

## ARTIFICIAL INTELLIGENCE IN TEACHING AND LEARNING HEALTH EDUCATION: IMPLICATIONS, OPPORTUNITIES, AND CHALLENGES IN NIGERIA

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### **Abstract**

*Artificial Intelligence (AI) is increasingly transforming the landscape of health education by redefining how teaching, learning, and assessment are conducted. This paper explores the implications, opportunities, and challenges associated with integrating AI into health education in Nigeria. It highlights how AI-driven tools such as adaptive learning platforms, virtual simulations, and automated assessments can enhance personalized learning, improve access to quality education, and address workforce shortages. However, the paper also identifies major challenges, including inadequate infrastructure, limited digital literacy, ethical concerns, and data governance issues that may hinder equitable implementation. The paper emphasizes the need for robust national policies, institutional readiness, faculty training, and regulatory frameworks to ensure responsible and inclusive AI integration. If strategically harnessed, AI can serve as a catalyst for innovation and capacity-building in Nigeria's health education sector, fostering a more efficient and equitable system.*

**Keywords:** Artificial intelligence, Health education, Teaching and learning, Nigeria, Opportunities, Challenges, Policy, Ethics

### **Introduction**

Artificial Intelligence (AI) is rapidly transforming the landscape of education and healthcare across the globe. Defined as the ability of computer systems to perform tasks that typically require human intelligence such as reasoning, learning, problem-solving, and decision-making AI has become a vital tool in modern teaching and learning environments (Sun et al., 2023). In education, AI technologies are being deployed to enhance instructional efficiency, personalize learning, and improve student outcomes. Within the health education sector, these technologies offer innovative approaches to preparing competent, ethical, and responsive healthcare professionals through adaptive learning systems, simulation-based training, and data-driven assessments (Knopp et al., 2023).

In Nigeria, the need for AI integration in health education has become increasingly urgent due to persistent challenges such as inadequate infrastructure, shortage of qualified health educators, limited clinical training opportunities, and uneven access to quality learning resources (Okanlawon et al, 2025). These challenges contribute to disparities in health workforce training and performance. AI has the potential to address these gaps by supplementing traditional teaching methods with intelligent tutoring systems, virtual laboratories, and automated feedback mechanisms that enhance learning experiences (Rincón et al., 2025). Through these tools, AI can provide learners with

personalized pathways that match their strengths, learning pace, and career goals thereby improving retention and competence.

Globally, AI applications in health education have been shown to improve diagnostic reasoning, decision-making, and clinical skills acquisition through virtual patients, machine learning-based assessment tools, and simulation technologies (Gordon et al., 2024). For Nigeria, where access to sophisticated clinical equipment and mentorship opportunities is often limited, AI-driven virtual environments can democratize access to quality learning and bridge the gap between theory and practice. Furthermore, AI can support health educators by automating administrative tasks, grading assignments, and providing predictive analytics that identify at-risk students early for targeted interventions (Gazquez-Garcia et al., 2025).

However, the integration of AI into Nigeria's health education system is not without its challenges. Barriers such as inadequate technological infrastructure, unstable electricity supply, poor internet connectivity, and limited institutional readiness hinder effective implementation (Adedinsewo et al., 2025). Additionally, both educators and students often lack digital literacy and exposure to emerging educational technologies. Beyond infrastructural challenges, ethical and governance issues also arise particularly concerning data privacy, algorithmic bias, and accountability (Chustecki et al., 2024; World Health Organization WHO, 2024). The absence of a national framework to regulate the use of AI in education further complicates the landscape, leaving institutions to navigate implementation independently and unevenly.

Despite these constraints, AI offers remarkable opportunities for innovation and inclusivity in Nigerian health education. It can serve as a tool for bridging the digital divide between urban and rural institutions, enhancing access to up-to-date educational materials, and fostering research collaboration through AI-powered databases. With appropriate policy frameworks, capacity building, and investment in infrastructure, AI can revolutionize health education and produce a workforce equipped for 21st-century healthcare challenges (UNESCO, 2025).

### **Conceptual framework of AI in education**

#### ***Technology-Enhanced Learning (TEL) Model***

The Technology-Enhanced Learning (TEL) Model is an educational framework that promotes the use of technology to improve teaching and learning processes. The model was developed gradually through the works of educational technology researchers in the late 20th and early 21st centuries rather than by a single proponent. Its purpose is to enhance learning experiences through digital tools, improve accessibility, increase learner engagement, and support collaborative learning. Key components include learners, teachers, technological tools, learning content, and the learning environment. Examples of TEL include online learning platforms, virtual classrooms, educational mobile applications, artificial intelligence tutors, and multimedia presentations. In health education, students may use virtual anatomy software and online simulations to practice clinical procedures and improve learning outcomes.

### Socio-Technical Systems Theory

Socio-Technical Systems Theory was developed by Tavistock Institute researchers, particularly Eric Trist and Fred Emery, in the 1950s. The theory was designed to explain how organizations can achieve effectiveness by balancing social and technical elements. Its main purpose is to optimize both human performance and technological efficiency within a system. The major components include the social subsystem (people, skills, culture, communication, and relationships) and the technical subsystem (machines, tools, procedures, and technology). For example, in a hospital, successful implementation of electronic health records depends on both the technology and the healthcare workers using it. In education, effective e-learning requires reliable digital platforms and active participation from teachers and students.

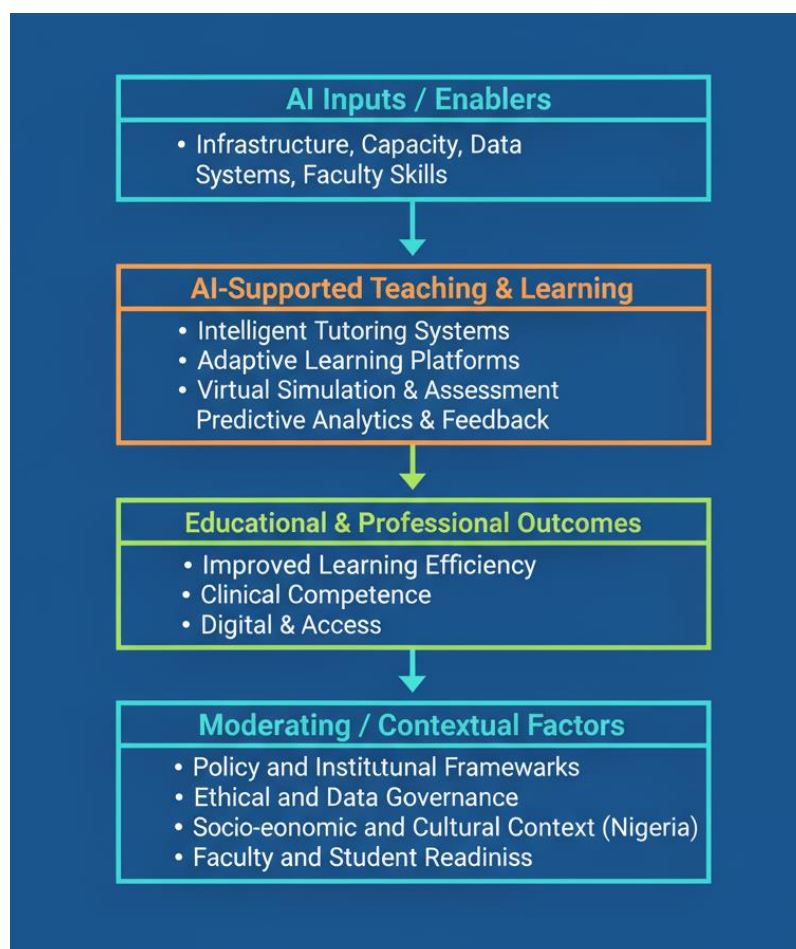


**Figure 1:** Conceptual framework for AI in Teaching and Learning Health Education in Nigeria

**Source:** Authors Designed

The following are foundational conditions necessary for implementing AI in health education:

#### *Technological Infrastructure*

Technological infrastructure is essential for implementing Artificial Intelligence (AI) in health education. According to Erwin Hernando Hernández Rincón et al. (2025), reliable internet access, digital devices, and stable electricity supply are necessary for effective use of AI-powered learning platforms. These resources enable students and educators to access virtual simulations, intelligent tutoring systems, and online educational materials. For example, medical students can use AI-based virtual laboratories and clinical simulation software to improve practical skills. Inadequate infrastructure may limit access to digital learning opportunities and reduce the effectiveness of AI integration in health education.

#### *Institutional Capacity*

Institutional capacity refers to an organization's ability to support AI adoption through policies, leadership, and resources. According to Sara Shishehgar et al. (2025), successful implementation of AI in health education requires strong ICT policies, administrative commitment, and sustainable funding. Institutions need clear guidelines for ethical AI use, staff training, and technological maintenance. For example, universities that invest in AI-powered learning management systems and faculty development programs are better positioned to improve teaching quality and student outcomes. Adequate institutional support ensures the effective and responsible integration of AI technologies into health education programmes.

#### *Human Capital*

Human capital involves the knowledge, skills, and competencies of educators and learners in using AI technologies. According to Knopp et al. (2023), faculty members must possess adequate competence in AI tools, while students need strong digital literacy skills to benefit from AI-enhanced learning. Training programs can help educators effectively use AI for assessment, content creation, and personalized instruction. For example, health educators trained in AI applications can use intelligent tutoring systems to monitor student progress and provide customized feedback. Skilled users maximize the educational benefits of AI and promote successful technology adoption.

#### *Data Systems for Educational Analytics and Content Personalization*

Data systems play a critical role in AI implementation by collecting, analyzing, and interpreting educational information. According to Rincón et al. (2025), AI-driven data systems support learning analytics, performance monitoring, and personalized content delivery. These systems analyze students' learning patterns and provide tailored educational materials based on individual needs and abilities. For example, an AI-powered platform may recommend additional study resources to students struggling with anatomy or pharmacology. Effective data systems improve learning outcomes, enhance

student engagement, and support evidence-based decision-making in health education. Proper data management and privacy protection are also essential for successful implementation.

### **AI-Supported Teaching and Learning Processes**

At the core of the framework are AI-enabled pedagogical practices, which reshape how instruction, assessment, and feedback occur. These processes include:

- i. Intelligent Tutoring Systems (ITS): Personalized learning paths adapting to students' strengths and weaknesses (Rincón et al., 2025).
- ii. Adaptive Learning Platforms: Systems that use learner data to adjust pace and content dynamically.
- iii. Virtual Simulations and AI-based Labs: Used for clinical training in health education (Knopp et al., 2023).
- iv. Predictive Analytics: For early identification of struggling students, guiding remedial interventions (Gordon et al., 2024).

### **Educational and Professional Outcomes**

When effectively implemented, AI transforms learning experiences and outcomes:

- i. Improved Learning Efficiency and Retention through personalized instruction (Shishehgar, 2025).
- ii. Enhanced Clinical Competence via virtual simulation and real-time feedback.
- iii. Increased Access and Equity -particularly important for underserved or rural Nigerian institutions.
- iv. Development of Digital Literacy and AI Readiness among future healthcare professionals (Sun et al., 2023).

Such outcomes align with national goals of strengthening human resource capacity in healthcare delivery.

### **Moderating / Contextual Factors**

The effectiveness of AI integration is influenced by multiple contextual variables, especially within Nigeria's socio-economic and educational environment. These variables are:

- i. Policy and Institutional Frameworks: Regulatory structures, accreditation guidelines, and digital education policies (UNESCO, 2021; WHO, 2024).
- ii. Ethical and Data Governance Issues: Concerns about privacy, bias, and fairness in AI use.
- iii. Socio-economic and Cultural Context: The readiness and adaptability of Nigerian institutions and learners.
- iv. Faculty and Student Readiness: Digital competence and attitudes toward technology-driven instruction (Adedinsewo et al., 2025).

These moderating factors determine the sustainability, fairness, and impact of AI adoption.

### Theoretical Basis

The framework draws on two main theoretical underpinnings:

i. Technology-Enhanced Learning (TEL) Theory:

Technology-Enhanced Learning (TEL) highlights the transformative potential of digital tools and platforms in enriching educational experiences. It emphasizes that technology is not merely a replacement for traditional teaching but a catalyst for more interactive, flexible, and student-centred learning. TEL promotes active engagement, personalised learning paths, and the development of higher-order thinking skills such as analysis, synthesis, and problem-solving. It also underscores the importance of equitable access, ensuring that all learners benefit regardless of socio-economic background. In the context of modern education, TEL supports blended and virtual learning models that expand learning beyond physical classroom boundaries, enhancing inclusivity and participation (UNESCO, 2021).

ii. Socio-Technical Systems Theory:

Socio-Technical Systems Theory was developed by Eric Trist and Fred Emery at the Tavistock Institute during the 1950s. The theory asserts that effective implementation of technology requires a harmonious integration of technical tools with human, cultural, and organizational elements. Rather than viewing technology as an independent solution, the theory emphasizes that technological systems must be designed to support both organizational efficiency and human well-being. It recognizes that people, organizational structures, work processes, values, and technology are interconnected and must function together for optimal performance.

For this study on the implementation of Artificial Intelligence (AI) in health education, Socio-Technical Systems Theory provides a useful framework for understanding how AI can be successfully adopted within educational institutions. The theory suggests that the effectiveness of AI depends not only on the availability of technological infrastructure such as internet access, digital devices, electricity, and AI software, but also on institutional capacity, supportive policies, adequate funding, and administrative commitment. Furthermore, the competence of lecturers, digital literacy of students, and acceptance of AI-driven learning tools are critical human factors that influence successful implementation. The theory therefore supports the view that sustainable integration of AI in health education requires a balance between technological resources and the social, cultural, and organizational environment in which the technology operates. This balance enhances teaching quality, student learning outcomes, and overall educational effectiveness.

### Framework Proposition

The conceptual framework posits that:

Effective integration of Artificial Intelligence into health education in Nigeria depends on the synergy between AI enablers (inputs), technology-driven learning processes, and

contextual governance mechanisms, which collectively shape the quality, equity, and sustainability of educational outcomes.

### **Application of the Framework**

This conceptual model can guide:

- i. Policy formulation - identifying leverage points for investment and regulation.
- ii. Curriculum design - embedding AI-supported teaching strategies in health education programs.
- iii. Institutional planning - assessing readiness and capacity for AI adoption.
- iv. Empirical research - providing a structure for analyzing relationships among AI inputs, learning processes, and educational outcomes.

### **Applications of AI in Teaching and Learning Health Education**

Applications of AI in health education cluster around several high-value domains:

#### **i. Personalised learning and adaptive tutoring**

AI-driven platforms can analyze learner interactions to create individualized learning trajectories, adjusting difficulty and recommending targeted resources (Sun et al., 2023). For clinical reasoning and medical knowledge acquisition, adaptive systems help close knowledge gaps efficiently and support spaced repetition for long-term retention.

#### **ii. Simulation and virtual patients**

High-fidelity simulation and virtual patient systems powered by AI (including conversational agents and generative models) allow students to practise clinical reasoning, communication, and decision-making in realistic but safe environments. AI can create diverse case mixes, provide immediate formative feedback, and scale simulated experiences beyond physical laboratory capacity (Knopp et al., 2023).

#### **iii. Automated assessment and feedback**

Automated scoring for objective structured clinical examinations (OSCEs), written tests, and even reflective writing can reduce faculty burden and provide rapid feedback. AI can identify patterns in student errors and suggest remediation pathways (Rincón et al., 2025).

#### **iv. Clinical skills training and procedural simulation**

Computer vision and sensor fusion combined with AI enable objective measurement of procedural skills (e.g., suturing, resuscitation performance), giving quantifiable feedback on technique and timing that supplements human observation.

#### **v. Content generation and augmentation**

Generative AI models (large language models, LLMs) can draft learning materials, create case vignettes, produce exam items, and translate content into local languages. When used as an authoring assistant, generative AI accelerates curriculum development while requiring careful validation.

#### 6. Analytics for workforce and curriculum planning

Learning analytics powered by AI can identify cohorts at risk, predict student progression, and inform institutional resource allocation valuable in contexts with limited faculty or uneven clinical placement availability.

Recent systematic and scoping reviews emphasize that AI applications are rapidly expanding across undergraduate and postgraduate medical education, and call for integrating AI literacy and competencies into curricula (Gordon et al., 2024; Rincón et al., 2025). The WHO and other global actors have underscored the importance of embedding governance and ethics into all health-related AI (WHO, 2024).

#### **Opportunities and Benefits (Global and Nigerian Context)**

AI offers several strategic opportunities for health education globally and specifically for Nigeria:

##### i. Strengthening access and scale

In a country with uneven distribution of training institutions and faculty shortages, AI-enabled online platforms and virtual simulations can extend access to high-quality learning resources to remote or underserved regions. Personalized learning paths may accelerate competency acquisition without the proportional increase in faculty numbers.

##### ii. Enhancing clinical reasoning and preparedness

AI can simulate rare or complex cases that students might not otherwise encounter during training, improving preparedness for a wider range of clinical scenarios. Simulation combined with debriefing analytics can deepen clinical reasoning skills.

##### iii. Faculty support and efficiency gains

Automation of routine tasks (grading, creating formative assessments, generating teaching materials) frees faculty to focus on mentorship, clinical supervision, and higher-order instruction an important gain where faculty workloads are high.

##### iv. Data-driven curriculum improvement

Learning analytics can highlight curricular gaps, help tailor modules to population health needs, and guide investments in clinical placements and simulation resources.

##### v. Contextualization for local health priorities

When carefully adapted, AI-generated content and virtual patients can reflect Nigeria's disease profile (e.g., tropical infectious diseases, maternal and child health issues), helping produce graduates ready for national health needs.

##### vi. Building AI literacy in the health workforce

Incorporating AI in education offers a pathway to cultivate AI literacy among future clinicians skills increasingly relevant for clinical practice as AI tools enter decision-support roles (Gazquez-Garcia et al., 2025).

These opportunities are compelling: reviews and mapping studies recommend embedding AI education within health curricula to align workforce competencies with technological change (Shishehgar, 2025; Knopp et al., 2023). However, realizing benefits depends on addressing layered challenges.

### **Challenges and Ethical Considerations in Adopting AI in Health Education**

AI adoption in health education raises multiple intersecting challenges—technical, pedagogical, ethical, and structural—many of which are particularly consequential in low- and middle-income contexts as discussed below:

i.

#### **ii. Equity and the digital divide**

AI systems require reliable electricity, internet connectivity, and devices. In Nigeria, infrastructural deficits and regional disparities risk exacerbating existing inequities if digital investments are not intentionally inclusive. Access gaps may disproportionately affect students in rural areas or under-resourced institutions.

#### **iii. Data quality, representativeness, and bias**

AI models trained on datasets from high-income settings may not generalize to Nigerian clinical presentations, cultural contexts, or language variations. Biases in training data can produce misleading feedback or unfair assessment outcomes. Ensuring representative datasets and validating models locally is essential (Chusteki et al., 2024).

#### **iv. Privacy, consent, and data governance**

Student performance data, simulated patient interactions, and clinical case logs create sensitive datasets. Robust data protection policies, consent protocols, and secure infrastructure are prerequisites to protect student and patient privacy.

#### **v. Academic integrity and misuse**

#### **vi. Generative models can produce plausible but incorrect information and are readily misused for plagiarism or cheating. Institutions must redesign assessment strategies (e.g., more authentic assessments, oral exams, supervised practical) and teach students responsible AI use.**

#### **vii. Faculty capacity and cultural change**

Faculty may lack AI literacy, pedagogical design skills for AI-enabled learning, or time to redesign curricula. Change management, incentives, and continuous professional development are required to support adoption.

#### **viii. Regulatory and accreditation challenges**

Accrediting bodies and professional councils must define standards for AI-enabled education and assessment. Without clear guidance, institutions may adopt technologies that fail to meet professional competency standards.

ix. Ethical risks of AI outputs

Generative AI can hallucinate confident but incorrect outputs. Clinical reasoning taught using unvalidated AI could propagate unsafe practices. WHO guidance stresses governance to prevent harms from large multimodal models in health settings (WHO, 2024).

These concerns are echoed across international analyses and underscore the need for multidimensional governance and capacity-building (UNESCO, 2021; WHO, 2024; Gordon et al., 2024). Local validation, iterative piloting, and layered oversight are non-negotiable.

**Policy and Institutional Implications in the Integration of AI in Health Education**

To responsibly integrate AI into health education, Nigerian policymakers, training institutions, and professional bodies should consider a coordinated set of actions across governance, curriculum, infrastructure, and workforce development.

i. National strategy and standards

The Federal Ministry of Education, Federal Ministry of Health, and relevant regulatory bodies (e.g., Medical and Dental Council of Nigeria, Nursing and Midwifery Council) should collaborate on a national AI-in-education strategy. This strategy should set minimum standards for data governance, student protections, accreditation of AI-enabled learning, and interoperability.

ii. Curriculum reform and competency frameworks

Health curricula must include AI literacy: principles of AI, limitations, interpretation of outputs, ethical considerations, and safe use in clinical practice. Competency frameworks should be developed to specify AI-related learning outcomes at undergraduate and postgraduate levels (Gazquez-Garcia et al., 2025; Rincón et al., 2025).

iii. Institutional governance and ethics review

Universities and teaching hospitals should establish cross-disciplinary AI governance committees (education, legal, ethics, IT) to vet tools, oversee pilots, and ensure compliance with data protection standards. Institutional review processes should include AI risk assessments for tools used in teaching and assessment.

iv. Investment in infrastructure and equitable access

Targeted investments in connectivity, learning management systems, and simulation centers are necessary alongside subsidized device programs or shared-access hubs to mitigate inequities. Public–private partnerships can be explored, but require contract safeguards and public-interest clauses.

v. Faculty development and incentives

Continuous professional development programs should build faculty competence in AI pedagogy, instructional design, and assessment innovation. Institutions should incentivize faculty participation (recognition, workload adjustments, promotion criteria alignment).

vi. Local research, validation, and co-creation

Nigeria should support research evaluating AI tools in local contexts, including pilot studies, validation of datasets, and assessments of learning outcomes. Co-creation with local educators and health experts will ensure relevance and safety (Adedinsewo et al., 2025; Shishehgar, 2025).

vii. Phased implementation and evaluation

Adopt a cautious, phased approach: pilot projects in selected institutions, rigorous evaluation (learning outcomes, equity impacts, faculty workload), and scale-up contingent on evidence. Transparent reporting and knowledge-sharing will accelerate learning across institutions.

Global organizations (WHO and UNESCO) recommend integrated policies that pair AI adoption with governance, capacity-building, and equity safeguards principles that should shape Nigeria's approach (WHO, 2024; UNESCO, 2021, 2025).

## Conclusion

Artificial Intelligence (AI) holds immense potential to revolutionize health education in Nigeria by enhancing teaching effectiveness, improving learning outcomes, and expanding access to quality training. Through adaptive learning, simulation, and data-driven assessment, AI can help address critical challenges such as faculty shortages and limited clinical exposure. However, realizing these benefits requires addressing key barriers, including inadequate infrastructure, limited digital literacy, data governance concerns, and ethical challenges. National policies and institutional frameworks must prioritize equity, accountability, and contextual relevance to ensure responsible adoption. Investment in faculty development, local research, and robust technological infrastructure will be essential to sustain progress. Ultimately, if implemented thoughtfully and ethically, AI can serve as a powerful catalyst for innovation, equity, and excellence in Nigeria's health education system preparing a new generation of healthcare professionals equipped to meet the evolving demands of modern healthcare. Based on the above conclusions, the following are hereby recommended:

- i. Develop a national AI-in-health-education strategy- jointly led by education and health ministries, with clear standards on governance, data protection, and accreditation. .
- ii. Integrate AI literacy into health curricula - from basic concepts to critical appraisal of AI tools mapped to competency frameworks at undergraduate and postgraduate levels .
- iii. Fund targeted infrastructure and access initiatives (connectivity, simulation hubs, shared device programs) to prevent widening the digital divide.
- iv. Establish institutional AI governance bodies (education, IT, ethics, legal) to approve tools, monitor use, and enforce data protection.
- v. Invest in faculty development with incentives and protected time for redesigning pedagogy and assessment to leverage AI effectively.

- vi. Support local research and validation studies to ensure AI tools and datasets are relevant and safe for Nigerian clinical and cultural contexts Adopt phased, evidence-driven scale-up with independent evaluation of learning outcomes, equity impacts, and ethical risks.

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