

Artificial Intelligence in Physics Education: Opportunities and Challenges in Yobe State Tertiary Institutions in Nigeria

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Received: 15.04.2026 | Accepted: 24.05.2026 | Published: 25.05.2026

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DOI: [10.5281/zenodo.20382309](https://doi.org/10.5281/zenodo.20382309)

Abstract

Case Studies

In physics education, Artificial Technologies (AI) like intelligent tutoring systems, virtual laboratories, adaptive learning platforms, machine learning applications, and AI-powered simulations are reshaping instructional delivery and students' learning experiences. This paper explores the opportunities and challenges associated with the integration of AI in physics education. AI has emerged as a transformative technology in education, significantly influencing teaching, learning, assessment, and research processes across disciplines. Three research questions served as the basis for the study's descriptive survey research design. Structure questionnaires were used to collect data from physics instructors and students, and descriptive statistics were used for analysis. The results showed that AI improves conceptual understanding, helps virtual experimentation, enhances tailored learning, boosts student engagement, and enables efficient assessment procedures in physics education. Effective AI integration is hampered by issues like inadequate infrastructure, bad internet access, inadequate teacher competency, high implementation costs, ethical concerns, and a lack of institutional support. The study comes to the conclusion that although AI has a great deal of promise to change physics education, sustained deployment would require strategic investments in infrastructure, training, policy creation, and curriculum modification.

Keywords: Artificial Intelligence, Physics Education, Teaching and Learning, Educational Technology, AI Integration, Virtual Laboratories.

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Introduction

Innovative teaching and learning strategies have resulted from the worldwide transformation of educational systems brought about by the quick development of digital technology (Holmes et al., 2019). Among these technologies, artificial intelligence (AI) has become one of the most significant developments influencing contemporary education. Artificial intellect (AI)

is the term for computer programs created to carry out activities that often require human intellect, such as learning, problem-solving, reasoning, decision-making, and language comprehension (Russell & Norvig, 2021). AI technologies are being employed more and more in the educational industry to improve assessment systems, automate instructional chores, customize learning, and increase student engagement (Luckin, 2018).

Because of its abstract concepts, mathematical complexity, and experimental nature, physics is a science discipline that frequently presents challenges to students (Adeyemo, 2010). As a result, many students view physics as challenging, which leads to poor academic performance and low interest in the subject (Aina & Adedo, 2013). As a result, educators are constantly looking for innovative ways to improve physics teaching and learning. Artificial intelligence offers significant opportunities for addressing these challenges by providing intelligent tutoring systems, virtual laboratories, and automated feedback systems that can increase students' comprehension and engagement (Woolf, 2010).

Through interactive simulations and individualized learning experiences, AI-powered tools help students learn physics concepts (UNESCO, 2021). For instance, machine learning algorithms can identify students' learning challenges and suggest personalized learning pathways (Luckin, 2018). Similarly, AI-powered virtual laboratories allow students to conduct experiments remotely, overcoming the limitations associated with physical laboratories (Holmes et al., 2019).

Despite these advantages, there are a number of obstacles in the way of integrating AI into physics teaching. Inadequate technology infrastructure, unprepared teachers, ethical issues, a lack of technical know-how, high implementation costs, and digital disparities among students are some of these (Okonkwo & Ade-Ibijola, 2021). Effective AI implementation in educational institutions is further hampered by inadequate internet connectivity and restricted access to digital resources in many developing nations, particularly in Africa and Nigeria (Adigun et al., 2023). In order to give educators, policymakers, and researchers with insights, it is necessary to critically analyze the opportunities and difficulties related to AI integration in physics education.

Statement of the Problem

Poor student performance, subpar lab facilities, low motivation, and trouble grasping abstract

concepts are just a few of the many instructional and learning issues that physics education still faces (Aina & Adedo, 2013). Conventional teaching approaches may restrict students' active engagement in the learning process and frequently fail to address individual learning differences (Adeyemo, 2010). Through individualized training, intelligent tutoring programs, virtual labs, and automated assessment tools, the development of artificial intelligence offers new opportunities to enhance physics education (Woolf, 2010).

However, many educational institutions find it difficult to successfully incorporate AI technology into physics teaching and learning, despite the increased demand in these tools (UNESCO, 2021). AI adoption is still hampered by inadequate infrastructure, low digital literacy, inadequate training, budgetary limitations, and a lack of institutional policies (Okonkwo & Ade-Ibijola, 2021). As a result, it is still unclear how much AI can improve physics education, especially in developing nations (Adigun et al., 2023).

The potential and difficulties of artificial intelligence in physics education are thus examined in this work.

Objectives of the Study

The objectives of this study are to:

1. Examine the opportunities provided by AI in physics education, in Yobe State, Nigeria.
2. Identify the challenges affecting the integration of AI in physics teaching and learning.
3. Determine strategies for enhancing effective AI integration in physics education.

Research Questions

The following research questions guided the study:

1. What opportunities does artificial intelligence provide in physics education, Yobe State, Nigeria?
2. What challenges affect the integration of artificial intelligence in physics teaching and learning?

3. What strategies can enhance effective integration of artificial intelligence in physics education?

Literature Review

Concept of Artificial Intelligence in Education

The term "artificial intelligence" describes how computers and computer systems mimic human intelligence processes (Russell & Norvig, 2021). Machine learning, natural language processing, robotics, expert systems, and neural networks are examples of AI technology. Through automation and intelligent data analysis, artificial intelligence (AI) supports teaching, learning, evaluation, and administrative tasks in education (Holmes et al., 2019).

Intelligent tutoring systems, adaptive learning platforms, automated grading systems, virtual assistants, predictive analytics, and educational chatbots are examples of AI uses in education (Luckin, 2018). Personalized learning experiences, progress tracking, and instant feedback are all made possible by these technologies (UNESCO, 2021).

Artificial Intelligence in Physics Education

Scientific concepts pertaining to matter, energy, force, and motion are taught in physics classes (Adeyemo, 2010). AI tools improve physics teaching by making difficult ideas easier to understand through interactive models, animations, and simulations (Woolf, 2010). While intelligent teaching systems help students solve physics issues, AI-powered virtual laboratories offer remote experimentation chances (Holmes et al., 2019).

By analyzing students' learning behaviors and forecasting academic challenges, machine learning techniques allow teachers to intervene promptly (Luckin, 2018). Additionally, AI enhances students' interest and engagement, fosters inquiry-based learning, and facilitates collaborative learning (UNESCO, 2021).

Opportunities of AI in Physics Education

Personalized learning experiences, intelligent tutoring systems, better conceptual

understanding, virtual labs and simulations, automated assessment and feedback, higher student engagement, flexible learning opportunities, and improved data-driven instruction are just a few of the advantages AI offers to physics education (Holmes et al., 2019).

AI-powered simulations improve understanding and retention by helping students grasp abstract physics concepts like motion, electricity, waves, and magnetism (Woolf, 2010). By modifying content in response to students' performance, adaptive learning systems provide tailored training (Luckin, 2018).

Challenges of AI in Physics Education

Inadequate technology infrastructure, high implementation costs, low teacher competency, poor internet connectivity, ethical concerns, resistance to technological change, and a lack of institutional policies are some of the obstacles that AI integration must overcome despite its advantages (Okonkwo & Ade-Ibijola, 2021).

Inadequate electrical supply and digital inequality have a major impact on how well AI technologies are implemented in classrooms in developing nations (Adigun et al., 2023). Additionally, many educators lack the necessary expertise and self-assurance to use AI-powered teaching resources (UNESCO, 2021).

Methodology

In order to investigate the function and use of artificial intelligence in physics education, this study used a descriptive survey research approach. Because it allows the researcher to collect data from a chosen community and explain current conditions, beliefs, attitudes, and behaviors linked to the phenomenon under inquiry, the descriptive survey design was deemed appropriate (Creswell, 2018). Physics instructors and undergraduate physics students from particular universities made up the study's population. A sample of 120 respondents, 40 physics lecturers and 80 undergraduate physics students, were chosen from this demographic. To provide equitable participation opportunities and reduce sample bias, the respondents were chosen using a straightforward random sampling procedure.

A structured questionnaire called the "Artificial Intelligence in Physics Education Questionnaire (AIPEQ)" was used to gather data for the study. It was intended to gather pertinent information about participants' opinions and experiences regarding the incorporation of artificial

intelligence in physics education. Descriptive statistical methods, such as frequency counts, percentages, mean scores, and standard deviation, were used to evaluate the gathered data in order to summarize and interpret the participant replies.

Results and Discussion

Research Question 1:

What opportunities does artificial intelligence provide in physics education?

S/N	Opportunities of AI in Physics Education	Mean	Decision
1	AI increases students' understanding of abstract ideas	3.72	Agree
2	AI supports personalized learning	3.58	Agree
3	AI-powered simulations improve practical learning	3.73	Agree
4	AI escalations students' commitment in physics	3.48	Agree
5	AI accelerates automated feedback and assessment	3.56	Agree

Source: Field Survey, 2026

Discussion

In line with Holmes et al. (2019), who found that AI technologies improve learning effectiveness and student participation, and Woolf (2010), who highlighted that intelligent tutoring systems

and virtual simulations enhance science learning experiences, the results show that AI significantly improves physics teaching and learning by improving conceptual understanding, personalized instruction, and practical engagement.

Research Question 2:

What challenges affect the integration of artificial intelligence in physics teaching and learning?

S/N	Challenges of AI Integration	Mean	Decision
1	Inadequate technological infrastructure	3.65	Agree
2	Poor internet connectivity	3.70	Agree
3	Insufficient teacher competence	3.53	Agree
4	High cost of AI implementation	3.68	Agree
5	Lack of institutional support	3.45	Agree

Source: Field Survey, 2026

Discussion

The results demonstrate that AI greatly enhances physics teaching and learning by improving conceptual understanding, individualized

instruction, and practical engagement. This is consistent with the findings of Holmes et al. (2019), who discovered that AI technologies improve learning effectiveness and student

participation, and Woolf (2010), who emphasized that intelligent tutoring systems and

virtual simulations enhance science learning experiences.

Research Question 3:

What strategies can enhance effective integration of artificial intelligence in physics education?

S/N	Strategies for Effective AI Integration	Mean	Decision
1	Provision of adequate ICT infrastructure	3.83	Agree
2	Training and retraining of physics teachers	3.67	Agree
3	Government funding for AI technologies	3.70	Agree
4	Development of institutional AI policies	3.68	Agree
5	Curriculum redesign to include AI competencies	3.81	Agree

Source: Field Survey, 2026

Discussion

According to the study, curriculum changes, teacher preparation, supporting policies, and sufficient infrastructure are necessary for successful AI integration. This result is in line with UNESCO's (2021) emphasis on the necessity of governmental support and capacity building for the sustainable application of AI in education. Additionally, Holmes et al. (2019) emphasized that successful AI deployment depends on institutional preparation.

Conclusion

AI has the potential to significantly change physics education by boosting student engagement, increasing teaching efficacy, and facilitating individualized learning experiences (Holmes et al., 2019). Intelligent tutoring programs, simulations, and virtual labs are examples of AI-powered solutions that can enhance learning outcomes and make difficult physics concepts easier to understand (Woolf, 2010). Effective AI integration is hampered by issues like insufficient institutional support, high implementation costs, inadequate infrastructure, and low teacher competency (Okonkwo & Ade-Ibijola, 2021). To maximize the advantages of AI in physics education, these issues must be

addressed through strategic investments, policy support, and teacher capacity building.

Recommendations

1. Educational institutions should offer sufficient ICT infrastructure to support AI integration in physics education.
2. Physics teachers should receive constant training on AI technologies and digital instructions.
3. Governments should strengthen funding for AI implementation in education.
4. Institutions should develop clear policies and ethical strategies for AI use in teaching and learning.
5. Physics curricula should be reformed to integrate AI skills and digital learning methodologies.

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