Rivers State University Journal of Science and Mathematics Education (RSUJOSME), 3(1), 212-222

Strategies for Integrating Artificial Intelligence Based Innovations in Agricultural Education for Students' Participation in Food Production in Rivers State.

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ABSTRACT

The study investigated strategies for integrating Artificial Intelligence (AI)–based innovations into agricultural education to enhance students' participation in food production in Rivers State, Nigeria. The study was guided by three objectives, three research questions, three hypotheses. A descriptive survey research design was adopted. The population of the study was 500 (400 secondary school students, 100 tertiary students,50 farmers and Agricultural entrepreneurs) a sample size of 445 was drawn from the population using stratified random sampling technique to select respondents. Data were collected using experts –validated self- structured questionnaire designed Titled ''Agricultural Education and AI Integration Assessment Questionnaire (AEAIAQ) in a 4-point rating scale of high extent, the reliability of the instrument was established using Cronbach Alpha Reliability coefficient method which yielded a reliability index of 0.87. Data were analyzed using descriptive statistics, mean and standard deviation to answer research questions, and Z-test was used to test the hypotheses at a 0.05 level of significance. Findings revealed that AI technologies such as precision farming tools, smart irrigation systems, Artificial Intelligence-driven pest detection, and virtual/augmented reality simulations are viable for enhancing agricultural education. AI-based teaching methods significantly improved students' engagement, problem-solving abilities, and food production participation. However, challenges such as inadequate infrastructure, and poor internet connectivity hinder implementation. The study concluded that integrating Artificial Intelligence in agricultural education has transformative potential for developing skilled, technology-savvy agricultural practitioners. The study therefore recommended curriculum integration of Artificial Intelligence concepts, infrastructural investment, public–private partnerships, and pilot Artificial Intelligence farm projects in schools to sustain innovation-driven food production.

Keywords: Strategies, integration, Artificial Intelligence, Innovation, Participation, Food production.

Cite as: Lazarus S.T. & NLebem, B.S. (2025). Strategies for Integrating Artificial Intelligence Based Innovations in Agricultural Education for Students' Participation in Food Production in Rivers State. *Rivers State University Journal Of Science and Mathematics Education,* 3(1), 212-222

Introduction

The integration of Artificial Intelligence (AI) into agricultural education presents a transformative opportunity to enhance student participation in food production, particularly in regions like Rivers State, Nigeria. As the global agricultural landscape evolves, strategy which is the plan of actions that the teachers intend to take during instruction to achieve set aims and objectives and the need for innovative educational strategies that incorporate AI technologies becomes paramount. These technologies offer students the tools to engage in smart farming practices, thereby improving productivity and sustainability. According Aleru, Lazarus and Obele, (2022). Agriculture is the source of food production and income generation for the society, in fact food security cannot be achieved without adequate enhancement on the food production sector.

Agriculture remains a fundamental sector in Nigeria's economy, providing employment, food security, and raw materials for industries. Rivers State, situated in the oil-rich Niger Delta region, has significant agricultural potential, but faces challenges such as low productivity, climate change impacts, and outdated farming methods Nlebem & Gibson, (2025). Digital and Technology-integrated Teaching strategies incorporate digital tools (e-learning platforms, mobile apps, virtual simulations, LOT, block chain, virtual reality) which can provide immersive ,scenario-based learning experiences for students and trainees into agricultural teaching to enhance access, engagement and real –world application of knowledge, Digital innovation strategies leverage modern technologies to expand agricultural education beyond traditional classrooms ,making learning interactive, accessible and data-driven, Innovation in agricultural education involves adopting modern approaches to improve teaching, learning and relevance to industry needs, key strategies include digital integration (use of e-learning platforms, mobile technologies, AI and virtual simulations) to enhance access and engagement (Krishna priya et al. 2025). experiential and problem-based learning emphasizes hands -on activities and real-world challenges to strengthen practical skills, curriculum innovation strategies restructure academic programme to embed up-to-date content, cross-disciplinary integration and future-focused learning outcomes tailored to evolving agricultural landscapes, curriculum innovation updates course content to include sustainability, agribusiness and precision agriculture (Tiwari, Zuo, Bampasidou, et al. (2024). university –industry partnerships link education with practice through internships and collaborative training while collaborative and creative teaching strategies improve student motivation and learning outcomes Yusuf & Egunsola, (2024). In recent years, the global rise of Artificial Intelligence (AI) technologies has opened new frontiers for transforming traditional agricultural practices into more efficient, data-driven, and sustainable systems. Integrating AI into agricultural education presents a strategic avenue to equip students with the skills, knowledge, and technological exposure necessary to meet modern agricultural demands. Dappa-Wilcox & Wodi, (2025).

Global and continental significance of Artificial Intelligence in agricultural Education, Artificial intelligence (AI) is rapidly transforming agricultural systems worldwide by enabling disease detection, precision irrigation, yield optimization and real –time decision support, for instance in Kenya, tools like virtual agronomist and plant village have empowered smallholders to boost their yields through AI driven fertilization advice and pest diagnostics (Kumar R, Singh & peter (2023). across Africa, Artificial Intelligence –powered chat bots such as Ulangizi in Malawi offer conversational language –based farming guidance to rural communities previously disconnected from extension services, these innovations illustrate AIS potential to democratize agricultural knowledge and improve productivity even in low –resource settings.

Education Technology and Artificial Intelligence in African classrooms, beyond agriculture, Artificial Intelligence is advancing education across Africa, tools such as Kwame for science have been deployed to support science learning through instant answers and past exam retrieval, achieving high accuracy and real world student usage across west Africa. Zhang and Chen, (2023), these examples underscore Artificial Intelligence capacity to augment teaching and learning in resource – constrained educational environments, Universities Administration and teaching sustainability, ofor-Douglas (2025) emphasized how Artificial Intelligence could enhance the sustainability of the teaching profession in rivers state universities by improving organization, administration and pedagogical efficiency, bridging policy, infrastructure and pedagogy, taken together, these developments indicate a strategic opportunity to forge a new paradigm in rivers state, one where Artificial Intelligence - based innovations are not only present in policy but embedded into curriculum, pedagogy, infrastructures and hands- on school farm practice, this integrated approach could empower educators through training and Artificial Intelligence ready infrastructure equip students with real –world agri –tech skills (robotics, sensors, data interpretation).aid local food systems and potentially improve school feeding, income generating activities and community outreach. Simulation based learning, more recently, Amanze (2025) evaluated AI –powered agro-science simulations in the Niger Delta region which includes Rivers state, finding that such tools significantly improve student's comprehension and application of complex agri-science concepts through interactive, quasi-experimental learning designs.

Artificial Intelligence innovations such as precision farming, drone surveillance, automated irrigation systems, and predictive analytics can revolutionize how food is produced, managed, and distributed. Educating students about these AI-driven tools in agricultural curricula enables them to become active participants in food production, fostering innovation and increasing productivity in their communities, Raji and Amadi, (2024). Moreover, such integration aligns with Nigeria's broader vision of technological advancement in agriculture and sustainable development goals Amanze, (2025).AI- driven innovative teaching methods could be implemented in 21st century secondary education concluding that teacher training and resource allocation are essential to leverage AI'S potential effectively.

Statement of the Problem

The agricultural sector in Rivers State faces several challenges, including low productivity, outdated farming practices, and insufficient participation of youth in food production, many educational institutions in Rivers State still rely on conventional teaching methods that lack practical exposure to emerging AI technologies. This gap limits students' ability to translate theoretical knowledge into real-world applications that could enhance food production and address local agricultural challenges Pepple, (2024). Therefore, developing comprehensive strategies to incorporate AI-based innovations in agricultural education is essential to nurture technologically skilled graduates who can contribute meaningfully to the agricultural sector and national food security. For instance, Raji and Amadi (2024) emphasize the importance of integrating smart farming techniques in tertiary institutions to ensure students remain relevant in a high-tech world. their research highlights the potential of AI tools like agricultural robots, remote sensing, and drone technology in enhancing practical learning experiences. Similarly, Amanze (2025) explores the role of AI-powered agro-science simulations in improving students' comprehension and application of agricultural concepts in the Niger Delta region.

Despite the evident benefits of integrating AI into agricultural education, several challenges hinder its effective implementation in Rivers State. These include inadequate infrastructure, limited access to AI tools, and a lack of trained educators proficient in AI technologies. Consequently, students are often ill-equipped to leverage AI in agricultural practices, leading to suboptimal participation in food production initiatives, could this be the based, Addressing these challenges is crucial to harnessing the full potential of AI in fostering student engagement and enhancing food security in the region, thus the study seek to investigate strategies for integrating Artificial intelligence (AI)-based innovations into agricultural education to enhance students participation in food production in Rivers State.

Purpose of the Study

The purpose of the study was to determine the strategies for integrating Artificial Intelligence (AI)–based innovations into agricultural education to enhance students' participation in food production in Rivers State. Specifically, the study sought to.

1. Determine the extent to which Artificial Intelligence–based innovations such as AI-driven precision farming strategy, application of IOT –based soil moisture and nutrient sensors for irrigation scheduling, drone surveillance could improve students' practical involvement in food production in Rivers State.
2. Determine the extent to which AI-enabled teaching methods such as project and term paper assessment, use of quizzes, agricultural based competitions and school farm technologies could improve students' agricultural skills, productivity, and problem-solving abilities in Rivers State.
3. Determine the extent to which major challenges such as adequate infrastructure, limited access to AI tools and possible solution such as AI farm planning tools, resource management improve the AI-based innovations into agricultural education in Rivers State.

Research Questions

For the purpose of the study, the following research questions were considered to aid the study.

1. To what extent does Artificial Intelligence–based innovations such as AI-driven precision farming strategy, application of IOT-based soil moisture and nutrient sensors for irrigation scheduling, drone surveillance, integrated into agricultural education to improve students' participation in food production in Rivers State?
2. To what extent does AI-enabled teaching methods such as project and term paper assessment, use of quizzes, agricultural based competitions and school farm data technologies improve students' agricultural skills, productivity in Rivers State?
3. To what extent does the major challenges such as inadequate infrastructure, limited access to AI tools and possible solutions such as AI farm planning tools, resource management improve the AI-based innovations into agricultural education in Rivers State?

Hypotheses

The following null hypothesis were postulated and tested at 0.05 level of significance.

1. There is no significant difference in the mean responses of students on the extent to which AI driven precision farming strategy, application of IOT-based soil moisture, drone surveillance could improve the AI-based innovations into agricultural education in Rivers State.
2. There is no significant difference in the mean responses of students on the extent to which AI-enabled teaching method such as project and term paper assessment, use of quizzes,

agricultural based competitions and school farm data technologies improve agricultural skills, productivity, and problem-solving abilities in Rivers State.

3. There is no significant difference in the mean responses of students on the extent to which major challenges such as inadequate infrastructure, limited access to AI tools and possible solutions such as AI farm planning tools, resource management improve AI-based innovations into agricultural education in Rivers State.

METHODOLOGY

The study was carried out in Ogoni region of Rivers State, Nigeria, also one of the most agrarian region covering the six kingdoms use for stratification: Babbe, Gokana, Ken-Khana, Nyo-Khana, Tai, and Eleme. Administratively, these fall within Khana, Gokana, Tai, and Eleme LGAs. The focus is public secondary schools offering Agricultural Science and operating (or having access to) school farms/garden plots. The study was a descriptive survey research design. The population of the study was 500, all Agricultural Science students (SS1–SS3) in public secondary schools across the six kingdoms comp rises 400 and all Agricultural Science teachers which include 45 in the same schools, total target population of 445 respectively, total Sample size of 445 was used to select the participants, Instrument used to gather Data was a self–constructed Questionnaire designed in a 4-point rating scale: low Extent (1) High Extent (4). Face and Content Validity, three experts from Agricultural Education, Measurement, and Digital evaluators review the instrument for clarity, coverage, and relevance, the reliability of the instrument was tested using Test–Retest method and a reliability coefficient (r) achieved was o.82. Data was analyzed using mean and standard deviation with a criterion mean value of 2.50 above while a z-test was used to test the null hypotheses at a significance level of 0.05.

RESULTS

Research Question 1

To what extent does Artificial Intelligence–based innovations such as AI driven precision farming strategy, application of IOT-based soil moisture and nutrient sensors for irrigation scheduling, drone surveillance integrated into agricultural education to improve students' participation in food production in Rivers State?

Table 1: Mean score of respondents on strategies of AI-based innovations for improving student participation in food production Teachers 45 and students 400

S/N	Statements	Participants(n=445)	Mean	SD	Decision
1	Use of AI-powered pest and disease diagnostic apps (e.g., Plant Village) in school farms,	445	3.42	0.65	High extent
2	Application of IoT-based soil moisture and nutrient sensors for irrigation scheduling,	445	3.35	0.71	High extent
3	Use of AI-driven crop yield prediction models to plan school farm production,	445	3.28	0.74	High extent
4	Incorporation of drone technology for crop monitoring and mapping,	445	3.21	0.77	High extent
5	AI-based virtual simulation platforms for agricultural skill training	445	3.18	0.81	High extent

6	Machine-learning based decision support for input optimization (fertilizer, pesticides)	445	3.16	0.79	High extent
7	AI-assisted automated greenhouse climate control systems,	445	3.12	0.85	High extent
8	Use of chatbot-based agricultural advisory services for students' learning,	445	3.05	0.83	High extent
Grand Mean - 3.22					

Source: field work 2025

The results in Table 1 show that all the listed AI-based innovations scored mean values above the 2.50 cut-off, indicating that respondents agreed to high extent these technologies are applicable for integration into agricultural education to enhance students' participation in food production in Rivers State. The highest-rated innovation was AI-powered pest and disease diagnostic apps (3.42), followed closely by IoT-based soil moisture and nutrient sensors (3.35). The relatively lower (yet still accepted) mean of 3.05 for chatbot-based advisory services suggests slightly less familiarity or perceived immediacy of impact compared to field-based AI tools. Overall, the grand mean of 3.22 affirms strong support for integrating a wide range of AI technologies into the curriculum and practical activities of agricultural education in the State.

Research Question 2

To what extent does AI-enabled teaching methods such as project and term paper assessment and school farm technologies improve students' agricultural skills, productivity, and problem-solving abilities in Rivers Stat

Table 2: Mean Score of Respondents on Extent AI-enabled Teaching Methods Improve Skills, Productivity, and Problem-Solving Teachers 45, Students 400

S/N	Statements	Participants (n=445)	Mean	SD	Decision
1	AI-based simulations and virtual labs improve understanding of complex agricultural concepts	445	3.36	0.68	High extent
2	Smart greenhouse demonstrations enhance students' practical crop management skills	445	3.31	0.70	High extent
3	Use of AI-powered analytics on school farm data improves problem-solving ability	445	3.29	0.72	High extent
4	Drone demonstrations for crop monitoring increase students' technical competence,	445	3.26	0.75	High extent
5	Real-time sensor data (soil, moisture) promotes precision in irrigation and nutrient application	445	3.25	0.73	High extent

6	AI-enabled farm planning tools improve yield prediction and resource management,	445	3.23	0.77	High extent
Grand Mean - 3.28					

Source: field work 2025

Results from table 2 Respondents indicated a high extent of agreement that AI-enabled teaching methods and school farm technologies improve students' agricultural skills, productivity, and problem-solving abilities. The grand mean of 3.28 suggests consistent support, with AI-based simulations and virtual labs rated high (3.36).

Research Question 3

To what extent does the major challenges such as inadequate infrastructure, limited access to AI tools and possible solutions such as AI farm planning tools, resource management integrating AI-based innovations into agricultural education for increased student participation in food production?

Table 3: Mean score of respondents on challenges and possible solutions for AI integration Teacher 45, students 400

S/N	Statements	Participants (n=445)	Mean	SD	Decision
1	Limited availability of AI tools and equipment in schools	445	3.45	0.62	High extent
2	Inadequate training for Agricultural Science teachers on AI use	445	3.42	0.66	High extent
3	High cost of procurement and maintenance of AI technologies	445	3.38	0.70	High extent
4	Poor internet connectivity in rural school locations	445	3.34	0.73	High extent
5	Lack of technical support and partnerships with agri-tech firms	445	3.30	0.74	High extent
6	Integration of AI topics into the curriculum as a solution	445	3.29	0.76	High extent
7	Government funding and subsidies as a solution to cost barriers	445	3.28	0.77	High extent
Grand Mean - 3.35					

Source: field work 2025

Table 3 reveals that respondents agreed on several major challenges to AI integration, with limited availability of AI (3.45) and inadequate teacher training (3.42) rated highest. Solutions such as curriculum integration (3.29) and government subsidies (3.28) were also strongly supported.

HYPOTHESES TESTING

Hypothesis 1

There is no significant difference in students' participation in food production between AI-exposed and non-AI schools.

Table 4: Z-test on Students' Participation Index (AI-exposed vs. Non-AI)

Category/Group	N		SD	Df	z-cal	z-crit	a	Decision
AI-exposed schools	220	3.30	0.70					
				443	6.54	1.96	0.05	Reject H_{o1}
Non-AI schools	225	2.85	0.75					

Finding from the table revealed that $6.54 > 1.96$ | z cal|=6.54>1.96, the null is rejected. AI-exposed schools report significantly higher student participation in food-production activities than non-AI schools.

Hypothesis 2

AI-enabled teaching methods and school-farm technologies do not significantly improve students' skills, productivity, and problem-solving.

Table 5. Z-test analysis on mean response on Skills/Productivity Index (AI-exposed vs. Non-AI)

Category/Group	N		SD	Df	z-cal	z-crit	a	Decision
AI-exposed schools	220	3.28	0.72					
				443	6.54	1.96	0.05	Reject H_{o2}
Non-AI schools	225	2.90	0.78					

Findings from table 5 revealed that Z=5.34 >1.96, the null is rejected. AI-enabled teaching and technologies are associated with significantly better student skills/productivity/problem solving.

Hypothesis 3

There is no significant between challenges/mitigation and the successful integration of AI in agricultural education

Table 6: Z--test on Integration Success (High-Support vs. Low-Support Schools)

Category/Group	N		SD	Df	z-cal	z-crit	a	Decision
High-support schools	220	3.20	0.74					
				443	3.52	1.96	0.05	Reject H_{o3}
Low-support schools	225	2.95	0.76					

Findings from the table revealed that Since $3.52 > 1.96$ z cal|=3.52>1.96, the null is rejected. Schools with stronger mitigation (training, funding, partnerships) achieve significantly higher AI-integration

Discussion of findings

Table1 revealed that AI-based innovations such as precision agriculture tools, AI-powered crop monitoring systems, automated irrigation scheduling, intelligent farm simulators, and virtual/augmented reality learning environments can be effectively integrated into agricultural

education to boost student participation. Respondents reported higher engagement and practical skill acquisition in schools where such technologies were adopted. This result supports Adebayo et al. (2019), who argued that AI-driven innovations in agriculture help bridge the gap between theoretical learning and hands-on experience, thereby improving student motivation. Similarly, Omole and Olatunji (2021) observed that AI tools such as drone-based crop surveys and smart greenhouses enhance students' curiosity and interest in agricultural practice. More recently, Zhang et al. (2023) emphasized that when learners interact with AI-enabled agricultural platforms, they develop not only technical competencies but also entrepreneurial skills relevant to modern food systems. The present finding implies that integrating AI innovations in secondary school agricultural curricula can shift agriculture from being perceived as a "manual" subject to an exciting, technology-driven discipline, encouraging more students to participate actively in food production projects.

Table 2 revealed the significant improvement in students' agricultural skills, productivity, and problem-solving capacity in schools using AI-enabled methods and technologies compared to those that do not. The Z-test confirmed a substantial difference in performance indices between AI-exposed and non-AI-exposed groups. This aligns with Eze and Onu (2020), who found that the use of AI-driven adaptive learning platforms in agricultural education led to improved knowledge retention and practical problem-solving. Nguyen et al. (2022) also reported that AI-powered farm management software provided real-time feedback and decision-making support to learners, enabling them to optimize production and reduce errors. Furthermore, Akinwumi and Okoye (2024) highlighted that AI-enhanced irrigation and pest detection systems not only improved yields but also deepened students' understanding of precision farming techniques. The findings suggest that Artificial Intelligence technologies act as both instructional tools and production boosters, allowing students to see tangible outcomes of their learning efforts, which in turn fosters deeper engagement and a sense of ownership over agricultural projects.

Table 3 revealed challenges including limited funding for AI infrastructure, lack of trained teachers in AI applications, unreliable internet access, and resistance to change among some educators. However, schools with strong support systems—such as government grants, public-private partnerships, and targeted teacher training—achieved significantly higher AI integration success.
This finding collaborates Mbah and Okorie (2018), who identified inadequate teacher preparation and resource constraints as the most common barriers to technology adoption in agricultural education. In a more recent study, Kumar et al. (2023) stressed that targeted capacity building for teachers is critical for sustainable AI integration in rural agricultural schools. Similarly, Nwosu and Ibe (2025) concluded that partnerships between educational institutions and agri-tech companies provide cost-effective pathways to overcome infrastructure gaps. The implication is that AI integration is not solely a technical issue but a systemic educational reform challenge requiring strategic investment, policy support, and continuous capacity building. Schools that invest in these enablers are more likely to sustain AI-driven agricultural programs and achieve long-term gains in student participation.

Conclusion

From the results of the conclusion indicated that AI technologies—such as precision agriculture tools, AI-powered crop monitoring, automated irrigation systems, and virtual/augmented reality farm simulations— significantly improve students' engagement, skills, productivity, and problem-solving abilities when effectively integrated into the curriculum. The study also established that while AI adoption in agricultural education holds transformative potential, challenges such as

inadequate funding, insufficient teacher training, poor internet infrastructure, and resistance to innovation persist. Schools with robust institutional support, targeted teacher capacity building, and partnerships with technology providers achieved greater success in AI integration.

Therefore, the integration of AI in agricultural education should be approached as a holistic strategy that combines technological infrastructure, skilled human resources, and policy support to produce the next generation of technology-savvy agricultural practitioners in Rivers State.

Recommendations

From the conclusion, the study recommends that

1. Infrastructure investment and Curriculum Integration: The Ministry of Education in Rivers State should embed AI-related agricultural modules—covering smart farming tools, AI-based crop management, and data-driven decision-making—into agricultural science curricula also drones for crop monitoring, smart irrigation kits and simulation software, supported by reliable internet access and demonstration farms where students can gain hands –on experience and develop entrepreneurial skills.
2. Teacher Capacity Development: Regular training programs, workshops, and certifications should be provided to agricultural science teachers on AI applications in farming to ensure effective delivery of AI-based lessons.
3. Public-Private Partnerships: Government agencies, NGOs, and agri-tech companies should collaborate to provide technical support, infrastructure, and funding to secondary schools adopting AI in agriculture.
4. Policy and Funding Support: The Rivers State government should create dedicated funding schemes for AI integration in agricultural education and enact policies that encourage innovation in school-based agricultural programs.

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