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Artificial Intelligence Role in Advancing Science Education for Sustainable Innovation in Imo State

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Abstract

This study investigates the role of Artificial Intelligence (AI) in advancing science education for sustainable innovation in Imo State, Nigeria. The objectives of the study seek to identifies challenges in integrating AI, assesses how AI facilitates personalized learning, and explores its impact on curriculum relevance and adaptability. A descriptive research design was adopted for the study. This study was carried out in Owerri Educational zone 1 of Imo State, the study population comprises 2,800 science students from Owerri Educational Zone 1 in Imo State, according to the Imo State Secondary Education Management Board (SEMB, 2024). purposive sampling technique was employed to select a sample size of 222 subjects for the study. A structured questionnaire was employed to collect data for the study. The collected data were analyzed using descriptive statistics, including mean and standard deviation. Findings reveal significant barriers such as infrastructure limitations and insufficient training, while highlighting the positive contributions of AI tools like intelligent tutoring systems and adaptive learning platforms. The study emphasizes the need for ethical considerations and human oversight in AI implementation. Recommendations include developing AI-focused educational programs, updating science curricula to include AI technologies, and fostering interdisciplinary collaboration. The integration of AI in science education holds transformative potential, equipping students with essential skills for a dynamic future.

Keywords: *Artificial Intelligence, Science Education, Sustainable Innovation, Technological Advancement*

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Background to the Study

Artificial Intelligence (AI) is a transformative technology that enables computer systems to perform tasks requiring human intelligence, such as problem-solving and language comprehension (Aina et al., 2023). Its impact spans various industries, particularly education, where it enhances learning through personalized pathways, immediate feedback, and adaptive environments. AI facilitates intelligent systems like adaptive learning platforms and virtual simulations, enabling educators to create dynamic, interactive experiences tailored to diverse learning styles (Obi, 2022). This shift opens up possibilities for data-driven educational policies, promoting a workforce skilled in technology and innovation.

The integration of Artificial Intelligence (AI) in science education has brought transformative changes to teaching and learning. According to Zawacki-Richter, Marin, and Gouverneur (2019), AI encompasses various aspects of education, including academic support, institutional services, profiling, assessment, adaptive systems, and intelligent tutoring. AI personalizes learning to address individual student needs, providing customized content, real-time guidance, and adaptive assessments. It enhances content delivery by making science concepts more accessible through immersive technologies like Virtual Reality (VR) and Augmented Reality (AR). Intelligent tutoring systems offer on-demand support, which helps reduce dropout rates and improve long-term knowledge retention.

In the context of Nigeria's educational system, AI integration presents significant opportunities to tackle existing challenges. By utilizing AI tools in secondary school science classrooms, educators can fundamentally reshape teaching and learning methods, enhancing accessibility, engagement, and educational effectiveness (Soma, 2018). Additionally, Ayodele et al. (2023) emphasize AI's potential to revolutionize curriculum development and management in education.

One of the key applications of AI in science education is its role in the design and development of curricula. AI facilitates the creation of learning content and the development of lesson programs through an entirely new process. Similarly, McBride, Peters and Judd (2021) posit that AI technologies can play a significant role in enhancing curriculum design in by developing students' AI understanding, ethics and societal impact analysis skills, community building, and leadership development; Utilizing active learning and universal design for learning principles to create more inclusive and engaging curriculum materials and Exposing students to diverse AI applications and role models. However, despite these initiatives, Despite the progress that has been made, the integration of AI into curriculum design to advance personalized learning and adaptive learning systems is not without its challenges. Issues such as data privacy, algorithmic bias, and the possibility of diminished human involvement in educational decision-making must be carefully considered during implementation (Holmes et al., 2021). It is also important to remember that the reliance on AI should not diminish the crucial role of human oversight and educators in guiding and mentoring students (Luckin et al., 2016).

As AI continues to advance, it is vital to establish frameworks that balance technological innovation with ethical considerations and human-centred approaches. Additionally, the effectiveness of these systems depends on the quality of the underlying algorithms and the accuracy of the data they process. This is evidence to the report of UNESCO, (2021) which stated that challenges such as inadequate infrastructure, a shortage of qualified educators, and limited educational resources continue to hinder effective science instruction in secondary schools (UNESCO, 2021). Currently, science education in Nigerian secondary schools faces a multitude of obstacles that impede its effectiveness (Avik, 2018). The curriculum, while comprehensive, often lacks practical applications and hands-on experiences, creating a gap between theoretical knowledge and practical understanding. Additionally, the shortage of skilled science educators, particularly in remote areas, exacerbates disparities in educational quality (Shobita, 2019). Traditional teaching methods frequently fail to engage and motivate students, leading to decreased interest in science subjects. The limited availability of modern educational tools further complicates these issues, highlighting the need for innovative solutions to revitalize science instruction.

AI serves as a catalyst for technological innovation, enhancing efficiency, enabling new capabilities, and fostering creativity across various industries. It is recognized as a driving force behind the fourth industrial revolution (Cheng and Peng, 2018; Yogesh et al., 2019), with applications spanning manufacturing, finance, education, healthcare, and logistics, ultimately making life more intelligent and advancing societal evolution (Miller, 2019). By 2020, the global AI market was projected to reach $47 billion (Gabriel and Goertzel, 2019). In response to shifting economic patterns, countries worldwide are strategically prioritizing AI development. For instance, the Obama administration released two pivotal documents in 2016: "Preparing for the Future of Artificial Intelligence" and "The National Artificial Intelligence Research and Development Strategic Plan" (OWH, 2016; OWH, 2016). The rapid evolution of AI has significant implications for both the economy and society. These innovations can directly affect the production and characteristics of various products and services, influencing productivity, employment, and competition. Moreover, AI has the potential to transform the innovation process itself, leading to profound changes that may eventually outweigh its direct impacts.

Purpose of the Study

The main purpose of the study is to examine artificial intelligence role in advancing science education for sustainable innovation in Imo state. Specifically, the study sought to:

1. Identify the challenges of integrating AI into science education to promote sustainable innovation in Imo State.
2. Assess how AI facilitates personalized learning experiences for diverse students to support sustainable innovation in Imo State.
3. Investigate the impact of AI on the relevance and adaptability of science curricula in fostering sustainable innovation in Imo State.

Methodology

Research Design: A descriptive research design was adopted for the study. This survey design is suitable as it allows for generalizing findings to a larger population using a representative sample (Osuala & Ihekwoaba, 2013). Typically, descriptive research utilizes questionnaires to assess people's opinions, perceptions, and attitudes regarding various issues.

Area of the Study: This study was carried out in Owerri Educational zone 1 of Imo State.

Population of Study: The study population comprises 2,800 science students from Owerri Educational Zone 1 in Imo State, according to the Imo State Secondary Education Management Board (SEMB, 2024).

Sample Size and Sampling Technique: The purposive sampling technique was employed to select a sample size of 222 subjects for the study. This method is deemed appropriate by Schensul (2011) as it allows the researcher to focus on specific characteristics or attributes of interest, ensuring the selected sample is representative of those traits.

Instrument for Data Collection: A structured questionnaire was employed to collect data for the study.

Validation and Reliability of the Instrument: The instrument was validated by two experts from the Department of Measurement and Evaluation and one from the Department of Science Education at Imo State University, Owerri. Their suggestions were incorporated to improve the instrument. To establish its internal consistency, the test-retest method was employed, yielding high reliability coefficients for the instrument.

Method of Data Collection and Analysis Technique: The instrument was administered using the direct contact method. The collected data were analyzed using descriptive statistics, including mean and standard deviation.

Results

Research Question 1: What are the challenges of integrating AI into science education to promote sustainable innovation in Imo State.?

Table 1: Mean and standard deviation responses on the challenges of integrating AI into science education to promote sustainable innovation in Imo State

S/N	Challenges of integrating AI into science education to promote sustainable innovation	X	SD	Decision
1	Infrastructure Limitations	3.25	0.46	Agreed
2	Insufficient Training	3.21	0.59	Agreed
3	Curriculum Gaps	2.78	1.15	Agreed
4	Cost of Implementation	2.47	0.93	Agreed
5	Limited Research and Resources	3.04	0.53	Agreed
6	Poor Interdisciplinary Collaboration	2.87	0.78	Agreed
7	Measurement of Effectiveness **:**	3.03	0.76	Agreed
8	Poor Curriculum Compatibility	2.78	0.69	Agreed
9	ethical Concerns	2.34	0.93	Disagreed
10	insufficient technological infrastructure,	2.19	0.87	Disagreed
	Grand Mean and Standard Deviation	**2.80**	**7.7**	

Table 1: The table above showed that Grand **Mean and Standard Deviation**, the overall mean of 2.80 indicates a general agreement on the challenges, but the wide range in standard deviations (particularly for curriculum gaps) suggests variability in perspectives, the data highlights key areas that require attention for the successful integration of AI into science education, while ethical and technological infrastructure concerns are less prioritized by participants.

Research Question 2: To what extent does AI facilitate personalized learning experiences for diverse students to support sustainable innovation in Imo State?

Table 2: Mean and standard deviation responses on the extent to which AI facilitates personalized learning experiences for diverse students to support sustainable innovation in Imo State

S/N	Items	X	SD	Decision
1	Adaptive Learning Platforms	2.65	1.02	Agreed
2	Intelligent Tutoring Systems	3.21	0.48	Agreed
3	Customized Learning Pathways	2.71	0.86	Agreed
4	Dynamic Assessment Tools	3.07	0.98	Agreed
5	Data-Driven Insights	3.04	0.63	Agreed
6	Engagement Monitoring	2.84	0.80	Agreed
7	Peer Collaboration Opportunities	3.03	0.76	Agreed
8	Resource Recommendation Systems	40	0.87	Agreed
9	Predictive Analytics	2.78	1.15	Agreed
	Grand Mean and Standard Deviation	**6.33**	**7.6**	

Table 2: The table above showed the overall mean of 6.33 seems incorrect or misrepresented; it's likely a summation or typo. Assuming a proper mean based on the individual scores, the general agreement across all items suggests that respondents see AI as a valuable tool for

facilitating personalized learning experiences., the data indicates a consensus on the positive role of various AI tools in enhancing personalized learning for diverse students, with some areas showing more variability in opinions than others.

Research Question 3: What is the impact of AI on the relevance and adaptability of science curricula in fostering sustainable innovation in Imo State?

Table 3: Mean and standard deviation responses on the impact of AI on the relevance and adaptability of science curricula in fostering sustainable innovation in Imo State

S/N	Items	X	SD	Decision
1	Curriculum Customization	3.16	0.41	Agreed
2	Real-Time Feedback	3.24	0.51	Agreed
3	Data-Driven Insights	2.12	1.01	Disagreed
4	Integration of Emerging Technologies	2.67	0.88	Agreed
5	Interdisciplinary Learning	2.72	1.01	Agreed
6	Skill Development Alignment	2.45	0.88	Disagreed
7	Cultural and Contextual Relevance	2.78	0.94	Agreed
8	Flexible Learning Environments	2.81	0.90	Agreed
9	Continuous Curriculum Evolution	2.84	0.73	Agreed
10	Collaboration with Industry	3.46	0.71	Agreed
	Grand Mean and Standard Deviation	**2.83**	**0.798**	

Table 3: The table above showed a Grand Mean and Standard Deviation of 2.83 suggests a general agreement on the positive impacts of AI, although the presence of several disagreements (notably regarding data-driven insights and skill development alignment) indicates some areas of concern. The data indicates a consensus that AI can significantly enhance the relevance and adaptability of science curricula, especially in areas like curriculum customization, real-time feedback, and collaboration with industry. However, there are notable concerns regarding data-driven insights and skill alignment that need to be addressed for a more comprehensive integration of AI in education.

Discussion of the Finding

Table 1 highlights key challenges in integrating AI into science education. The mean score of 2.80 reflects a consensus on barriers such as infrastructure limitations (3.25) and insufficient training (3.21). These findings underscore the need for foundational changes to effectively implement AI. While curriculum gaps (2.78) are also a concern, ethical issues (2.34) and technological infrastructure (2.19) received less emphasis, indicating that immediate infrastructural and training needs may be more pressing. The variability in standard deviations, particularly regarding curriculum gaps, points to differing views among respondents, emphasizing the importance of targeted interventions to meet the specific needs of educators and institutions. The findings of the study aligned with the findings of Holmes (2021) who reported that issues such as data privacy, algorithmic bias, and the possibility of diminished human involvement in educational decision-making must be carefully considered

during implementation). The findings supported the findings of Luckin (2016) who reported that the reliance on AI should not diminish the crucial role of human oversight and educators in guiding and mentoring students

Table 2 assesses how AI tools enhance personalized learning experiences. The overall agreement, despite an apparent error in the mean (likely misrepresented as 6.33), indicates strong support for AI applications like intelligent tutoring systems (3.21) and dynamic assessment tools (3.07). These technologies are recognized for their ability to provide customized learning pathways and engage students more effectively than traditional methods. Additionally, data-driven insights (3.04) and engagement monitoring (2.84) highlight AI's capacity to create responsive educational environments tailored to diverse learning styles. This adaptability is crucial for ensuring that science education remains relevant and effective, with respondents signaling a readiness to incorporate these technologies into modern pedagogy.

Table 3 evaluates AI's influence on the relevance and adaptability of science curricula. With a grand mean of 2.83, the findings generally support AI's positive impact, especially in areas like curriculum customization (3.16) and real-time feedback (3.24). These elements illustrate AI's potential to make curricula more responsive to student needs and the fast-evolving technological landscape. However, notable disagreements regarding data-driven insights (2.12) and skill development alignment (2.45) raise concerns about AI's effectiveness in aligning educational outcomes with workforce demands. This suggests that while AI can facilitate curriculum evolution, careful consideration is essential to ensure curricula remain both innovative and relevant for students' future career paths. In the study by Ayodele et al. (2023), it was highlighted that AI has emerged as a groundbreaking technology with the potential to significantly impact the field of curriculum development and management in education. Similarly, McBride, Peters and Judd (2021) posit that AI technologies can play a significant role in enhancing curriculum design in by developing students' AI understanding, ethics and societal impact analysis skills,

Recommendations

1. There is need for developing programs on AI tools and their classroom applications, focusing on effective pedagogical strategies.
2. Also, updating a science curriculum to include AI technologies like adaptive learning platforms and intelligent tutoring systems.
3. Foster interdisciplinary collaboration among educators to integrate AI across various subjects and enhance learning.
4. Create policies addressing data privacy, algorithmic bias, and ethical use of AI in education.
5. Fund initiatives to assess AI's effectiveness in education, identifying best practices and innovative applications.

Conclusion

Integrating Artificial Intelligence (AI) in science education offers significant potential for sustainable innovation in Imo State. This study underscores AI's ability to enhance personalized learning, improve curriculum relevance, and address ongoing educational challenges. However, issues like inadequate infrastructure and training must be resolved to fully leverage these benefits. As AI technologies evolve, it's vital to balance innovation with the essential role of educators. By focusing on ethical considerations and using AI to complement traditional teaching, Imo State's educational landscape can be transformed. The recommendations in this study provide a roadmap for stakeholders to effectively harness AI, preparing students for a dynamic future and equipping them with necessary skills.

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