ARTIFICIAL INTELLEGENCE (AI) IN EDUCATION FOR SUSTAINABILITY AND DEVELOPMENT IN NIGERIA

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Abstract
Artificial Intelligence (AI) has emerged as a transformative force across various sectors, including education, offering innovative solutions to complex challenges. This study explores the relevance of AI in addressing Nigeria's educational and developmental challenges, such as inadequate access to quality education, teacher shortages, and limited inclusivity. It examines how AI-powered tools can enhance learning outcomes, promote inclusivity for marginalized groups, and support lifelong learning, aligning education with sustainable development goals (SDGs). Using a mixed-method approach, the study analyzes existing literature, case studies, and empirical data to evaluate AI's potential impact. Findings reveal that AI can significantly improve access to education in the under -developed areas, reduce teacher workloads and provide data-driven insights for policymakers. Artificial Intelligence (AI) offers innovative solutions to issues like, teacher shortages, outdated curricula, quality of education, inclusivity and inequitable resource distribution. Furthermore, Artificial Intelligence (AI)-driven systems can foster lifelong learning, align education with industrial demands, and support data-driven policymaking for sustainable development. However, for Nigeria to fully harness the benefits of AI in education, it is crucial to invest in infrastructure, capacity building and the development of ethical policies. It was therefore recommended that adequate funding should be allocated to provide schools with the necessary technology, such as computers, internet access, and Artificial Intelligence (AI)-enabled tools, to bridge the digital divide between urban and rural areas. Schools and universities should introduce Artificial Intelligence (AI)-related courses to equip students with skills relevant to the digital age and foster awareness of AI's applications in various sectors.

Keyboard: *Artificial Intelligence, Development, Education, Sustainability.*

Introduction

The rapid advancement of technology has created a paradigm shift in various sectors globally, and the education sector is no exception. In Nigeria, the integration of Artificial Intelligence (AI) into education has emerged as a potential solution to several challenges facing the education system, such as, inadequate infrastructure, large class sizes, lack of qualified teachers, and unequal access to educational resources, which have long hindered the quality and inclusivity of education in the country. Despite efforts made by the Nigerian government and other stakeholders to improve educational outcomes through various reforms, the country continues to face significant challenges in achieving the goals set under Sustainable Development Goal (SDG). However, ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all will surely address these issues (United Nations, 2020).

Artificial Intelligence, is often referred to as the simulation of human intelligence in machines, has been recognized for its transformative potential in addressing educational challenges worldwide. In recent years, Artificial Intelligence (AI) technologies such as machine learning, natural language processing, and robotics have gained attention for their ability to revolutionize teaching and learning processes (Oni, Akinyele & Fasanya, 2021). Artificial Intelligence(AI)'s applications in education are vast, ranging from personalized learning platforms that cater for individual student needs, automated administrative tasks, to Artificial Intelligence(AI)-driven tools that support teachers in assessment, feedback, and instructional design (Eze & Ani, 2023). Globally, Artificial Intelligence (AI) has been adopted in various educational settings to enhance the quality of education, improve access to learning, and foster innovation.

In Nigeria, where educational disparities are prevalent across urban and rural areas, Artificial Intelligence (AI) holds significant promise in improving both access to and quality of education. Research shows that a large portion of the Nigerian population lacks access to quality education due to issues such as poor infrastructure, inadequate

teaching materials, and a lack of qualified educators in certain regions (Olatunji & Adebayo, 2022). Artificial Intelligence(AI) offers an opportunity to bridge this gap by providing personalized learning experiences, offering support to educators, and reducing the administrative burden on schools, allowing teachers to focus on more impactful aspects of their work (Alabi & Olufunke, 2023).

Furthermore, the Nigerian government has recognized the importance of technology in the educational sector, evidenced by the introduction of initiatives like the National Policy on Information and Communication Technology (ICT) in Education, which aims to promote digital literacy and integrate ICT into the national curriculum (FRN, 2018). However, despite these efforts, there is a noticeable lag in the widespread adoption ofArtificial Intelligence (AI)-driven educational technologies. According to Akpan et al. (2022), a major challenge remains the lack of technological infrastructure, particularly in rural and underdeveloped areas, where the absence of reliable internet access, electricity, and computing devices hampers the effective use of Artificial Intelligence (AI) in education.

In addition to infrastructure challenges, Nigeria's education system faces issues of overburdened teachers, outdated curriculum content, and a lack of professional development opportunities for educators. Artificial Intelligence(AI) technologies, such as intelligent tutoring systems, can alleviate some of these pressures by offering personalized tutoring and feedback, allowing teachers to address the diverse needs of their students more effectively (Olaniyi & Adefolalu, 2021). Also, Artificial Intelligence(AI) has the potential not only to enhance educational quality but, contribute to the achievement of broader goals for sustainable development, which is a key consideration for policymakers, educators and other stakeholders.

Despite these opportunities, the integration ofArtificial Intelligence (AI) in Nigerian education is fraught with barriers, including resistance to change, lack of expertise in Artificial Intelligence(AI) among educators, and concerns around data privacy and security (Adewale & Adeyemi, 2023). Additionally, there is a need for regulatory frameworks to guide the ethical use of Artificial Intelligence(AI) in education and to ensure that it benefits all segments of society, particularly marginalized groups who may be excluded from the digital divide. This study, therefore, seeks to explore the role of AI in advancing sustainability and development in Nigeria's education system.

Historical Evolution of Artificial Intelligence (AI)

The concept of Artificial intelligence was coined by John McCarthy at the Dartmouth conference, which was proceeded by a preparatory document dated August 31st, 1955 at the Council of Europe (Cordeschi, 2007). Since then, several definitions have been provided forArtificial Intelligence(AI). For instance; Council of Europe (2021) defined AI as some set of sciences, theories and techniques whose main purpose is to reproduce the cognitive abilities of human beings in machines such as entrusting a machine with complex tasks previously delegated to humans. The notion behind AI is that machines can exhibit human intelligence. The concept of machine learning started in 1956 such that algorithms are used to interpret data and guided the decision-making processes as well as execution of tasks. Artificial intelligence (AI) sometimes called machine intelligence, is intelligence demonstrated by machines in contrast to natural intelligence displayed by humans and other animals (McCorduck et al., 2004; McCorduck et al. 1977). This implies that machines can be made to perform tasks commonly associated with intelligent beings like humans and animals. Artificial Intelligence (AI) basically, is computer code that displays some of intelligence, learning and problem solving in what has been referred to as super intelligence.

Artificial Intelligence(AI) application has been around for some time particularly in communication for instance, Artificial Intelligence(AI) has been used to streamline the amount of spam appearing in one's emails. In the travel industry, Artificial Intelligence (AI) has been used as a guide to locate destinations. Applications such as the Google map and Waze use machine learning algorithms. The Autopilot in aircrafts also qualifies as Artificial Intelligence(AI) tool. In addition, online shopping and banking services are now advanced using humanoids for customer service engagements. The emergence of generative artificial intelligence especially the ChatGPT in November 2022 signposts a major breakthrough in educational research and practice. Generative Artificial intelligence otherwise known as 'GenAI' is an application that creates contents such as texts, codes, images and videos based on prompts and automatic language processing.

The potential benefits offered by Artificial Intelligence (AI) in fostering the tasks of educators and learners is therefore not in doubt (Poelhuber et al., 2024). Although literature has shown that research on AI in education began in 1970s, it has been an integral part of the higher education for many years (Southgate, (2020), Poelhuber et al., 2024). For instance, education data mining has resulted in significant growth of learning analytics in the field of education. Learners' data can be accessed and analysed to understand students who are at risk of

dropping out of an online programme or within the Learning management systems. Also, Chabot has been developed within these environments to support students learning (Heryandi, 2020).

Artificial Intelligence(AI) in Education is predominantly concerned with natural language processing, conversational robots (Humanoids), adaptive learning, speech and visual recognition, expert systems, intelligent tutoring systems, feedback mechanisms, and decision support systems. (Poelhuber et. al., 2024). Artificial Intelligence(AI) is fundamentally grounded on personalized learning experiences. However, Holmes et al. (2019) vividly captured the real essence of the core of Artificial Intelligence (AI) in education, thus; Artificial Intelligence (AI) in education encompasses all that is AI-driven from personalized instructional dialogues systems, AI-supported exploratory learning, analysis of students writing, intelligent agents in game-based environments, and students-support chatbots, to Artificial Intelligence(AI)-facilitated student/tutor matching that emphasises student centred learning.

Sustainability and Development in Nigeria

Nigeria, Africa's most populous nation and largest economy, faces significant challenges in balancing economic growth with environmental sustainability. As a signatory to the United Nations' Sustainable Development Goals (SDGs), the country has committed to fostering inclusive growth while addressing critical environmental, social, and economic issues (United Nations, 2015). Nigeria's economy heavily relies on oil, which contributes significantly to its GDP and government revenues, however, the dependence on fossil fuels has led to environmental degradation, including oil spills, deforestation, and air pollution in the Niger Delta region and the need to diversify the economy by investing in renewable energy, agriculture, and technology is crucial for sustainable development (Odeyemi & Ogunseitan, 1985).

The energy sector is pivotal to Nigeria's sustainable development andover 40% of Nigerians lack access to electricity, relying on biomass and fossil fuels, which contribute to deforestation and greenhouse gas emissions (World Bank, 2022). Investments in solar, wind, and hydroelectric power can not only reduce environmental impacts but also improve energy access and drive economic growth (Ighodaro et al., 2021). Nigeria's rapid urbanization, with over 50% of its population living in urban areas, has strained existing infrastructure and resources. Urban centers like Lagos face challenges such as inadequate housing, waste management issues, and water scarcity (UN-Habitat, 2019). Sustainable urban planning and investment in green infrastructure are essential to mitigate these challenges.

Sustainability in Nigeria also involves addressing poverty and inequality and over 40% of the population live below the poverty line with limited access to education, healthcare and clean water (National Bureau of Statistics, 2021). Initiatives such as the National Social Investment Programme aim to alleviate poverty and promote social inclusion, contributing to the broader SDG agenda (NSIP, 2020). Nigeria is highly vulnerable to climate change impacts, including rising temperatures, desertification in the north, and coastal erosion in the south (IPCC, 2021). Policies promoting climate resilience, such as afforestation programs and sustainable agricultural practices, are critical for mitigating these effects and ensuring food security. Strong governance is essential for achieving sustainability. The lack of policy implementation and corruption have historically hindered progress in Nigeria (Transparency International, 2023). Strengthening institutions and fostering accountability can accelerate the transition to sustainable development.

Artificial Intelligence(AI) Applications in Education for Sustainability

Artificial Intelligence (AI) has emerged as a transformative force in education, offering innovative solutions to enhance learning outcomes and promote sustainable development. In Nigeria, integrating Artificial Intelligence(AI) into the educational sector presents both opportunities and challenges.

1. **Personalized Learning:** Artificial Intelligence (AI) can provide tailored learning experiences for students based on their individual needs, preferences, and progress. For example, adaptive learning platforms use Artificial Intelligence(AI) algorithms to identify knowledge gaps and suggest customized learning paths, enabling students to better understand sustainability concepts at their own pace (Holmes et al., 2019). Example: Tools like Dream Box and Knewton adapt content for students, making it easier to teach sustainability topics.
2. **Intelligent Tutoring Systems (ITS):** Artificial Intelligence (AI)-driven ITS can guide students through sustainability topics by providing instant feedback and explanations. These systems simulate a one-on-one tutoring experience, which has been shown to enhance learning outcomes (Woolf, 2020). Example: Systems like Carnegie Learning provide real-time support for complex environmental and sustainability issues.

3. Data-Driven Insights for Curriculum Design: Artificial Intelligence(AI) analyses large data sets from students' interactions to identify trends, strengths and areas for improvement. Educators can use these insights to develop or refine sustainability-focused curricula (Zawacki-Richter et al., 2019). Example: Artificial Intelligence (AI) analytics platforms like Edmodo Insights help educators track engagement with sustainability content.

4. Gamification and Simulations: Artificial Intelligence (AI) enables immersive simulations and gamified learning experiences that make sustainability education engaging. For example, AI-powered serious games simulate real-world sustainability challenges, allowing students to explore solutions in a risk-free environment (Johnson et al., 2021).**Example:** Games like "SimCity EDU" teach urban planning with sustainability principles.

5. Predictive Analytics for Student Engagement: Artificial Intelligence (AI)predicts student engagement levels and flags at-risk learners. Educators can then intervene to ensure students remain engaged in sustainability courses (Nguyen et al., 2018). **Example:** Artificial Intelligence (AI) systems in platforms like Blackboard Learn use predictive models to enhance retention in environmental studies programs.

6. Artificial Intelligence(AI)-Powered Language Translation and Accessibility: Artificial Intelligence(AI) tools like Google Translate and Microsoft Immersive Reader break language barriers and enhance accessibility, making sustainability education more inclusive for global audiences (Wu et al., 2020). **Example**: Real-time translation helps disseminate sustainability knowledge in regions where resources are not available in local languages.

7. Virtual and Augmented Reality (VR/AR) for Experiential Learning: Artificial Intelligence(AI) enhances VR/AR technologies to provide hands-on experiences in sustainability. Students can explore ecosystems, understand renewable energy systems, or model the effects of climate change in virtual environments (Freina & Ott, 2015). **Example:** Artificial Intelligence(AI)-powered VR tools like "Eco Learn" immerse students in environmental scenarios.

8. Automated Assessment and Feedback: AI automates the grading of assignments, quizzes, and projects related to sustainability topics, providing immediate and detailed feedback to students (Heffernan & Heffernan, 2014). **Example:** Platforms like Grade scope help evaluate complex sustainability essays and problem-solving tasks.

9. Artificial Intelligence (AI) in Research Support: Artificial Intelligence (AI)tools assist students and researchers in sustainability fields by analysing data, suggesting resources, and generating reports. For example, natural language processing (NLP) tools summarize large data sets and academic papers (Mihalcea & Tarau, 2004). **Example:** Tools like Zotero and Mendeley leverage AI to organize and reference sustainability research.

10. Behavioural Nudging: Artificial Intelligence(AI) applications in sustainability education use nudging techniques to encourage environmentally friendly behaviours among students. For example, AI chatbots send reminders to conserve resources or participate in green initiatives (Thaler & Sunstein, 2008). **Example:** Chatbots like Replika can promote daily eco-friendly habits.

Relevance of Artificial Intelligence(AI) to Nigeria's Educational and Developmental Challenges

Artificial Intelligence (AI) holds immense potential to address some of the most pressing educational and developmental challenges in Nigeria. These challenges include inadequate access to quality education, teacher shortages, high dropout rates, and an over-reliance on traditional teaching methods. Integrating Artificial Intelligence (AI) into the educational system could provide innovative solutions that enhance accessibility, inclusivity, and sustainability.

1. Bridging Access to Education

Nigeria faces significant disparities in access to education, especially in rural areas where infrastructure and teacher availability are limited. Artificial Intelligence (AI)-powered solutions, such as adaptive learning platforms, can help bridge this gap by delivering personalized learning experiences to students irrespective of their location. For instance, Artificial Intelligence(AI)Artificial Intelligence-based tools like chatbots and virtual tutors can provide on-demand support, helping students learn at their own pace (Luckin et al., 2016). Moreover, these platforms can be designed to function offline, ensuring that students in areas with limited internet connectivity can still benefit.

2. Addressing Teacher Shortages

Nigeria has one of the highest teacher-to-student ratios globally, leading to overcrowded classrooms and poor learning outcomes (UNESCO, 2021).Artificial Intelligence (AI) can mitigate this challenge by automating administrative tasks,

enabling teachers to focus on teaching and mentoring. AI tools can also assist in content delivery, grading, and monitoring student progress, reducing the workload on educators. For example, systems like AI-driven grading tools have been shown to significantly reduce the time spent on assessments, allowing teachers to allocate more time to lesson planning and individual student needs (Holmes et al., 2019).

3. Enhancing Quality of Education

The quality of education in Nigeria is often undermined by outdated curricula and a lack of resources. AI can provide access to up-to-date educational content tailored to individual learning needs. Platforms such as Coursera and Khan Academy use Artificial Intelligence (AI) to recommend courses and resources based on a learner's progress and preferences (Nguyen et al., 2018). Integrating such platforms into Nigeria's educational framework can enhance the quality of instruction and ensure that students acquire relevant skills for the modern workforce.

4. Promoting Inclusivity

Artificial Intelligence(AI) has the potential to make education more inclusive for marginalized groups, including individuals with disabilities. Artificial Intelligence(AI)-driven tools like speech-to-text and text-to-speech systems can support students with hearing or visual impairments, ensuring that they can actively participate in the learning process (World Bank, 2020). Additionally, AI applications can provide translation services for Nigeria's diverse linguistic landscape, fostering inclusivity in multilingual classrooms.

5. Fostering Lifelong Learning and Skill Development

As Nigeria transitions to a knowledge-based economy, the need for continuous skill development becomes critical. AI-powered platforms can facilitate lifelong learning by providing personalized learning paths for individuals at different stages of their careers. This approach aligns with the demands of industries such as technology, healthcare, and agriculture, where skill gaps hinder productivity (McKinsey, 2020).

6. Supporting Data-Driven Decision Making

Artificial Intelligence(AI) can enable data-driven decision-making in education by analysing large datasets to identify trends and areas requiring intervention. For instance, predictive analytics can be used to monitor dropout rates and implement timely interventions to keep students in school. Policymakers can also use AI-generated insights to allocate resources more effectively, ensuring that underserved regions receive the support they need (UNESCO, 2021).

Conclusion

Artificial Intelligence(AI) offers innovative solutions to long-standing issues by improving access to education, enhancing quality and promoting inclusivity, as well as fostering lifelong learning, aligning education with industry demands and support data-driven policymaking for sustainable development.

Recommendations

Based on the discussion in this study, it is recommended that:

1. Government should invest in infrastructure, capacity building, and the development of ethical and inclusive policies, through strategic implementation. Comprehensive policies should be established to govern the ethical and inclusive use of AI in education, ensuring that no group is left behind in its implementation.
2. Schools and universities should introduce AI-related courses to equip students with skills relevant to the digital age and foster awareness of AI's applications in various sectors. Adequate funding should be allocated to provide schools with the necessary technology, such as computers, internet access, and AI-enabled tools, to bridge the digital divide between urban and rural areas.
3. Professional development programmes should be introduced to help educators understand and effectively use Artificial Intelligence (AI) applications in teaching and learning. Partnerships between technology companies and schools should be encouraged to provide AI solutions, resources, and technical support tailored to Nigeria's educational needs.
4. Developers should design Artificial Intelligence(AI) systems that address Nigeria's unique challenges, such as multilingual education, by incorporating local languages and contexts into the software. Regular assessments should also be conducted to measure the impact of AI in education, ensuring that implementation aligns with national goals for sustainability and development.

References

Adewale, A. A., & Adeyemi, B. S. (2023). Artificial Intelligence in Nigerian education: opportunities and challenges. Nigerian Journal of Educational

Technology, 15(2), 65-78.
Akpan, E. U., Udofia, U. E., & Eze, M. C. (2022). The impact of technology on education in Nigeria: the case for Artificial Intelligence (AI). Education and Development Journal, 12(4), 134-148.
Alabi, A. M., & Olufunke, O. A. (2023). Revolutionizing Nigerian Education with AI: challenges and prospects. International Journal of Educational Research, 9(1), 45-56.
Cordeschi, R. (2007). AI Turns Fifty: Revisiting its Origin. Retrieved from https://doi.org/1080/08883951070125304
Eze, M. C., & Ani, P. F. (2023). AI-driven personalized learning and teacher support in Nigerian classrooms. Journal of African Educational Technology, 5(2), 12-27.
Federal Republic of Nigeria (2018). National Policy on Information and Communication Technology in Education. Federal Ministry of Education, Lagos: NERDC.
Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education. Journal of Educational Studies,4(2) 34-56
Heffernan, N. T., & Heffernan, C. L. (2014). The ASSISTments ecosystem: building a platform that brings scientists and teachers together for minimally invasive research on human learning and teaching. Journal of Educational Studies,5(2) 45-65
Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial Intelligence in education: promises and implications for teaching and learning. Journal of Educational Studies,6(2) 67-87
Ighodaro, C. et al. (2021). Renewable energy for sustainable development in Nigeria. Energy Policy Journal,4(2)34-49
IPCC (2021). Climate Change 2021: the Physical science basis. Intergovernmental Panel on Climate change. IPCC Report.UK
Johnson, L., et al. (2021). Gamification for sustainability: engaging learners in real-world challenges.UK.Lon Press
Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence unleashed: An Argument for AI in Education. Pearson.
McKinsey & Company. (2020). The Future of Work in Africa: Embracing Technology for a Prosperous Future. McKinsey & Company. USA
Mihalcea, R., & Tarau, P. (2004). Text rank: bringing order into texts. China.Chin Press Ltd
National Bureau of Statistics (2021). Poverty and Inequality in Nigeria 2021.Statistical Report
Nguyen, A., Gardner, L., & Sheridan, D. (2018). "A multi-method evaluation of AI Applications in education." Computers & Education Journal,5(2) 126, 1-17.
Nguyen, H., et al. (2018). Predictive analytics in education: data-driven approaches to student engagement. Nigerian Journal of Educational Psychology,8(2) 71-98
NSIP (2020). National social investment programme. USA. Annual Report.
Odeyemi, O., & Ogunseitan, O. (1985). Petroleum industry and its pollution potential in Nigeria. Environmental Pollution Series B. Lagos, Nigeria
Olaniyi, O. P., & Adefolalu, O. B. (2021). Artificial Intelligence in Nigerian educational systems: Teachers' Perspectives. Nigerian Journal of Educational Psychology, 8(4), 56-70.
Olatunji, S. A., & Adebayo, B. I. (2022). Barriers to educational access and technology in Nigeria: the role of Artificial Intelligence. Journal of Educational Development Studies, 10(3), 222-235.
Oni, I. T., Akinyele, O. D., & Fasanya, A. O. (2021). Global trends in AI education: lessons for Nigeria. Journal of Global Education and Innovation, 6(1), 103-116.
Thaler, R., & Sunstein, C. (2008). Nudge: improving decisions about health, wealth, and happiness. USA. Thai Press
Transparency International (2023). Corruption perceptions index 2023. Transparency International Report
UNESCO. (2021). Global education monitoring report: inequality in education. UNESCO Report
UN-Habitat (2019). Urbanization in Nigeria: challenges and Opportunities. 'UN' Report
United Nations (2015). Transforming our world: the 2030 agenda for sustainable development. United Nation Report
United Nations. (2020). Transforming Education: the role of technology and innovation in achieving the SDGs. United Nations Education and Research Group.
Woolf, B. P. (2020). Building intelligent interactive tutors: student-centered strategies for revolutionizing e-learning. India, Indiana Press Ltd
World Bank (2022). Energy access in Sub-Saharan Africa: Nigeria country profile. World Bank Report
World Bank. (2020). Inclusive education: the role of technology in supporting marginalized Learners. World Bank Report
Wu, D., et al. (2020). AI-powered language translation and its impact on education.
Zawacki-Richter, O., et al. (2019). Systematic review of research on artificial intelligence applications in higher education. India, Indiana Press Ltd.