LEVERAGING THE POTENTIALS OF ARTIFICIAL INTELLIGENCE-POWERED TECHNOLOGIES FOR SCIENCE TEACHING AND LEARNING IN SOUTH EAST NIGERIA

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Abstract
The adoption of artificial intelligence (AI)-driven technologies in science instruction has been revealed to be a radical solution to the longstanding issues of teaching and learning with regard to resource-based issues in some areas such as South East Nigeria. This paper investigates how artificial intelligence, through adaptive learning systems, intelligent learning, and virtual simulation, could improve the learning process of science courses and student achievement. Based on a mixed-method design, the primary data were observed in the form of questionnaires and the survey of 200 teachers of science and 500 students of secondary schools in the five states of South East Nigeria (Abia, Anambra, Ebonyi, Enugu and Imo). The model of action thus assumed is the Technological Pedagogical Content Knowledge (TPACK) model that focuses on synergy of technology, pedagogy and content knowledge as a means of successful integration. Results show that the application of AI technologies can be used to create personalized learning, automate assessment, and promote critical thinking, yet the implementation is hindered by the lack of infrastructure, insufficient teacher training, and digital divide. Demographics of the participants shows that it has a good concentration of male teachers (62%), with average of 12 years experience whereas the students are well balanced in terms of gender; however they can access technology differently depending on the urban to rural geographical differences. The paper mentions such positive outcomes as better interaction and acquisition of skills and is consistent with global trends in AI and education and deals with specific realities of economic transformation in Nigeria. The policy interventions that are recommended are the AI infrastructure and professional development. The study is relevant to the debate when it comes to the fair and balanced integration of AI in developing settings, which facilitates sustainable educational progress.

Keywords: artificial intelligence, science education, TPACK framework, South East Nigeria, personalized learning, technology integration

Introduction

Science education is also a foundation block of national development as it encourages critical thinking, innovation and problem solving skills that are critical to economic and social development. Overcrowded classes, poor resources, and outgoing pedagogy are some of the challenges that have persistently affected science teaching and learning in Nigeria, especially in the South East region, something that has impaired the quality of education and subsequent poor performance of students in national exams (Okunade, 2024). With the entry of technologies driven by artificial intelligence, one can take advantage of these possibilities to bring transformative change and make the process of instruction more interactive, personalized, and

efficient. In the current article, the author analyzes the possibility of utilizing AI to improve the process of teaching science in South East Nigeria by relying on both past and recent literature that would help place the topic in context. The context of this research is the educational environment of Nigeria, science education of which is central in realising the Sustainable Development Goals, in particular, Goal 4 of quality education. A rather high literacy level initiated by the cultural specificities of the South East Nigeria, which includes the states of Abia, Anambra, Ebonyi, Enugu, and Imo, is marked by the high concentration of entrepreneurial activity, but there are differences in access to the latest educational and educational resources (UNICEF, 2023).

Technology integration in education has had its historical progression as simple technologies such as radio broadcasts during the mid 20 th century up to a more advanced digital platform currently. Early writings have placed technological emphasis on scientific literacy, which is evident in attempts to introduce audiovisual technologies in the classroom in the 1980s and 1990s (Laugksch, 2000). As an example, research at the time revealed the potential of basic technologies to fill resource-lacking environments, which is the predecessor of the modern uses of AI (National Academies of Sciences, Engineering, and Medicine, 2000). Over the past few years, AI has transformed the worldwide educational process, as an adaptive system allows modifying the content based on the needs of individual learners, automating the routine work process, thereby giving teachers more free time to interact on a more meaningful level (U.S. Department of Education, 2023). Artificial intelligence (AI) can help solve learning crises in developing countries by offering scalable solutions, including chatbots to solve queries and virtual laboratories to perform practical experiments (World Bank, 2024). In Nigeria, however, the uptake has been low, especially in the field of science where rote learning is the norm (Ayeshung, 2025).

This paper develops these findings and explores how AI could cause the development of such skills as data analysis and critical thinking that were essential to the development of the country in terms of the economy (Imoniri, 2025). The problem statement highlights that the potential-implementation gap regarding AI in South East Nigeria exists. Even with the state of development in the world, the teachers of sciences in the region typically have no training and the infrastructures to integrate AI, and inequities in the outcomes of learning persist. As an illustration, the students in rural regions of the state of Ebonyi might have very little experience with the use of the digital tools, which contributes to the urban-rural divide further (Education Policy Data Center, 2004). The recent research shows that although AI can improve personalized learning, issues, such as data privacy problems and high cost, slow down developments in African settings (UNESCO, 2024).

The threats of growing inequalities due to unequal distribution of technology were also reflected in older literature (Bates, 2014). The study will focus on these questions by researching the topic using first hand data in a bid to come with empirical evidence about the viability of AI and its effects. The presence of AI in the context of science education is justified by the appropriate current literature. As an example, a survey on AI in Nigerian secondary schools showed that intelligent tutoring systems enhanced learning and achievement in such subjects as chemistry and

physics (Okunade, 2024). The AI has been associated with improved results in STEM educational areas worldwide, including such tools as adaptive platforms easing the load of administration on educators (PowerSchool, 2025). In third world countries, AI can bridge educational inequalities by providing inexpensive solutions to traditional resources as seen in Pakistan where virtual classrooms were used to reach more people (Kausar, 2025).

However, there are still some issues, such as the moral hazard of AI bias and the necessity of teacher upskilling (Chen et al., 2024). This viewpoint is supported by the historical views, where all the works written before 2000 promoted an idea that conceptual knowledge was greater when compared to simple memorization (Springer, 2007). Through bringing together these strands, this article hypothesizes that AI can be used to restore science education in South East Nigeria, provided there is alignment of the needs to such AI. Another impact of AI on promoting inclusivity that is mentioned in the literature is its use in fostering inclusivity. In Kogi State, Nigeria, AI was seen to be helpful in changing the architecture of science education in universities, although infrastructure barriers were observed (EJMSE, 2025). Elsewhere, AI-led evaluations have provided timely feedback and have strengthened learning in situations where there are limited resources (AMPLYFI, 2025). The previous research concerning technology in science teaching was focused on experiential learning in the form of simulations, which is the forerunner of the currently existing AI virtual worlds (ERIC, 2021). This meeting new with old enlightenment guides the present inquiry that aims to empirically prove the capabilities of AI as well as establishing issues around contextual limitations.

Theoretical Framework

The research strategy will be based on Technological Pedagogical Content Knowledge TPACK Model which assumes that successful combination of technology in teaching must be a balanced integration of three basic knowledge areas that are technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) (Mishra and Koehler 2006). TPACK is based on Pedagogical Content Knowledge (PCK) model developed by Shulman (1986), except that technology is now introduced as a significant part of it, given that teachers have to acquire knowledge on how digital tools can augment the subject-specific pedagogy.

TPACK can be used to analyze the context of AI-driven science education through the prism of how teachers in South East Nigeria can use AI to provide pedagogically-appropriate content such as a biology experiment or physics simulation. An example is technological knowledge, which entails an understanding of AI applications like chatbots or adaptive software, and pedagogical knowledge, which keeps these applications in favor of active learning, and not passive consumption. Content knowledge will guarantee compliance to science curriculum, e.g., the Basic Education Curriculum in Nigeria. The intersections of the framework, Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK) lead to TPACK making it possible to employ new technologies, such as AI-assisted personalized education pathways. According to the recent uses of TPACK in health professions education, it proves to be helpful in assessing the effect of technology on professional growth (PMC, 2023).

Other early forms of technology incorporation models that focused on teacher preparation have historically evolved into these models (National Academies, 2000). TPack is used in this study, where AI is analyzed to improve teaching of science to bridge the gaps in teacher competencies used in Nigeria settings (Somadina and Olabisi, 2025). The research by embracing TPACK has guaranteed a whole approach to it, which encourages the adoption of AI in a sustainable way depending on the education realities in South East Nigeria.

Methodology

The research design used in this study is a mixed method because it took into consideration all the possibilities of AI-powered technologies in science teaching and learning. The design was a combination of quantitative surveys to gather substantial information on the perceptions and use pattern of products and qualitative interviews to get detailed information on experience and difficulties. Such a method corresponds to pragmatic paradigms, and it is possible to perform triangulation of data in order to increase its validity (Creswell and Plano Clark, 2017).

The study was done in South East Nigeria with secondary schools as the area of interest to get the level of education where science plays a very vital role. These teachers and students of the five states included in the population were science teachers and students of government and non-government schools at the secondary levels. Participants were chosen by means of a purposive technique of sampling and were representative of both urban and rural regions. A total of 200 teachers and 500 students were included in the sample because they were available and willing to take part. The educators were bred among biology, chemistry and physics departments and students were bred among senior secondary levels (SS1-SS3).

Participants had demographic features that were analyzed in order to place the findings in context. Among teachers, the demographic factor showed a means age of 42 years (SD = 8.2) 62 males and 38 females. The level of experience was between 5 and 25 years with the average of 12 years. The educational education was 55 percent, bachelor in science education, 30-percent master and 15-percent, postgraduate diplomas. A total of 45 percent lived in an urban area (e.g., Enugu and Onitsha), and 55 percent lived in a rural one. The amount of AI tools was low, with the proportion of frequent use of digital resources being 28% in teaching. The demographics of the students represented a mean age of 16-years old (SD = 1.5), making half of them male and the other half female. There was a diversity in the socioeconomic status; 40 percent of low-income families, 35 percent of middle-income families and 25 percent of high-income families were present. The percentage of urban students was 48, rural 52. There was a lack of equal access to technology with 65% of them having smartphones, but only 35% having reliable internet.

Such demographics demonstrate age inequalities affecting AI use as per national statistics, which show a higher lack of school attendance rate in rural South East (UNICEF, 2023). Primary methods of collecting data were used. The instrument that used to test perceptions of the potentials of AI was a structured questionnaire that was created around TPACK constructs and measured these perceptions on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Topics were such as personalization (e.g., "AI can be adapted to the needs of individual

students) and problems (e.g., "Lack of training impede the use of AI). This instrument was pilot tested based on 50 individuals and had a reliability coefficient of Cronbach 0.87. The semi-structured interviews were carries out with 50 teachers and 100 students and took between 20-30 minutes, asking about the experience of using AI-based tools such as Khan Academy or local apps. There was a consideration of ethics, that is, informed consent, anonymity, which was accepted by the ethics committee of the University of Nigeria.

The analysis of the data was done through descriptive statistics that conducted quantitative analysis using means, standard deviations, and frequencies. Urban-rural differences were compared by using inferential statistics, i.e., the t-tests. Catagetically, the themes were categorized using NVivo software, which revealed such trends as improved participation and infrastructure obstacles. Integration was done in the interpretation, which linked the findings of the surveys with the descriptions of the interviews. Findings The survey and interview findings give empirical data about the prospects of AI in science education. Table 1 shows the descriptive statistics of the benefits of the AI as perceived by teachers.

Table 1

Teachers' Perceptions of AI Potentials in Science Teaching (N = 200)

Aspect	Mean	SD
Personalization of learning	4.2	0.8
Automation of assessments	4.0	0.9
Fostering critical thinking	3.8	1.0
Enhancing accessibility	3.5	1.1

Teachers scored the personalization factor as the highest implying that AI has the capacity to match science ideas to different learners. This was backed by qualitative information, one teacher wrote that AI simulations are useful because they allow learners to imagine the structure of atoms in notably costly laboratories. These views were echoed in the responses of students as represented in Table 2 although emphasis was made on engagement.

Table 2

Students' Perceptions of AI in Science Learning (N = 500)

Aspect	Mean	SD
Improved understanding	4.1	0.7
Increased motivation	3.9	0.8
Skill development (e.g., data analysis)	3.7	0.9
Inclusivity for diverse needs	3.4	1.0

The difference between rural and urban was considerable ($t = 2.45$, $p < .05$), with urban students presenting higher access. Interviews demonstrated such obstacles as challenges with power as one Ebonyi student reported that AI applications are very good, but no electricity will result in

no learning. The demographic factors were felt. The male teachers (M = 4.1) rated AI more highly than female teachers (M = 3.6), which might also be because of gender-related knowledge of technology. Better results were shown among high-income groups of students. In general, 72 percent of the respondents thought AI would change science education, which is consistent with economic positive changes in the literature (Imoniri, 2025).

Discussion

The results highlight the transformative possibilities of AI in science education in South East Nigeria, which can be related to the literature on AI internationally and nationally. Personalization adds to the adaptive abilities of AI in developing nations (AMPLYFI, 2025), and has a longer historical focus on experiential learning (Laugksch, 2000). Nonetheless, barriers such as infrastructure are a repeat of difficulties in the Nigerian universities (EJMSE, 2025). The application of TPACK indicates gaps in the knowledge about technology in teachers, which imply the specific training. Uneven demographic differences outline the inequity, which is in line with the UNICEF statistics (2023). Modern AI is highly interactive in comparison to previously, when technology was primitive (National Academies, 2000), however, there are still ethical issues (UNESCO, 2024). The research contributes to the area of research by giving region-specific knowledge, which spans between informing new and old paradigms. Conclusion and

Recommendations

Conclusively, AI-driven technologies have the huge potential of transforming the science teaching and learning in South East Nigeria as it facilitates skill transfer to support economic development as well as dealing with educational disparities. With the help of TPACK, it is possible to optimize the process of integration, yet it is necessary to overcome obstacles. Suggestions include government financing of AI infrastructure, teacher education programs and uses ethical policy. The longitudinal effects should be addressed in future studies.

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