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ASSESSING THE EEFECTIVENESS OF AI-BASED INSTRUCTIONAL TOOLS IN TEACHING OF AGRICULTURAL SCIENCE IN COLLEGES OF EDUCATION IN DELTA STATE: LECTURERS' PERCEPTION

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Abstract

This study assessed the effectiveness AI-Based instructional tools in teaching of Agricultural Sciences in Colleges of Education (COEs) in Delta State, looking at the lecturers' perception. Three research questions guided the study. The study adopted a descriptive survey research design. The estimated population for this study comprised all the 68 Agricultural Science lecturers in the three public (one Federal and two State Government-owned) Colleges of Education in Delta State (that is: Federal College of Education (Technical), Asaba – 25 lecturers; Delta State College of Education, Mosogar – 26 lecturers; and Delta State College of Education, Warri – 17 lecturers). Sample size for the study comprised all the 68 lectures from the three COEs selected using a purposive sampling technique. The instrument for data collection was a researcher self-structured questionnaire titled "Effectiveness of AI-Based Instructional Tools in Teaching of Agricultural Science Questionnaire (EAIBITTASQ)" containing 29 items. Both validity and reliability of the questionnaire was established. Data collated were analyzed using mean ($\bar{x}$) statistics and standard deviation (SD) statistics in order to answer the research questions. Findings of the study revealed among others that the AI-based instructional tools such as the intelligent tutoring systems, adaptive learning platforms, Agricultural simulation and visualization tools and learning analytics dashboards can be effectively utilized in teaching Agricultural Science in COEs in Delta State. Based on the findings, it was recommended among others that the Government (both federal and state), educational policymakers and other important education stakeholders should assist the colleges of education in Delta State through adequate resource mobilization to provide the necessary digital infrastructure (reliable internet, functional ICT labs, intelligent tutoring systems, adaptive learning platforms, virtual simulations, VR/AR tools, AI-enhanced LMS, and mobile AI tools, among others) alongside clear policies for ethical and sustainable use of AI-based instructional tools in teaching of Agricultural Science. This will ensure equitable access and maximize the positive impact of AI tools towards promoting effectiveness of teaching and learning in Agricultural Science in the COEs.

Keywords: *Agricultural Science, AI-Based, Effectiveness, Instructional, Teaching, Tools.*

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Introduction

Agricultural Science is a course of study offered under the School of Vocational Education in the Colleges of Education (COEs), which equips the student-teachers with a broad knowledge and practical skills essential for improving food/crop production, livestock management, agribusiness, creating jobs and sustaining the environment. For student-teachers in the COEs, studying Agricultural Science not only prepares them for their careers in agriculture in order to be effective teachers and agents of transformation in both urban and rural communities; but also, for fostering self-reliance, problem-solving and national development. Adekunle and Fatunsin (2019) defined Agricultural Science as a multidisciplinary field concerned with the production of crops and animals, improvement of farming techniques, and sustainable use of agricultural resources. Ogunbameru (2001) explained that Agricultural Science is a branch of applied science that applies biological, physical, and social sciences in the practice of farming, livestock rearing, and natural resource management. With the above definitions, the effectiveness in the teaching of Agricultural Science in teacher education institutions like the COEs remains of utmost importance. Teaching on one hand, can be described as the practice of arranging contingencies of learning in such a way that learners are able to acquire knowledge, skills and values in a guided manner. It is a system of activities designed to facilitate the process of learning by providing conditions under which students can construct knowledge (Bruner, 1996). Effectiveness on the other hand, has been described by Boulmetis and Dutwin (2011) as a measure of how well goals are achieved, particularly, in educational and organizational settings. It is also the extent to which an intervention or strategy achieves its intended objectives under real-world conditions. Hence, enhancing effective teaching of Agricultural Science in the COEs requires the support of such technological devices as the Artificial Intelligence (AI). Besides, the COEs according to Ofojebe (2014), are teacher-training institutions mandated to provide academic and professional programmes that prepare individuals for effective teaching and research in Nigeria's education sector. The Federal Republic of Nigeria (FRN, 2014) in the National Policy on Education (NPE) acknowledged that the COEs are tertiary institutions established to produce highly motivated, conscientious and efficient classroom teachers for basic education. As regards, improvement of teaching and learning in the COEs cannot be actualized alone without the effective support of Information Technology (IT) such as the Artificial Intelligence (AI). The FRN (2014) further stressed that "teacher education programmes shall be structured to equip teachers for effective performance of their duties. Information Technology (IT) training shall be incorporated into all teacher-training programmes" (p.44). The incorporation of IT as one of the educational support services complimenting the Artificial Intelligence, is a means of promoting effectiveness of the educational system, enhancing teaching, providing conducive environment for learning, and promoting effective use of innovative materials in educational institutions (FRN, 2014, P.57). Thus, the integration of Artificial Intelligence (AI) which introduces the utilization of various types of AI-based instructional tools into educational contexts, is transforming approaches to teaching and learning across disciplines, including, in Agricultural Science.

The integration of AI in academic instructional delivery in education has been proven by most literatures to possess great potentials in the aspect of improving students' engagements, that is, behavioural, cognitive, emotional and social engagements leading to high academic

performances and achievements. AI deepens understanding of complex concepts and increases student engagement in science education broadly. AI-based instructional tools, such as: intelligent tutoring systems, simulations, chatbots and adaptive learning platforms, offer personalized feedback, simulation-based learning, and enhanced instructional responsiveness (Azcona et al., 2019; Balakrishnan, 2018; Koć-Januchta et al., 2020). The Artificial Intelligence (AI) as described in the works of Russell and Norvig (2021) is the science and engineering of making intelligent machines, especially, intelligent computer programs, capable of perceiving, reasoning, learning, and acting. Copeland (2020) also described AI as the simulation of human intelligence processes by machines, particularly, computer systems, including learning, reasoning, and self-correction. AI can also be defined as any theory, method, or technique that assists computers in analyzing, simulating, exploiting, and investigating human behaviour and thought processes. The primary goal of AI is to build an intelligent system capable of performing tasks that humans were previously incapable of performing intelligently. From the foregoing explanations, utilization of AI-based instructional tools in teaching a course or subject like Agricultural Science in such teacher education institution like the Colleges of Education (COEs), play significant role in enhancing effective instructional delivery, promoting students learning and academic performance. AI-based instructional tools in higher education include intelligent tutoring systems, adaptive learning platforms, learning analytics dashboards, generative-AI assistants (e.g., chatbots), virtual/remote labs and simulations, automated assessment/feedback systems, and recommendation engines. Bond et al. (2024), Copeland (2020), Financial Times (2025), and Russell and Norvig (2021) provided some examples of AI-based instructional tools which can be effectively utilized to enhance teaching and learning in Agricultural Science in tertiary education institutions, including, COEs and they include: Intelligent Tutoring Systems (ITS) and Adaptive Learning Systems (ALS) which provides personalized guidance to student-teachers in Agricultural Science, by simulating one-on-one tutoring in topics like soil management and crop production, and providing scaffolded practice (e.g. adaptive quizzes on soil fertility, crop management modules). Such platforms increase opportunities for mastery learning in mixed-ability COE cohorts and can be integrated into Learning Management System (LMS) workflows. AI-powered simulations and virtual labs is an AI-based instructional tool which enable student-teachers in Agricultural Science to conduct virtual farm experiments, such as: pest control, irrigation management and livestock feeding. Also, crop growth models, pest-management simulators and virtual soil-testing labs allow student-teachers to experiment safely with management choices and see consequences across seasons, an affordance, particularly, valuable where physical field access is limited. Reviews of AI in agriculture emphasize simulations as a core pedagogy-enhancing technology (Zhou et al. 2020; Frontiers, 2024). Chatbots (Virtual Assistants) and Conversational (LLM) Assistants offer instant answers to students' questions on agricultural concepts, providing supplementary explanations outside classroom hours. Studies of agriculture students using generative AI show that these tools can accelerate tasks such as programming or technical write-ups when used responsibly and with educator oversight.

Adaptive Learning Platforms (e.g. Knewton, Smart Sparrow), tailors learning materials on crop science or animal husbandry to individual student-teachers' learning pace. Automated grading systems help lecturers grade quizzes and assignments related to agricultural practices quickly, saving time for feedback. Image-based recognition systems/computer vision tools (e.g.

Plantix-style systems), assist students in identifying and diagnosing plant/crop diseases, pests and nutrient deficiencies using uploaded plant or leaf images. This mobile/web apps serve both as teaching aids and field-decision tools; and they convert real agricultural problems into class activities and case studies. Recent reviews document high accuracy of image-based detection pipelines and strong pedagogical value when embedded in lab and field assignments (Frontiers, 2024). Another AI-based instructional tool used in Agricultural Science is the AI-driven data analytics tools which analyzes agricultural research data, allowing students to interpret soil fertility results and crop yield patterns. Speech recognition tools (e.g. voice assistants like Alexa/Google Assistant) which supports voice-enabled learning where students ask questions and receive audio explanations about farming practices. There is also an Automated Assessment and Feedback Systems tool useful for auto-marking of objective items, rubric-assisted scoring, and the automated formative feedback tool, shorten feedback loops so that students can iterate on reports and farm plans faster, which is important for courses with large cohorts and limited lecturer grading capacity (Zhou et al. 2020). Other AI-based instructional tools further include: the AI-based Virtual Reality (VR), Augmented Reality (AR) and Immersive Environments, which provides immersive farm experiences, such as operating machinery or exploring livestock management virtually. Where available, AR/VR can simulate equipment operation, farm layouts, or animal handling safely; however, these are often limited by cost and infrastructure in COEs. Pilots show high engagement but require durable planning and resources (Zhou et al. 2020). Predictive/Prescriptive Analytics tools also help students simulate future crop production outcomes based on weather, soil and fertilizer inputs. For instance, these models help demonstrate how inputs (fertilizer, planting date, irrigation) influence yield under different scenarios, which is useful for lessons on decision trade-offs and simulation labs. There are also Hybrid tools (Domain AI + Pedagogy) which are tools that combine domain AI (e.g. pest identification) with pedagogical scaffolds (guided inquiry prompts, reflection tasks) in order to produce the strongest instructional alignment because they convert raw AI outputs into learning experiences. Hence, all the above AI-based instructional tools showcase that they can effectively be utilized in enhancing the teaching and learning of Agricultural Science in the COEs in Delta State. From all the foregoing discussions, effective teaching with AI-based instructional tools has great advantages and benefits in terms of their effectiveness in enhancing Agricultural Science lecturers' instructional delivery likewise improves student-teachers' learning engagements and academic performance. In agricultural science education, educational technologies have been embraced to effectively meet the increasing demand for practical, interactive training; and AI is the next frontier.

Observations from a global scoping review document has shown the effectiveness in incorporation of educational technologies such as simulations, digital games and online learning in agricultural disciplines, which continues to lead to better student interest, retention and critical thinking (Xu et al., 2023). However, focused investigations into AI-based tools, especially, within tertiary agricultural education in regions like Nigeria, remain limited, indicating a gap in empirical literature. Furthermore, other scholarly literature identified several mechanisms by which AI tools enhance lecturers' instructional delivery and they include: automation of routine tasks (grading, quiz generation), rapid formative feedback, adaptive materials for differentiated instruction, and access to richer, data-driven examples (simulations, diagnostics) that make

explanations concrete (e.g. visualizing pest progression under different management regimes). These mechanisms reduce time-burdens and enable lecturers to focus on higher-order pedagogical tasks such as designing authentic assessments and mentoring practicum students. Empirical syntheses in higher education confirm consistent instructor-level benefits in planning efficiency and feedback timeliness (Zhou et al. 2020). Evidence from education and agriculture studies on AI interventions in tertiary settings reported reliable improvements in instructor-reported outcomes (in terms of: task efficiency, ability to provide individualized feedback) and student outcomes when AI is integrated with instructional redesign. Agriculture-specific work (simulation trials, case studies) also showed that when lecturers embed AI simulations into lesson sequences and align assessment to simulation tasks, students demonstrate clearer application of agronomic principles, suggesting a real pedagogy–technology synergy timeliness (Zhou et al. 2020; Frontiers, 2024). In the aspect of AI-based instructional tools effectiveness in improving student-teachers' learning engagements and academic performance in Agricultural Science, evidence from several literatures like those of Luo, Zheng, Yin and Teo (2025) shows that AI is also the next frontier. A recent synthesis of reviews in higher education confirms that AI is most often deployed for adaptive/personalized learning, automated or AI-supported feedback, and intelligent tutoring. Reported benefits include improved learner performance on course assessments, faster feedback loops and efficiencies in course/material preparation by instructors; however, authors urge cautious integration, emphasizing transparency, ethics and support for critical thinking (Bond et al, 2024). In improving engagement effects (behavioural, cognitive, affective), empirical reviews of Luo et al (2025) reported that AI tools, particularly, simulations, adaptive systems and conversational agents, can increase student engagement by providing interactive, immediate and personalized learning paths. In Agricultural Science, simulation-based tasks and image-diagnosis activities are especially effective at increasing situational interest and problem-solving engagement because they present authentic, context-rich problems similar to real farm decision-making. Studies of agriculture students using generative AI and simulation tools document improved task completion rates, faster iteration on assignments, and higher self-reported engagement when instructors scaffold activities (Zhou et al. 2020).

In the connection to effectiveness of AI-based instructional tools in improving student-teachers' academic performance and skill transfer, meta-analyses of AI interventions in higher education have indicated small–to-moderate positive effects on short-term academic performance (test scores, assignment quality) when AI supports formative practice and timely feedback. Agriculture-domain trials (e.g. simulation pilots, guided diagnostic exercises) show improved conceptual understanding and decision accuracy in controlled comparisons. However, literature consistently cautions that transfer from simulated tasks to real-world practicum outcomes (e.g. field placement performance) is not automatic; transfer requires explicit bridging activities, supervised practicum alignment, and opportunities for reflection and calibration against real contexts (Zhou et al. 2020; Frontiers, 2024). Indicating a notable progress in utilizing AI-based tools which surfaced within the Nigerian context, specifically, in the Niger Delta region of Nigeria, according to Amanze (2025), demonstrated that AI-powered agro-science simulations significantly improved university students' comprehension and practical application of agricultural concepts through quasi-experimental designs (pre-test/post-test groups). Similarly, Gen-AI systems such as AgroLLM, using large language models, delivered highly accurate and

contextually relevant agricultural information (up to 93% accuracy) across key agriculture domains, suggesting great potential for enhancing knowledge transfer and decision-making in agriculture education (Financial Times, 2025). Notwithstanding, the benefits of AI-based instructional tools in education system, its effectiveness in teaching and learning of Agricultural Science in the COEs depends strongly on contextual enablers such as reliable electricity and connectivity, institutional procurement of digital technologies and licensing, coherent professional development, and policy guidance on ethical and pedagogical use, among other factors. Several Nigerian studies and policy briefs highlight that lecturers' gains are muted where training is ad-hoc and where institutional supports (time, technical help, assessment redesign) are not provided. In other words, tools on their own rarely transform instruction; structured capacity building and institutional incentives are required. Within Delta State, Nigeria, agricultural education institutions, particularly, Colleges of Education (COEs), play a critical role in preparing student-teachers for Agricultural Science. However, studies at the University of Delta (formerly COE Agbor) indicate only moderate technology integration, challenging factors include inadequate infrastructure, limited funding, occasional resistance to change, and disparities in usage between faculty and students (Perculiar & Okoh, 2025). Additionally, broader studies in Nigeria have identified significant infrastructural limitations, unequal access, concerns about privacy, and digital literacy gaps in educational AI adoption (Okolie & Egbon, 2025). The World Bank (2024) also raised issues of equity, access, and validity as areas of concerns. According to the World Bank, gains are unevenly distributed when students lack device access, data bundles, or digital literacy, and these issues have been documented in Nigerian digital literacy assessments and higher-education capacity studies. Moreover, reliance on generative models without verification can propagate inaccuracies; lecturers must teach AI-evaluation skills (how to validate AI outputs) alongside content. These equity and validity issues moderate the effectiveness of AI for improving academic outcomes across the whole student population, thus, having implications for practice in COEs. Therefore, to lecturer and student benefits, COEs should adopt an AI-in-pedagogy approach (training that pairs tool use with lesson redesign), institute implementation-fidelity monitoring (lesson artifacts, analytics), and revise assessment practices, so that AI-mediated formative work maps onto summative practicum requirements.

UNESCO's AI Competency Framework for Teachers indicated building teacher competencies across AI pedagogy, ethics, and AI-for-professional learning, an actionable template for COE professional development programmes (UNESCO, 2024). Also, the National Commission for Colleges of Education (NCCE, 2013) issues minimum standards and establishment requirements that anchor its programme quality; indicating expectations for instructional quality, curriculum alignment and teaching practice, levers into applying AI-enabled methods that can be integrated into teaching with appropriate guidance. Emerging practice reports from universities and national committees (inside and outside Nigeria) also highlight the need for balanced approaches, enabling AI for learning while safeguarding critical thinking, integrity, and equitable access, useful templates for COEs designing institutional policies and staff training (The Times of India, 2025). Collectively, the present study indicated three critical insights showcasing that AI-based instructional tools can enhance learning outcomes, academic engagements and conceptual mastery in science, and increasingly, in agricultural education. Also, Agricultural science education in Nigeria, particularly, in the Niger Delta region, shows early yet

promising adoption of AI tools, but empirical evidence on effectiveness remains scarce. However, COEs in Delta State, as pivotal institutions for teacher training in Agricultural Science, face infrastructure, capacity, and policy limitations, therefore, creating both barriers and opportunities for AI adoption. Never minding all odds and challenges, it is important that stakeholders in teacher education sector embrace and adopt the use of AI-based instructional tools in order to enhance effectiveness of teaching and instructional delivery, likewise, promote student learning engagement and academic performance. Thus, the researcher is motivated to conduct a field investigation in order to assess and address issue connected to the effectiveness of AI-Based instructional tools in the teaching of Agricultural Science in Colleges of Education (COEs) in Delta State.

Statement of the Problem

Across higher education, Artificial Intelligence (AI)–based instructional tools, such as: adaptive learning systems, intelligent tutoring, virtual/simulated labs, chatbots, automated assessment/feedback, and learning analytics, are increasingly promoted for improving teaching quality and student outcomes. However, the reality in Colleges of Education (COEs) in Delta State indicates a persistent mismatch between this promise and day-to-day practice in Agricultural Science teacher education. Many Agricultural Science lecturers still rely on conventional lecture-dominant methods with limited use of interactive technologies; where AI tools are present, they are used inconsistently, often without clear pedagogical integration, and rarely aligned to course learning outcomes. Moreover, institutional constraints such as uneven connectivity and device access, irregular power supply, limited professional development, and lack of explicit guidelines for ethical and effective AI use, raise questions about the effectiveness of utilizing AI-based tools in enhancing instructional delivery and student-teachers' learning engagements and performance in Agricultural Science. Empirical evidence in the Delta State COEs within this specific context, is particularly scarce. Existing campus or state-level technology initiatives seem to report inputs (procurement, trainings) or broad perceptions (attitudes, readiness) rather than rigorously measured effects on teaching quality and student learning.

In Agricultural Science, a practice-oriented field where mastery of concepts (e.g. soil fertility, agroecology, pest/disease management) must translate into classroom/laboratory competence, there is little verified information on types of AI-based instructional tools used in teaching, how they are integrated into lessons and assessments, whether they increase lecturers' effectiveness (e.g. differentiation, feedback quality, assessment validity), and the extent to which they improve student-teachers' behavioural including cognitive engagements and academic achievement. Additionally, much of the available discussion around AI in education within Nigeria is system-wide and descriptive, emphasizing opportunities and challenges, but not providing discipline-specific, context-sensitive evaluations. Without credible local evidence from Agricultural Science programmes in COEs, institutional leaders and policy makers lack the guidance needed to decide which AI-based tools to prioritize, how to scaffold lecturer capacity, how to safeguard academic integrity and data privacy, and how to allocate scarce resources for maximum instructional impact. Consequently, there is a critical need for a focused, evidence-based assessment of AI-based instructional tools in the teaching of Agricultural Science within

COEs in Delta State, one that identifies the tools in use or feasible for use, evaluates their effectiveness on lecturers' instructional delivery, and determines their significant impact on student-teachers' engagement and academic performance using valid measures. This study sought to address some theoretical and knowledge gaps by identifying types of AI-based instructional tools relevant to Agricultural Science in Delta State COEs, coupled with their effectiveness in enhancing lecturers' instructional delivery including student-teachers' learning engagement and academic performance. Thus, assessing the effectiveness of Artificial Intelligence (AI)-Based instructional tools in teaching of agricultural science in Colleges of Education (COEs) in Delta State is the problem of this study.

Purpose of the Study

The purpose of this study was to assess lecturers' perception of the effectiveness of Artificial Intelligence (AI)-Based instructional tools in teaching of agricultural science in Colleges of Education (COEs) in Delta State. Specifically, the objectives of this study sought to examine lecturers' perception of the:

1. various types of AI-based instructional tools that can be effectively utilized in the teaching of Agricultural Science in COEs in Delta State.
2. effectiveness of AI-based instructional tools in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta Stat.
3. effectiveness of AI-based instructional tools on student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State.

Research Questions

The following three research questions guided the study:

1. What are the various types of AI-based instructional tools that can be effectively utilized in the teaching of Agricultural Science in COEs in Delta State?
2. How effective are AI-based instructional tools in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta State?
3. How effective are AI-based instructional tools in improving student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State?

Methods

This study adopted a descriptive survey research design. This design is considered appropriate because the study sought to gather data from a large population of Agricultural Science lecturers in Colleges of Education (COEs) in Delta State on their experiences, perceptions and opinions regarding the effectiveness of AI-based instructional tools in teaching of agricultural science in Colleges of Education (COEs) in Delta State. According to Creswell and Creswell (2023), descriptive survey designs are suitable for investigating current practices, attitudes, and challenges in natural educational settings without manipulation of variables. The estimated population for this study comprised all the 68 Agricultural Science lecturers in the three public (Federal and State Government-owned) Colleges of Education in Delta State (that is: Federal College of Education (Technical), Asaba – 25 lecturers; Delta State College of Education, Mosogar – 26 lecturers; and Delta State College of Education, Warri – 17 lecturers) (Source:

Department of Agricultural Education in the three colleges, 2025). Sample size for the study comprised all the 68 lectures selected using a purposive sampling technique to ensure that lecturers from the three COEs were adequately represented. It was convenient for the researcher to sample all the lecturers because of their number. Nworgu (2015) opined that the purposive sampling techniques is applied based on the researcher's discretion. The instrument for data collection was a researcher self-structured questionnaire titled "Effectiveness of AI-Based Instructional Tools in Teaching of Agricultural Science Questionnaire (EAIBITTASQ)" containing 29 items. The questionnaire which was constructed alongside with the purpose of the study and research questions was divided into three sections in order to determine the types of AI-based instructional tools utilized in teaching Agricultural Science; effectiveness of AI-based tools in enhancing lecturers' instructional delivery, and effectiveness of AI-based tools in improving student-teachers' learning engagement and academic performance. Items on the questionnaire was designed using a 4-point rating scale ranging from Strongly Agree (SA) – 4 points, Agree (A) – 3 points, Disagree (D) – 2 points, to Strongly Disagree (SD) – 1 point. The questionnaire was subjected to face and content validity by three experts, that is, one expert in Agricultural Education, one in Educational Technology and one Measurement and Evaluation expert from Faculty of Education, Nnamdi Azikiwe University (NAU), Awka, Anambra State. Their corrections were incorporated to improve clarity, relevance, and alignment with the study's objectives. To establish the reliability of the instrument, a pilot test was conducted on 20 Agricultural Science lecturers from one College of Education outside Delta State. The data gathered after computation were measured using the Cronbach Alpha method which gave internal consistency reliability values of 0.73, 0.77 and 0.79 for the three clusters respectively; which were added up and divided to generate an overall reliability coefficient value of 0.76, showcasing high internal consistency of the instrument, equally considered acceptable and reliable to gather data for the study (Taber, 2018). The researcher, with the assistance of three research assistants who were lecturers from the respective COEs sampled, administered the questionnaire physically and in person to the respondents through a direct and hand delivery process. This method was preferred to ensure high return rates and clarification of items when necessary. The research assistants were briefed about the purpose of the study and directed on how to collect the necessary data from their colleagues. Distribution of the questionnaire to the respondents took a period of one week before retrieval and compilation for final computation using appropriate data analysis. All the 68 copies of the questionnaire distributed to the lecturers were retrieved at a 100% rate o return. Data collated were analyzed using descriptive statistics such as frequency counts, mean statistics rated at 2.50 and standard deviation statistics in order to answer the research questions. The decision rule was that any mean score of 2.50 and above was used as the benchmark for acceptance of each item as agree; while any mean score below 2.50 was considered as disagree.

Results

Research Question 1: What are the various types of AI-based instructional tools that can be effectively utilized in teaching Agricultural Science in COEs in Delta State?

Table 1: Mean Scores and SD of Respondents concerning the Various Types of AI-Based Instructional Tools that can be Effectively Utilized in the Teaching of Agricultural Science in COEs in Delta State.

N = 68 Lecturers

S/N	Please indicate your level of agreement with each statement concerning the various types of AI-Based instructional tools which can effectively be utilized in teaching agricultural science in your institution	SA	A	D	SD	X	SD	Decision
1	Intelligent tutoring systems including adaptive learning platforms (systems that adapt content to learners' levels)	23	29	10	6	3.01	0.92	Agree
2	Agricultural simulation and visualization tools (e.g. AI-driven crop growth simulators, lab simulations, virtual labs) used for practical teaching in Agricultural Science	25	30	5	8	3.06	0.95	Agree
3	Learning analytics dashboards (progress/engagement tracking)	18	27	13	10	2.78	1.00	Agree
4	AI-based tutoring systems (e.g. Chatbots, conversational AI, Virtual Assistants/ large language model assistants) for Q&A, lesson prompts in Agricultural Science instruction	22	26	14	6	2.94	0.94	Agree
5	AI-enabled assessment and feedback tools (automated grading, adaptive quizzes, auto-marking, instant feedback) utilized in Agricultural Science classes	17	28	12	11	2.75	1.01	Agree
6	Mobile AI apps for agriculture (pest diagnosis, soil testing guidance)	20	32	6	10	2.91	0.98	Agree
7	Geographic Information Systems (GIS) / remote sensing AI tools taught or demonstrated in course	16	31	9	12	2.75	1.01	Agree
8	Augmented Reality (AR) including Virtual Reality (VR) tools for experiential learning	21	28	12	7	2.93	0.94	Agree
9	AI-powered learning management systems (LMS) such as Moodle, Google Classroom with AI plugins used in Agricultural Science teaching	19	25	10	14	2.72	1.08	Agree

Overall Mean Score & SD = 2.87 | 0.99 | Agree

Analysis of data in Table 1 revealed the various types of AI-based instructional tools that can be effectively utilized in teaching Agricultural Science in COEs in Delta State. The result further indicated that all the items from 1 - 9 were rated above the acceptable mean score of 2.50 by the Agricultural Science lecturers to show that they agreed with all the statements. None of the items were rated below the acceptable mean score of 2.50 by the lecturers to show that they disagreed with any of the statements. The grand mean of 2.87 and standard deviation (SD) of 0.99 indicates closeness in the responses of the Agricultural Science lecturers showcasing that all these AI-based instructional tools can be effectively utilized in teaching Agricultural Science in COEs in Delta State.

Research Question 2: How effective are AI-based instructional tools in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta State?

Table 2: Mean Scores and SD of Respondents concerning the Effectiveness of AI-Based Instructional Tools in Enhancing Agricultural Science Lecturer's Instructional Delivery in COEs in Delta State.

N = 68 Lecturers

S/N	Please indicate your level of agreement with each statement concerning the effectiveness of AI-Based instructional tools in your instructional delivery in agricultural science in your institution	SA	A	D	SD	X	SD	Decision
10	AI-based tools help to personalize teaching to suit learners' needs	16	39	9	4	2.99	0.78	Agree
11	Integration of AI tools increases instructional creativity likewise productivity	25	23	13	7	2.97	0.98	Agree
12	AI-based instructional tools make Agricultural Science lesson preparation including planning easier and faster for more efficient delivery	21	32	10	5	3.01	0.87	Agree
13	Use of AI tools enhances clarity likewise quality of lesson delivery	28	26	5	9	3.07	1.00	Agree
14	It improves lecturers' efficiency to give students faster feedback	25	33	7	3	3.18	0.78	Agree
15	AI tools allow better differentiation for mixed-ability student groups	18	29	11	10	2.81	0.99	Agree
16	Using AI tools improves assessment practices (item quality, consistency)	15	30	19	4	2.82	0.84	Agree
17	It reduces routine workload (e.g. marking, administrative tasks)	20	27	12	9	2.85	0.99	Agree
18	Using AI tools increase the relevance and practicality of instructional examples (e.g. local agro-cases)	26	31	6	5	3.15	0.86	Agree

Overall Mean Score & SD = 2.98 | 0.91 | Agree

Analysis of data in Table 2 revealed the effectiveness of AI-based instructional tools in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta State. However, the result indicated that all the items from 10 - 18 were rated above the acceptable mean score of 2.50 by the Agricultural Science lecturers to show that they agreed with all the statements. None of the items were rated below the acceptable mean score of 2.50 by the lecturers to show that they disagreed with any of the statements. The grand mean of 2.98 and standard deviation (SD) of 0.91 indicates closeness in the responses of the Agricultural Science lecturers showcasing that the AI-based instructional tools were effective in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta State.

Research Question 3: How effective are AI-based instructional tools in improving student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State?

Table 3: Mean Scores and SD of Respondents concerning the Effectiveness of AI-Based Instructional Tools in Improving Student-Teachers' Learning Engagement and Academic Performance in Agricultural Science in COEs in Delta State.

N = 68 Lecturers

S/N	Please indicate your level of agreement with each statement concerning the effectiveness of AI-Based instructional tools in improving students learning engagement and academic performance in agricultural science in your institution	SA	A	D	SD	X	SD	Decision
19.	AI-supported lessons increase student-teachers' emotional engagement (affective) likewise interest in Agricultural Science topics	27	26	9	6	3.09	0.94	**Agree**
20.	**AI tools help improve students' conceptual including cognitive understanding of practical agricultural topics such as pest management, soil analysis, etc**	18	25	10	15	2.68	1.09	**Agree**
21.	**They assist to foster students' problem-solving including decision-making skills relevant to agriculture science**	17	28	18	5	2.84	0.88	**Agree**
22.	Students with limited prior knowledge benefit more from AI-guided instruction than from conventional lectures	20	19	13	16	2.63	1.14	**Agree**
23.	Students trust AI outputs in order to incorporate them into practical assignments (e.g. field plans)	22	30	11	5	3.01	0.88	**Agree**
24.	**AI tools promote collaborative learning among student-teachers in their group tasks including peer feedback**	21	27	14	6	2.93	0.93	**Agree**
25.	Adopting AI tools reduce students' anxiety about practical/lab work by providing safe simulations	25	21	12	10	2.90	1.06	**Agree**
26.	Students are more actively engaged (in terms of their participation, on-task behaviour) during AI-enhanced class activities	31	26	3	8	3.18	0.97	**Agree**
27.	Students' course performance (assessment scores) is highly improved in Agricultural Science when AI tools are used	23	27	9	9	2.94	1.00	**Agree**
28.	The use of AI-driven tools has positively impacted students' academic performance in practicum likewise school placement tasks	19	29	7	13	2.79	1.05	**Agree**
29.	Students are individually more motivated to learn Agricultural Science when AI-based instructional tools are applied	26	22	5	15	2.87	1.15	**Agree**
Overall Mean Score & SD =						**2.90**	**1.02**	**Agree**

Analysis of data in Table 3 revealed the effectiveness of AI-based instructional tools in improving student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State. Hence, the result indicated that all the items from 19 - 29 were rated above the acceptable mean score of 2.50 by the Agricultural Science lecturers to show that they agreed with all the statements. None of the items were rated below the acceptable mean score of 2.50 by the lecturers to show that they disagreed with any of the statements. The grand mean of 2.90 and standard deviation (SD) of 1.02 indicates closeness in the responses of the Agricultural Science lecturers showcasing that the AI-based instructional tools were effective in improving student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State.

Discussion of Findings

It was discovered through the findings of this study that all the AI-based instructional tools can be effectively utilized in teaching Agricultural Science in COEs in Delta State. This includes that such AI-based instructional tools as: the Intelligent tutoring systems including adaptive learning platforms (systems that adapt content to learners' levels), Agricultural simulation and visualization tools (e.g. AI-driven crop growth simulators, lab simulations, virtual labs), Learning analytics dashboards (progress/engagement tracking), AI-based tutoring systems (e.g. Chatbots, conversational AI, Virtual Assistants/ large language model assistants), AI-enabled assessment and feedback tools (automated grading, adaptive quizzes, auto-marking,

instant feedback), Mobile AI apps for agriculture (pest diagnosis, soil testing guidance), Geographic Information Systems (GIS) / remote sensing AI tools, Augmented Reality (AR) and Virtual Reality (VR) tools, AI-powered learning management systems (LMS) such as Moodle, Google Classroom with AI plugins; can be effectively utilized for practical teaching, Q&A and lesson prompts, and for experiential learning in Agricultural Science in the COEs. This finding corroborates and agrees with recent study of Luo, Zheng, Yin and Teo (2025) which discovered that higher education increasingly deployed adaptive/ITS platforms, simulations/virtual labs, learning analytics (LA) dashboards, chatbots/LLMs, AI-assisted assessment, mobile AI field apps, GIS/remote sensing, AR/VR, and AI-enabled LMS in complementary ways. This finding also aligns with the systematic reviews of Aguilar and John (2023) which confirmed three dominant instructional roles using AI-based tools: personalization (adaptive/ITS), assessment & rapid feedback (auto-grading, AI-feedback), and decision support/analytics (dashboards, predictive tools), a pattern that maps neatly onto Agricultural Science needs where authentic, data-rich, and practice-oriented learning is crucial (e.g. pest diagnosis, irrigation scheduling, soil analysis). The present study collaborates and does not deviate with the previous empirical studies' findings of Adeyemi, Ma, Xu and Landaverde (2024) and Sharma and Gupta (2025) which indicated that in agriculture specifically, simulation and computer vision–based tools (e.g. plant disease diagnosis from images) were highlighted as high-value for practical teaching, while AR/VR was promising for safe, experiential training where access to equipment/fields were limited.

It was revealed through this finding that the AI-based instructional tools were effective in enhancing Agricultural Science lecturers' instructional delivery in COEs in Delta State. The AI-based tools help to personalize teaching to suit learners' needs, increases instructional creativity likewise productivity, makes Agricultural Science lesson preparation including planning easier and faster for more efficient delivery, enhances clarity and quality of lesson delivery, improves lecturers' efficiency to give students faster feedback, allows better differentiation for mixed-ability student groups, improves assessment practices (item quality, consistency), reduces routine workload (e.g. marking, administrative tasks), and increase the relevance and practicality of instructional examples (e.g. local agro-cases). This finding is consistent with those of Abrahamson, DiSessa and Stamper (2024) which indicated small-to-moderate positive effects on learning when AI is embedded in well-designed pedagogy and document instructor-level efficiency gains from automation (quiz/item generation, auto-grading), AI-assisted feedback, and analytics-informed differentiation, freeing time for higher-order mentoring and assessment redesign. The findings of previous empirical studies of Chen, Li & Zhang (2025) and Di Mitri, and Martinez-Maldonado (2023) confirmed that dashboards assisted instructors to identify at-risk students, tailor supports and monitor implementation fidelity. This present study finding also aligns and concurs with those of Kim and Park (2024) study whose evidence on AI-assisted assessment and feedback demonstrated improved feedback timeliness, consistency and support for rubric-based assessment quality, provided staff receive training and ethical guidance. In agriculture education, simulation-anchored lesson sequences have been linked to clearer application of agronomic principles and richer case-based explanations which is consistent with the present study's finding of improved clarity and practicality using local agro-cases.

Finally, it was also discovered that the AI-based instructional tools were effective in improving student-teachers' learning engagement and academic performance in Agricultural Science in COEs in Delta State. In essence, utilizing AI-based instructional tools in Agricultural Science were effective in improving student-teachers' learning engagement and academic performance by increasing student-teachers' emotional engagement (affective) and interest in Agricultural Science topics. AI tools help to improve students' conceptual including cognitive understanding of practical agricultural topics such as pest management, soil analysis, etc. They assist to foster students' problem-solving including decision-making skills relevant to agriculture science. Students with limited prior knowledge benefit more from AI-guided instruction than from conventional lectures. Students also trust AI outputs in order to incorporate them into practical assignments (e.g. field plans). AI tools further promote collaborative learning among student-teachers in their group tasks including peer feedback. Adopting AI tools reduce students' anxiety about practical/lab work by providing safe simulations. Students are more actively engaged (in terms of their participation, on-task behaviour) during AI-enhanced class activities. Students' course performance (assessment scores) is highly improved in Agricultural Science when AI tools are used. The use of AI-driven tools has positively impacted students' academic performance in practicum likewise school placement tasks. Students are individually more motivated to learn Agricultural Science when AI-based instructional tools are applied.

This finding is in consonance and corresponds with the findings of recent studies on meta-analyses of Generative-AI/chatbot interventions, and simulation studies like those of Gamage and Whitelock-Wainwright (2025), Ha and Lee (2025), Sanyal and Kuri (2024) which indicated small-to-moderate positive effects on performance and motivation, especially, when AI supports formative practice, rapid feedback and scaffolded problem-solving. In agriculture contexts, students employing generative AI and domain-specific tools to prototype code, plan field tasks, and analyze diagnostics, with higher interest, more on-task behaviour, and better conceptual understanding when instructors explicitly scaffold evaluation/validation of AI outputs. Simulation studies in agricultural sciences also associated AI usage with gains in critical and creative thinking, reduced anxiety around practical work (safer practice before labs/field), and improved decision-making in authentic scenarios, echoing the present study finding that students with weaker prior knowledge benefit disproportionately from structured AI guidance. However, that transfer to practicum/placement performance improved mostly when simulations and chatbot support are paired with reflection prompts, authentic assessments and supervised field calibration, is equally a design implication for COEs seeking durable effects. This present study also corroborates with the findings of Johnson, Doss and Estepp (2024) study which confirmed that undergraduate agriculture students can successfully use generative AI chatbots/ ChatGPT to write microcontroller programs and that successful task completion increased student self-efficacy for writing microcontroller programs, likewise, attitudes toward generative AI.

Conclusion

The study investigated the effectiveness of AI-based instructional tools in teaching Agricultural Science in Colleges of Education (COEs) in Delta State. The findings established that a wide range of AI tools, including, intelligent tutoring systems, adaptive learning platforms, AI-powered simulations, learning analytics dashboards, chatbots, automated assessment systems, mobile agricultural apps, GIS/remote sensing, AR/VR tools, and AI-powered LMS, are available and can be effectively utilized in teaching Agricultural Science. These tools were found to significantly enhance lecturers' instructional delivery by supporting personalized teaching, reducing routine workload, making lessons more interactive, data-driven and student-centered, enhancing lesson clarity and improving assessment and feedback practices. Furthermore, AI-based tools were found to enhance student-teachers' learning engagement, motivation and academic performance, particularly, by stimulating interest in Agricultural Science, improving conceptual understanding, reducing practical-related anxiety, providing personalized feedback and experiential learning, and promoting collaborative and problem-solving skills. The study concluded that integrating AI-based instructional tools into Agricultural Science instruction has the potential to transform teaching practices and learning outcomes in COEs in Delta State. In essence, AI-based instructional tools have proven to be transformative in reshaping Agricultural Science education in COEs, bridging the gap between theory and practice, while equipping future teachers with the competencies needed to thrive in an AI-driven agricultural sector. Therefore, a more structured and systematic approach towards integrating AI-based instructional tools in education is necessary for sustainable improvements in teacher effectiveness and student outcomes. Hence, the recommendations made.

Recommendations

Based on the findings of this study, the following recommendations were proffered:

1. Government (both federal and state), educational policymakers and other important education stakeholders should assist the colleges of education in Delta State through adequate resource mobilization to provide the necessary digital infrastructure (reliable internet, functional ICT labs, intelligent tutoring systems, adaptive learning platforms, virtual simulations, VR/AR tools, AI-enhanced LMS, and mobile AI tools, among others) alongside clear policies for ethical and sustainable use of AI-based instructional tools in teaching of Agricultural Science. This will ensure equitable access and maximize the positive impact of AI tools towards promoting effectiveness of teaching and learning in Agricultural Science in the COEs.
2. The college management through adequate financial support and encouragement from their regulatory agency, that is, the National Commission for Colleges of Education (NCCE) and strong collaboration with relevant private sector should organize regular professional development training programmes such as workshops, physical and online training including guided practice and job coaching, to equip Agricultural Science lecturers with the technical competence and pedagogical skills required for effective utilization of AI-based instructional tools to positively impact on the effectiveness of teaching delivery. This will equally enhance their creativity, productivity and efficiency in instructional delivery as regards to supporting personalized teaching, reducing routine workload, making lessons more interactive, data-driven and student-centered, and improving assessment likewise feedback practices.

3. Through effective collaborations, government including NCCE, curriculum developers and COE management should effectively integrate AI-based instructional tools into Agricultural Science curricula systematically, as basic standard to improve the effectiveness of student learning engagement, academic performance and positive outcomes in areas of stimulating their interest in Agricultural Science, improving conceptual understanding, reducing practical-related anxiety, providing personalized feedback and experiential learning, among others.

References

Abrahamson, D., DiSessa, A. A. & Stamper, J. (2024). Have learning analytics dashboards lived up to the hype? A systematic review. *Proceedings of the ACM on Human-Computer Interaction*, *8* (LAK), 1–36. https://doi.org/10.1145/3636555.3636884.

Adekunle, O. & Fatunsin, O. (2019). Agricultural science education and sustainable development in Nigeria. *Journal of Agricultural Extension, 23* (2), 45–56.

Adeyemi, A. E., Ma, S., Xu, Z. & Landaverde, R. (2024). Outcome-based use of simulation in agricultural sciences: A systematic literature review. *Journal of Agricultural Education*, *65* (3), 75–98. https://files.eric.ed.gov/fulltext/EJ1450442.pdf.

Aguilar, S. J. & John, M. (2023). Learning analytics dashboards are increasingly becoming about learning and not just analytics: A systematic review. *Education and Information Technologies, 28*, 12963–12994. https://doi.org/10.1007/s10639-023-12401-4.

Amanze, P. C. (2025). AI-powered agro-science simulations: Enhancing comprehension and application among university students in the Niger Delta region of Nigeria. *Asian Journal of Education and Social Studies, 51* (6), 200–213. https://doi.org/10.9734/ajess/2025/v51i61987.

Azcona, G., Balakrishnan, P., Maestrales, J., Mirchi, N., & others. (2019). *[Studies on AI and personalized feedback in education]*. In Xu, Z., Adeyemi, A. E., Landaverde, R., Kogut, A. & Baker, M. (2023). A scoping review on the impact of educational technology in agricultural education. *Educ. Sci., 13* (9), 910. https://doi.org/10.3390/educsci13090910MDPI.

Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W. & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-023-00436-z.

Boulmetis, J. & Dutwin, P. (2011). *The ABCs of evaluation: Timeless techniques for program and project managers* (2nd ed.). Jossey-Bass.

Bruner, J. (1996). *The culture of education*. Harvard University Press.

Chen, X., Li, Y. & Zhang, H. (2025). Unraveling the mechanisms and effectiveness of AI-assisted feedback in higher education: A systematic review. *Computers and Education: X Reality, 5*, 100196. https://doi.org/10.1016/j.caeo.2025.100196.

Copeland, B. J. (2020). Artificial intelligence. *Encyclopedia Britannica*. https://www.britannica.com/ technology/artificial-intelligence.

Creswell, J. W. & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). Sage Publications.

Di Mitri, D. & Martinez-Maldonado, R. (2023). A current overview of the use of learning analytics dashboards. *Education Sciences, 14* (1), 82. https://doi.org/10.3390/educsci14010082.

Federal Republic of Nigeria (FRN, 2014). *National policy on education* (6th edition). Abuja: Nigerian Educational Research and Development Council (NERDC).

Financial Times (2025, July). *Chatbots in the classroom: How AI is reshaping higher education*. Financial Times

Frontiers in Plant Science (2024). Revolutionizing agriculture with artificial intelligence: Plant disease detection and related applications. *Frontiers in Plant Science*. https://www.frontiersin.org/articles/.

Gamage, D. & Whitelock-Wainwright, A. (2025). Chatbots in education: Hype or help? A meta-analysis. *Computers & Education: Artificial Intelligence, 6*, 100222. https://doi.org/10.1016/j.caeai.2025.100.

Ha, T. & Lee, S. (2025). The effect of ChatGPT on students' learning performance, perception, and higher-order thinking: A meta-analysis. *Humanities and Social Sciences Communications, 12*, 220. https://doi.org/10.1057/s41599-025-04787-y.

Johnson, D. M., Doss, W. & Estepp, C. M. (2024). *Agriculture students' use of generative artificial intelligence for microcontroller programming*. https://doi.org/10.1002/nse2.20155help.

Kim, S. & Park, J. (2024). AI-assisted assessment in higher education: A systematic review. *Journal of Educational Technology and Innovation, 4* (2), 55–89. https://jeti.thewsu.org/index.php/cieti/article/.

Koć-Januchta, M., Siddaway, J., Lamb, R., Ledesma, R., García, P. & others. (2020). *[Meta-analyses on AI in science education]*. In a systematic review (2024) showing improvements in academic performance and engagement. *Research in Science Education.* https://link.springer.com/.

Luo, J., Zheng, C., Yin, J. & Teo, H. H. (2025). Design and assessment of AI-based learning tools in higher education: A systematic review. *International Journal of Educational Technology in Higher Education*, (22) 42, 1-27. https://doi.org/10.1186/s41239-025-00540-2.

Nworgu, B. G. (2015). *Educational research. Basic issues and methodology, third edition.* Nsukka: University Trust Publishers.

Ofojebe, W. N. (2014). Teacher education and professionalism: Issues and challenges. *Journal of Teacher Education, 15* (2), 102–113.

Ogunbameru, B. O. (2001). *Practical agricultural communication*. Daily Graphics Nigeria Ltd.

Okolie, U. C. & Egbon, T. N. (2025). Artificial intelligence and teaching-learning process in education institutions in Nigeria: A study of undergraduate students of Delta State University, Abraka. *Journal Plus Education, 37* (1). https://uav.ro/jour/index.php/jpe/article/view/2273 UAV.

Perculiar, O. A. & Okoh, O. (2025). Integrating technology in agricultural education: A case study of University of Delta, Agbor, Delta State, Nigeria. *Asian Journal of Research and Review in Agriculture, 7* (1), 17–25. https://doi.org/10.56557/ajrra/2025/v7i1151.

Russell, S. & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.

Samuel, D. J., Skarga-Bandurova, I., Sikolia, D. & Awais, M. (2025). *AgroLLM: Connecting farmers and agricultural practices through large language models for enhanced knowledge transfer and practical application.* https://arxiv.org/.

Sanyal, N. & Kuri, J. (2024). Effects of generative AI on K-12 and higher education learning. *Journal of Educational Computing Research*. https://doi.org/10.1177/07356331251329185.

Sharma, S. & Gupta, P. (2025). Effectiveness of virtual learning systems in agricultural education: A review. *Frontiers in Education, 10*, 1588899. https://doi.org/10.3389/feduc.2025.1588899 show/123080374.cms.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48* (6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2.

Times of India (2025). *AI, but verify: Navigating future of learning* (IIT Delhi report on GenAI use). https://timesofindia.indiatimes.com/city/delhi/ai-but-verify-navigating-future-of-learning/article

UNESCO (2024). *AI competency framework for teachers*. UNESCO. https://www.unesco.org/en/articles/ai-competency-framework-teachers.

World Bank (2024). Exploring AI capacity building programs in Nigerian higher education. *Policy note on adopting a digital literacy framework in Nigeria* (World Bank policy note). https://thedocs.worldbank.org/...

Xu, Z., Adeyemi, A. E., Landaverde, R., Kogut, A. & Baker, M. (2023). A scoping review on the impact of educational technology in agricultural education. *Educ. Sci., 13* (9), 910. https://doi.org/10.3390/educsci13090910 MDPI.

Zhou, D., Fan, Y., Deng, G., He, F. & Wang, M. (2020). A new design of sugarcane seed cutting systems based on machine vision. *Computers and Electronics in Agriculture*, 175. https://doi.org/10.1016/j.compag.2020.105611.