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TEACHING AND LEARNING OF PHYSICS EDUCATION: THE ROLE OF ARTIFICIAL INTELLIGENCE

UGWU, D.U[1,] CHUKWUNENYE, J.N[2], ERUKPEME, A.H[4], OZIOKO, S.U[3.]
donatusuchechukwuugwu@gmail.com
[1,2,4]DEPARTMENT OF PHYSICS, ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION OWERRI.
[3]DEPARTMENT OF INTEGRATED SCIENCE, ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION OWERRI.

Abstract

This paper examines the integration of artificial intelligence (AI) in physics education, emphasizing its potential to transform pedagogical practices and address long-standing instructional challenges. With growing recognition of physics as a foundational science, the paper identifies critical barriers to effective instruction and learning, such as abstract concepts, limited teaching resources, and inadequate teacher preparation. through a conceptual and application-based review, the authors explore how AI can enhance personalized learning, facilitate complex simulations, and support educators with data-driven insights. Challenges to AI integration, including ethical concerns, infrastructural limitations, and professional capacity, are critically assessed. Recommendations for policy, curriculum inclusion, and teacher training were also provided.

Keywords: *Artificial intelligence, physics education, personalized learning, teaching challenges, instructional innovation*

Introduction

Physics is concerned with the study of matter, energy and the relationship between them. It provides the physical principles and laws that help explain the universe. Physics is a fundamental science that explores matter, energy, and the laws governing their interactions. It forms the backbone of technological and scientific advancement (Ugwu, Alachi, Nwaka, & Abah, 2022). It is expected that teachers of physics should apply all the theories and principles of learning and take into cognizance the complexities, divergence and dichotomies of learners disparities as a result of various factors affecting concentration and learning such as learning styles of students. It is believed that for improved learner performance, knowledge of the factors enable the teacher to deploy all known best practices and procedures to ensure improved quality instruction. Thus physics teaching and learning in schools in all countries is important because physics contributes to the technological infrastructure and provides trained personnel needed to advance and discoveries. it is fundamental in the education of chemist, engineers, doctors, pilots, and computer scientist as well as practitioners of the other physical and biological sciences. Physics improves quality of life by providing the basic understanding necessary for developing technology and techniques for medical applications such as ultra sound ,, x-rays, laser surgery and other imaging among others (Ugwu, Cookey and Nwokocha 2016). Physics education is an important area within

science education with focus on the teaching and learning of physics at all levels.It is concerned with physics teachers training and development as well as general physics literacy.Physics education is a vehicle for disseminating scientific information, knowledge or skills necessary in addressing scientific and environmental issues in the world today. The physics community can contribute to curriculum development, innovative teaching approaches and public awareness in physics. A robust physics education cultivates critical thinking, logical reasoning, and problem-solving skills, equipping learners . (Lacambra, 2016).

Despite its importance, the teaching and learning of physics remain challenging. Students struggle with abstract concepts and complex mathematical formulations, while teachers face issues such as insufficient training, large class sizes, and inadequate instructional materials (Ugwu, 2005; Obi & Ewuzie, 2014). The rapid advancement of **Artificial Intelligence** presents new opportunities to bridge these gaps. **The Role of Artificial Intelligence (AI) in Physics Education cannot be over-emphasized.** AI systems ranges from intelligent tutoring systems or devices to machine learning platforms which offers personalized adaptive learning experiences. (Chukwunenye 2016). These tools analyzes learners' data to tailor content, provide real-time feedback, and support students' individual learning paces (Chukwunenye 2019; Osigwelem, Emenike, & Osigwelem, 2022).The integration of AI in physics education could address many longstanding issue such as **f**acilitating personalized learning by tailoring content to students' individual learning styles and pace (Chukwunenye 2023). **Enabling** intelligent tutoring systems to **o**ffer immediate feedback and targeted interventions (Hossenfelder, 2023).Automate routine tasks by **a**ssisting teachers with grading, content creation, and data analysis. It also provides simulated experiments which allow students to conduct virtual experiments that are otherwise impossible in under-resourced schools.In the physics classroom, Artificial Intelligence can generate predictive analysisto guide pedagogical decisions, supporting collaborative and peer learning through intelligent systems. During the COVID-19 pandemic, AI applications helped maintain learning continuity, reducing physical interaction and mitigating health risks (Ugwu et al., 2022). According to Hossenfelder (2023), AI applications in physics research such as modeling cosmic ray interactions and quantum states can also inform instructional practices by simplifying complex phenomena.

However, the **challenges** in Teaching and Learning of Physics Physics education is hampered by various obstacles such as **s**tudent level challenges which includes **c**onceptual difficulties, lack of motivation, poor mathematical foundation, and limited study skills (Ugwu, Fagbenro, & Emelue, 2018). Also teacher level challenges such as **i**nsufficient pedagogical skills, lack of training on inquiry-based approaches, and poor content mastery (Ugwu et al., 2016). Institutional level challenges in the forms of **o**vercrowded classrooms, inadequate lab facilities, poor funding, and outdated curricula (Emajeju, 2010). These challenges contribute to declining interest in physics and consistently low academic performance, necessitating innovative solutions.

Despite the potential benefits, several challenges inhibit the seamless adoption of AI in physics classrooms such as **technological infrastructure.** Many schools, especially in developing countries, lack the necessary digital infrastructure (internet access, devices, electricity) to support AI systems (Emajeju, 2010). **Teacher readiness is another** major barrier that limits technical expertise among teachers to operate and integrate AI tools effectively (Ugwu et al., 2016). Also c**ost implications in the form of h**igh initial investment in AI tools and maintenance may be prohibitive for many educational institutions (Hossenfelder, 2023). The **ethical and privacy concern exhibited by raising issues on the use** of AI systems especially as regards to data privacy and algorithmic bias (OECD, 2023). The **resistance to change is another factor that promotes** traditional mindsets and lack of institutional support often hinders the adoption of innovative pedagogies. The challenge therefore is how do we make AI acceptable to every classroom teacher and stakeholders in education? Therefore the purpose of this study is to examine the teaching and learning of physics education; the role of Artificial Intelligence specifically; To ascertain the level of teachers' awareness and acceptance of AI,the extent of government's effort to popularize it and curriculum innovations involving AI since AI appears to hold the key to positive innovation in physics and science education in general,

Statement of the Problem

Despite concerted efforts to improve physics education, students' achievement levels remain low, interest continues to decline, and teachers often lack the tools and support required to deliver effective instruction .Existing pedagogies struggle to meet the diverse learning needs in overcrowded classrooms, and students frequently report that physics is "too abstract" or "too difficult" (Tobias & Birer, 1999). The research problem, therefore, centers on how AI can be effectively integrated to enhance both student outcomes and teaching efficiency in physics education

Research Questions

The following research questions will guide this study

i. What is the extent of teacher's awareness in the use of AI in teaching physics?
ii. What is the extent of use of AI technology in classroom instruction?
iii. What is the percentage of teachers/school that uses AI as a medium of instruction?
iv. What percentage of schools has AI as a strategy or recommended mode of instruction?
v. What are the Nigeria Government initiative for AI in education?

Extent of Teachers' Awareness and Utilization

Studies and report indicates that the awareness and utilization of AI among Secondary Schools Science Teachers in Nigeria especially for subject like physics are low but evolving (Ukoh & Nicholas 2022). Some teachers might have a general understanding of AI as a concept. There familiarity with specific AI tools and practical application in the classroom is often limited. Studies have shown that many AI resources remain unknown in secondary education (Chounta, Bardone, Raudsep & Pedaste 2022) where there are some awareness, it tends to be with widely recognized tools but not necessarily those specifically designed for

pedagogical purposes in physics. Despite the low utilization, there is strong positive perception among teachers regarding the potentials of AI

Extent of use of AI Technology in the Classroom

Introducing AI intelligent technology in the Nigeria Secondary Education is faced with challenges. Many schools are faced with infrastructural defiencies which is the most significant barriers. It includes erratic power supply which makes it difficult to power and utilize digital devices and AI platform consistently. Poor internet access especially in rural areas severely limits access to online AI tools or resource. Lack of hardwares such as computers, tablets or smart boards necessary to run AI applications

Teacher preparation and competence is another factor that contributed to low use of AI technology in the classroom. A significant number of teachers lacks the fundamental digital literacy and specific AI pedagogical skills required to effectively integrate AI into teaching. Insufficient training to expose the teacher to a widespread, consistent and in – depth training on AI tools and their application is still lacking. More so some educators are resistant to change as a result, find the challenging to adapt new technology due to unfamiliarity, fear of the unknown or a preference for traditional method.

Funding and resources also constitute key factor that makes AI tools inaccessible to schools with limited budgets under funding of educational sector in Nigeria generally suggests from under-funding which directly impacts the ability to invest in AI infrastructure and training. These factors discussed contribute to low use of AI in the classrooms in Nigeria.

Schools with AI Instructional Strategies in Nigeria

Schools with AI facilities or integrated AI as instructional strategy are insignificant in Nigeria. Recently the Federal Ministry of Communication, innovation and digital economy has been involved in drafting of a national AI strategy to ensure the deployment of AI across various sectors including education (Yakubu 2024; Nwuke & Yellowe 2025). The Federal Government launched Artificial Intelligence pedagogical skill training program for 6, 000 teachers selected from Secondary Schools in Nigeria across the 36 state and Federal Capital Territory Abuja. This initiative was organized by National Senior Secondary School Commission (NSSEC). This was sponsored by Google Research and supported by Data Science Nigeria and Olabisi Onabanjo University. The goal was to enhance AI as teaching method and prepare students for a technologically – driven future. The Federal Government has introduced e – learning platform through the Federal Ministry of Education with innovations and e – learning solution which includes "ignite for teachers" aimed at creating virtual classrooms and simplify lesson planning indirectly promoting digital literacy and preparation for AI tools. However, there is need for a larger training platform.

Further Initiative by Nigeria Government to Introduce AI in Curriculum

Reports shows that the Federal Government has announced the integration of AI into curriculum delivery as part of ongoing reform in educational sector. This demonstrate a commitment to "inclusive future – ready – education". There is collaboration and partnership with international communities and partner such as Korean International Co – operation Agency (KOICA) aimed at supporting Nigeria's Digital Transformation in basic education including smart school programs. Event such as inaugural AI awareness day in Higher education and the commemoration of the international day of education with the theme "AI

and Education' Preserving Human Agency in a World of Automation" is aimed at raising awareness and highlight AI's transformative role in education.

Nigeria recently launched the Nigeria Artificial Intelligence (AI) Scaling Hub in collaboration with Bill Gates Foundations. The initiative was aimed at accelerating the development and scale up of AI – driven solutions across health, education, and agriculture. The gates foundation committed about $ 7.5 million over three years to this hub.

Conclusion

In essence, AI has the potential to transform physics education in Nigeria from a teacher-centric, theoretical approach to a more student-centered, practical, and interactive learning experience, ultimately improving academic achievement and fostering a more positive attitude towards the subject. However, realizing this potential hinges on overcoming the significant challenges related to infrastructure, teacher capacity, and funding.

Nigerian secondary school teachers, particularly in sciences like physics, are beginning to acknowledge the immense potential of AI in transforming education, their actual awareness and practical utilization of AI tools are still in their early stages. The primary hurdles are a combination of inadequate infrastructure, insufficient training, and limited funding. However, the government and educational stakeholders are recognizing this gap and taking steps to address it through training programs and policy recommendations.

Recommendations

Recommendations: To harness AI's full potential in physics education:

Policy Development: Government must establish national AI strategies for education

Curriculum Integration: Embed AI literacy in teacher training and physics curricula

Professional Development: Organize workshops and continuous training on AI tools

Research and Evaluation: Encourage studies on AI effectiveness and equity in education

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