic fairness techniques such as fairness-aware machine learning algorithms, and conducting regular audits and evaluations of AI systems to ensure that they do not disproportionately harm marginalized groups (Bogina, et al., 2021; Xivuri, and Twinomurinzi, 2023).

Eden et al (2024) opined that the integration of AI in education raises complex ethical considerations that must be carefully navigated to ensure responsible and equitable use of AI technologies. Ensuring the privacy and security of student data is paramount in the integration of AI in education. Educational institutions and technology providers must adhere to strict data protection regulations and ethical guidelines to safeguard student privacy and prevent unauthorized access, use, or disclosure of sensitive personal information. This requires implementing robust data encryption, access controls, and security protocols to protect student data from cyber threats and unauthorized access.

Additionally, transparent data governance policies and procedures are essential to ensure that students and their families understand how their data will be collected, stored, and used, and to provide mechanisms for obtaining informed consent and exercising control over their personal information. Furthermore, educational stakeholders must be vigilant in monitoring and addressing emerging threats to data privacy and security, such as data breaches, phishing attacks, and malicious software, and take proactive measures to mitigate risks and enhance the resilience of educational systems and infrastructure against cyber threats (Slade, and Prinsloo, 2013; Mandinach, and Gummer, 2021).

AI systems, though powerful, have the potential to produce biased or inaccurate responses, leading to significant concerns about their ethical use and the integrity of the data they generate. As highlighted by van den Berg and du Plessis (2023) and Kasneci et al. (2023), these risks require ongoing human oversight, continuous checking, and quality assurance to prevent misuse and ensure the reliability of AI outputs. Finley (2023) further emphasized the critical importance of verifying AI-generated information for accuracy before it is presented to students, underscoring the need for vigilant human intervention in educational contexts to maintain ethical standards and protect learners. As a result, it is paramount that candidates acquire expertise in pedagogy they can use to evaluate AI-generated information.

Additional concerns among educators include plagiarism and the lack of accurate detection tools (Keegin, 2023). Copying and pasting text without critically analyzing or properly citing original sources has become a common practice, leading some to believe AI-generated text is unsuitable for academic writing. Moreover, the detection of AI-generated text has been unreliable, making it difficult to distinguish between fact and fiction in AI-generated content, which students can easily copy and paste into their assignments (Chatterjee & Dethlefs, 2023; GarcíaPeñalvo, 2023; Khalil & Er, 2023).

Benefits of Integrating AI in Agricultural Science Teacher Education Programme

In the realm of education, AI offers innovative solutions to enhance learning experiences, streamline administrative tasks, and personalize instruction (Rane, et al., 2023; Sajja, et al., 2023). With the potential to revolutionize traditional pedagogical approaches, AI integration in education presents a myriad of opportunities for educators, students, and institutions alike (George, and Wooden, 2023).

Eden et al (2024) observed that one of the most significant opportunities offered by integrating AI in education is the ability to provide personalized learning experiences for students. Traditional one-size fits-all approaches to education often fail to accommodate the diverse learning styles and paces of individual students. However, AI-powered adaptive learning systems have the capability to analyze vast amounts of data on student performance and preferences to tailor instruction to each student's unique needs (Gligorea, et al., 2023).

For assessment, teachers may use AI tools to evaluate student learning in various ways, such as creating quizzes (e.g., Quizziz), using voice-enabled assignments and assessments (e.g., Sherpa), monitoring interactions with educational chatbots (e.g., Mizou), creating slide presentations for in-class assessments and interactions (e.g., Curipod), and developing customized rubrics (e.g., ChatGPT, MagicSchoolAI).

Research has shown that assessment tools like ChatGPT reduce the time needed for grading, ensure consistency in scoring, and provide immediate scores and feedback on students' writing skills (e.g., Mizumoto & Eguchi, 2023). Candidates in preparation programs must be provided with opportunities to practice using AI to engage support their future students effectively (Alexandrowicz 2024).

REVIEW OF FRAMEWORK FOR AI INTEGRATION IN EDUCATION

Several frameworks have been presented by several scholars. Daher (2025) presented EQUIP Framework, which encompasses five key pillars: Ethical Governance, Qualified Professional Learning, Unified Collaborative Partnerships, Implementation Readiness, and Progressive Adaptation. This framework offers a structured approach to empower educators with the necessary knowledge, skills, and ethical principles for responsible AI use in education.

More so, UNESCO AI Competency Framework for Teachers and Students, was launched in 2024 [UNESCO. 2024]. This initiative underscores UNESCO's commitment to empowering both educators and learners with the essential skills needed to navigate the evolving AI landscape in education. It aligns with Europe's digital competency frameworks, DigCompEdu and DigComp 2.2, which offer comprehensive structures for digital competency in the education sector (Daher, 2025).

European Commission DigCompEdu is designed to support development of educator-specific digital competencies in Europe, detailing 22 competencies organized into six key areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. Importantly, DigCompEdu focuses not on technical skills but on how digital technologies can enhance and innovate education (European Commission, 2024).

In contrast, European Commission DigComp 2.2 presented the knowledge, skills, and attitudes needed for citizens to engage critically, confidently, and responsibly with digital technologies for learning, work, and societal participation. It identifies five key components of digital competence: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving (European Commission, 2025) .

Framework for Inclusive AI Learning Design, which provides a comprehensive and adaptable approach for integrating AI into educational environments. Grounded in Universal Design for Learning (UDL) principles, this framework emphasizes inclusivity, accessibility, and equity, ensuring that AI driven learning tools and curricula address the diverse needs of all students, particularly those from marginalized backgrounds (Daher, 2025).

Furthermore, the AI Curriculum Design Framework (Chiu 2021) focuses on AI curriculum development in K-12 education. It aims to address the challenges educators face when developing and implementing AI-related curricula and is built around four key aspects: content, product, process, and praxis. The framework emphasizes three main content components—AI knowledge, AI processes, and the impact of AI—while integrating praxes such as student relevance, teacher-student communication, and flexibility.

Presenting The 'Piece' Framework for AI Integration in Agricultural Science Teacher Education Programme

Here the authors of the paper present the PIECE framework for integrating AI in agricultural science teacher education programme in Africa. PIECE encapsulates five key pillars: Professional training, Institutional readiness, Ethical considerations, Curriculum integration, and Evaluation of outcomes. Fig 1 showed the relationship of these pillars. Though it is possible to start the process with institutional readiness, ethical consideration or curriculum integration; the authors recommend starting with professional training, which will ensure the teachers and other stakeholders that will implement the blended curriculum are well trained and equipped to drive the AI revolution process. This training could be mounted by consultants contracted by the institutions. The end of such intensive training will culminate into identifying institutional gaps and needs for AI integration. These requirements should therefore be met, thereafter ethical issues would be considered prior to identifying and including the needed AI courses in the curriculum. When the blended curriculum is implemented, evaluation of impact is done after few years of implementation.

Professional Training: there is need to equip the current people delivering teacher education curriculum in Agriculture with relevant AI skills and competencies. Daher, (2025) asserted that many educators currently grapple with substantial obstacles in incorporating AI literacy into their teaching practices, primarily due to insufficient professional preparation and training.

Institutional Readiness: teacher education institutions need to develop policies to ensure seamless integration of AI in curriculum for agricultural science teachers. Availability of facilities needed for this integration is the sole responsibility of the institutions. Essentially, integrating AI in agricultural teacher education in Africa is faced with multiple challenges ranging from existence of strong Institutional policies, availability of needed IT equipment/facilities, and strong network availability. A recent global survey, which included over 450 schools and universities, revealed that fewer than 10% of them have established institutional policies or formal guidance regarding the use of generative AI applications (UNESCO, 2023).

Ethical Considerations: ethical considerations are very important in AI integration. Stakeholders must ensure the 'safe and protected' use of AI tools. Furthermore, educational stakeholders must be vigilant in monitoring and addressing emerging threats to data privacy and security, such as data breaches, phishing attacks, and malicious software, and take proactive measures to mitigate risks and enhance the resilience of educational systems and infrastructure against cyber threats (Slade, and Prinsloo, 2013; Mandinach, and Gummer, 2021).

Curriculum Integration: there must be systematic and wholistic AI integration in agricultural science teacher education programme. Curriculum experts must examine the curriculum and decide AI tools, techniques, packages that and needed by agricultural science teachers. These are built as courses to be integrated into the curriculum. These AI courses will be aimed at imparting the AI competencies needed by the teacher education students of agriculture.

Evaluation of Outcomes: curriculum evaluation is critical to assess the performance of any curriculum. Accordingly, outcome of the integration is expected to be observed in agricultural science teachers who passed through the curriculum with AI integration. The effectiveness in delivery and understanding concepts in agriculture are key to assessing outcome of AI integration.

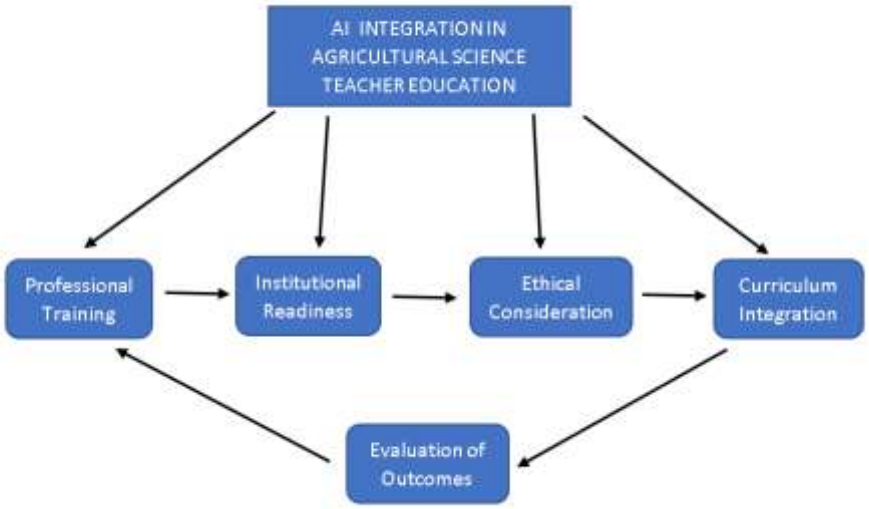

Fig 1: PIECE Framework for AI integration in Agric Teacher Education

CONCLUSION AND RECOMMENDATIONS

Integrating AI literacy into teacher education in agriculture is an urgent need for the present AI driven society. This paper employed a narrative literature review to explore the integration of AI in agricultural science teacher education, synthesizing insights from literature, successful initiatives, and counterarguments such as financial and ethical concerns. The PIECE framework was presented by the paper for AI integration in agricultural science teacher education. The five pillars were: professional training, institutional readiness, ethical consideration, curriculum integration, and evaluation of outcomes. Gaps identified from the evaluation will lead to modification at each stage for a continuous AI integration in agricultural science education curriculum. The following recommendations are posited:

- Establish AI resource centres for training and retraining of teachers.
- Need for collaboration with tech companies to provide infrastructure support for schools with limited connectivity.
- Identify Ai tools relevant in agricultural education programme
- Adopt AI implementation policy in teacher education institutions
- Use feedback from audits, global networks, and public platforms to continuously refine AI integration strategies.
- Conduct studies to measure outcomes in agricultural science teacher's performance, efficacy, and equity metrics.
- Redesign curricula to integrate AI ethics, embedding AI literacy into agricultural teacher education programme, with core modules on topics like algorithmic bias and data privacy.
- Develop written comprehensive guides for teachers on assessing and implementing AI tools, including ethical checklists and classroom strategies.

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