SADI International Journal of Science, Engineering and Technology
ISSN: 2837-1941| Impact Factor: 8.27
Volume. 12, Number 4; October-December, 2025;
Published By: Scientific and Academic Development Institute (SADI)
8933 Willis AveLos Angeles, California
https://sadijournals.org/index.php/sijset|editorial@sadijournals.org

EXPLORING THE FUTURE OF UNIVERSITY EDUCATION: THE ROLE OF ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION AND ITS IMPACT ON SCIENCE EDUCATION

[*1]Aminat Adekemi Ahmed (PhD) and [2]Shola Rasheed Amao (PhD)
[1]Department of Integrated Science Education, Faculty of Science Education, Emmanuel Alayande University of Education, Oyo, Oyo State, Nigeria
[2]Department of Agricultural Education, Faculty of Vocational, Innovation and Engineering Education, Emmanuel Alayande University of Education, Oyo, Oyo State, Nigeria
E-mail: *ahmedaminatadekemi@gmail.com, sholaamao@gmail.com
Phone Number: +2348037287177, +2348035312418
DOI: https://doi.org/10.5281/zenodo.17454395

Abstract: This study aims to explore the future of university education: The role of AI in higher education and its impact on science education in Nigeria. This study explores how AI-driven tools can enhance personalised learning, improve student engagement, and reshape teaching methodologies while addressing concerns regarding equity, accessibility and teacher-student interactions. A literature review and analysis of AI applications in education focusing on adaptive learning technologies, interactive simulations, and AI-driven feedback systems. AI technologies, including ChatGPT, facilitate personalized learning through adaptive feedback that targets individual knowledge gaps and learning preferences, promoting a more profound comprehension of intricate subjects such as physics. AI enhances learning experiences by providing personalised feedback, fostering interactive and collaborative learning environments, and supporting differentiated instruction. However, challenges such as limited access to technology, teacher training, and ethical considerations regarding data privacy must be addressed to ensure equitable AI implementation in education. AI can revolutionise science education by making learning more engaging and tailored to student needs. However, successful integration requires addressing challenges related to infrastructure, teacher training, and ethical concerns. This study highlights the need for widespread policies and professional development programmes to maximise the benefits of AI while ensuring fair and effective employment in science education.

Keywords: Artificial intelligence, science education, teaching, university

Introduction

Recent advances in artificial intelligence (AI) have attracted global attention as it is evolving into a new area of concentration for global competition and a new possibility for human and organisational progress. As AI technology has flourished, so have its applications in education, with tremendous potential to deliver dynamic assessments (Zhang *et al*., 2021). AI is improving education efficiency by helping with academic and

administrative tasks (Ahmad *et al.*, 2022). AI is now influencing daily lives, communities, and governmental structures more than ever before. It enables groundbreaking developments in fields such as healthcare, agriculture, education, technology, and transportation.

Generative artificial intelligence (GAI) such as ChatGPT is poised to revolutionise various sectors, including education (Zhai *et al.,* 2023). AI, characterised by its human-like cognitive functions across diverse tasks, offers significant potential to revolutionise teaching, learning, and research methodologies (Polat, 2023; Rahman & Watanobe, 2023). Miller (2024) defines AI as the advancement of computer systems that can execute tasks typically requiring human intelligence. These systems strive to emulate human-like cognitive functions such as learning, problem-solving, decision-making, and language comprehension. Artificial intelligence encompasses intelligent systems focused on acquiring abilities, such as language comprehension, learning, logical reasoning, and problem-solving that are conventionally linked with the human mind (Saveliev & Zhurenkov, 2021). AI encompasses various approaches, methodologies, and techniques aimed at mimicking human intelligence in machines. Ofcourse AI technologies operate according to specific models.

The concept of Artificial Intelligence

Computers or robots with "artificial intelligence" can perform intelligent tasks. This phrase generally refers to the construction of AI systems with human-like thinking, semantic comprehension, generalisation and experience learning. Since the 1940s, digital computers have successfully proven mathematical theorems and played chess. Despite greater computer processing speed and capacity, programmes can only match human flexibility in jobs requiring considerable baseline knowledge. AI machines outperformed human experts in various domains. This limits AI applications in speech and handwriting recognition, search engines, and medical diagnostics (Roll & Wylie, 2016). According to Sadiku *et al.* (2021), a computer system may execute human cognitive skills, such as reasoning and learning, normally reserved for humans. AI technology gives education a new degree of adaptability and versatility, changing the educational environment and simplifying the jobs of instructors.

Many academic definitions and studies of AI highlight similar qualities. Verma *et al*., (2021) call AI "devices that can approximate human reasoning". Similar to this, AI requires decades of study and development. System designers, data scientists, product designers, statisticians, linguists, cognitive scientists, psychologists, education experts, and others collaborated to create intelligent education systems that could support teachers and students (Nagao, 2019). AI is based on enhanced software and programme skills, such as algorithmic machine learning, which allows computers to perform activities that require human intelligence and environmental adaptability (Nguyen *et al*., 2021). Artificial intelligence refers a machine's or computer's ability to replicate human intelligence and behavior. Artificial intelligence is the development of computers with intelligence and the capacity to perform human-like tasks, including cognition, learning, decision-making, and environmental adaptation.

AI plays a pivotal role in providing solutions across diverse fields, including but not limited to health, education, and engineering. In recent years, AI applications have attracted increasing attracted interest and considerable attention in education (Taş, 2021; Zawacki-Richter *et al.*, 2019). Although, AI presents numerous opportunities to enhance teaching and learning, also introduces fresh ethical considerations and potential risks (Zawacki-Richter *et al.*, 2019). Incorporating AI into education (AIEd) represents a two-sided phenomenon capable of yielding unintended outcomes and prompting a reevaluation of our perspectives on learning, knowledge, skills, performance, creativity, and innovation (Gibson *et al.,* 2023). Indeed, integrating AI

opportunities with pedagogical components can drive a transformative paradigm shift in education. In this regard, the crucial emphasis lies not in attempting to exclude artificial intelligence from the teaching process by instructional designers and practitioners but rather in reimagining learning activities by incorporating AI advancements.

Application of Artificial Intelligence in University Education

AI is rapidly reshaping higher education, making significant improvements in teaching, learning, research, and administrative functions. As AI tools and technologies become more integrated into academic environments, universities can increase their operational efficiency, reduce the burden of administrative tasks, and offer students more personalised ways of learning. These developments not only improved traditional educational models but also led institutions to rethink their approach to teaching and learning (Chen *et al*., 2020). AI is autonomous, such that it can make decisions without requiring human intervention to accomplish a task- or purpose-related objective. It also possesses adaptability, indicating that the system can perceive its surroundings and modify its behaviour in response to environmental shifts (Dignum, 2021).

Furthermore, AI in the educational system is due to the increasing workload of teachers and the need to increase teacher productivity. AI in university education helps identify the gaps in teaching and learning and increases education proficiency (Van der Vorst & Jelicic, 2019). AI helps the education system in evaluation, assessment, prediction, personification, intelligent tutoring, and adaptive systems. Administrative tasks, such as monitoring students, are made easier through automated systems, and the desktop computer has been joined in the classroom by an increasing number of gadgets (Johnson *et al.*, 2016). A huge rise in data generation and computational power has occurred in tandem with the development of digital technologies and their growing interconnectedness. This has led to the widespread use of intelligent systems that can learn from themselves, reason like humans and generalise from massive datasets (Xu *et al.,* 2021). One of the most important applications of AI in university education is the development of AI-supported tutoring systems that provide real- time, personalised support to students. Its success in the field of health is important not only in understanding scientific concepts but also in properly communicating this information in a national and international academic context (Mehta *et al.,* 2023). Indeed, integrating AI opportunities with pedagogical components can drive a transformative paradigm shift in education. In this regard, the crucial emphasis lies not in attempting to exclude AI from the teaching process by instructional designers and practitioners but rather in reimagining learning activities by incorporating AI advancements.

AI has found applications within the education sector, contributing to the creation of curricula, educational materials, and lesson plans. These educational resources leverage on various tools and technologies, including virtual reality, web-based platforms, robotics, video conferencing, audiovisual materials, and 3-D technology. This integration of AI tools has resulted in more efficient and effective teaching practices, leading to more personalised and comprehensive learning experiences for students (Aldosari, 2020). Furthermore, a deeper examination of various sources has uncovered noteworthy insights. AI's has become apparent that AI's application in education can transcend the physical limitations imposed by national and international borders. This can be achieved by hosting learning resources on the Internet and the World Wide Web, allowing access from virtually anywhere. The incorporation of AI features, such as language translation tools, enables students to learn in a manner that aligns with their unique abilities and language preferences. Educational content has become readily accessible to learners across the globe through online learning or web-based educational platforms (Jain & Jain, 2019).

Artificial Intelligence and Science Education

Science education has significantly changed by artificial intelligence (AI), a fast-expanding field. Research papers on the application of AI in science education were gathered and examined for this overview of the literature. Recently, there has been a rise in interest in the study of AI in science education. Science education is only one of the many domains in which AI has applications. For example, Zhai *et al.* (2022) revealed that machine learning can be applied to automatically assess science models. AI is a constantly expanding and fascinating topic. The application of AI in science education may enhance the effectiveness of teaching and learning processes (AlKanaan, 2022). Numerous studies have been conducted on the application of AI in science education, including teaching, learning, assessment, and curriculum development (Al Darayseh, 2023; AlKanaan, 2022; Holmes & Tuomi, 2022; Swiecki *et al.*, 2022). AI is becoming more and more of a standard in science education, with much research investigating its applications and impacts. Wu and Tegmark (2019) explored the use of using AI in coaching physics and determined that it advanced scholar engagement and conceptual know-how of the subject. Similarly, Mahroof *et al.* (2020) tested a chatbot gadget powered by AI in coaching chemistry and determined that it was powerful in helping scholars get to know and improve instructional achievement. Similarliy, Nguyen *et al.* (2020) proposed that AI had the potential to enable personalised and adaptive learning experiences, which might assist college students in achieving greater educational outcomes in technology education. According to Yeo *et al.* (2022), AI and microbiome, exposure to various types of humour produced varying degrees of laughter and respondents' need for comedy mitigated the impact of humour on involvement intentions. In addition, a study conducted by Deveci *et al.* (2021) found that the chatbot application improved the experimental group students' online learning experience. The potential for addressing the challenges of science education using AI has been acknowledged. According to Dimitriadou and Lanitis (2023), collaborative learning environments, personalised and adaptive learning systems and virtual and augmented reality are among the AI-based innovations that promote scientific thinking skills, enhance student engagement, and improve learning outcomes. However, incorporating AI in science education poses challenges such as potential biases in AI algorithms and ethical considerations. Our bibliometric review seeks to offer insights into AI research in science education, highlighting major research themes gaps. In education, especially in science education, AI is gaining popularity while AI can enhance instruction, motivate students, and increase learning outcomes (Luan *et al*., 2020). In addition, a study conducted by Acisli *et al.* (2022) found that the AI had a beneficial effect on the students' viewpoints of science and robotics. Likewise, Su (2022) conducted statistical studies showed that those students developed their scientific cognitive problem-solving abilities through quantitative analyses and demonstrated them through qualitative ones. AI integration in science education has recently drawn attention. For instance, the findings showed that the inclusion of science, technology, engineering, and mathematics (STEM) education in AI teaching enhanced the experimental group of students' computational thinking abilities, learning motivation, and self-efficacy (Huang & Qiao, 2022). Similarly, Huang (2022) stated that it was very important to deepen the evaluation of STEM learning in elementary schools, improve the effectiveness of STEM teaching, and promote the healthy development of elementary pedagogical application. Huang *et al.* (2023) demonstrated that AI may have positive effects on instructional strategies, student motivation and engagement, and learning outcomes. Numerous important themes were identified by the analysis. The use of AI-based virtual and AR technologies to increase student engagement is an important topic of research. Numerous studies have shown how VR simulations in science instruction can help students better understand and retain difficult concepts.

Integration of AI in Science Pedagogy

The incorporation of AI in university education shows considerable promise for transformatively improving teaching methods and student learning results. A significant approach included the use of AI-driven platforms that enabled collaborative learning and customised instruction designed to address the varied needs of students (Alonso, 2020). These innovative systems tailored educational content to align with individual student preferences and learning styles while enhancing classroom engagement levels, a crucial factor for effective learning (Awad *et al.*, 2022). Moreover, a further study emphasised that with the backing of sophisticated AI tools, project-based learning approaches enabled educators to enhance their lesson plans and elevate classroom discussions, fostering a more vibrant and engaging learning atmosphere (Alam *et al*., 2022). A recent study of an AI-based adaptive learning Moodle plugin involving 102 Moroccan high school students highlighted its considerable effect on student engagement and academic performance when compared to traditional learning methods (Ezzaim *et al.*, 2024). This study highlights the effectiveness of AI in promoting an active learning environment, emphasising that carefully integrated AI not only improves instructional strategies but also significantly transforms science education. This approach fosters an environment that is attuned to learners' needs, promoting critical skills development through teamwork and exploration. It encourages students to actively engage in their educational experiences, equipping them with the vital competencies to tackle future challenges. The continuous advancement of AI in education has the potential to enhance and deepen the teaching environment in science classrooms in high schools. Incorporating AI into the science curriculum can markedly improve student engagement and learning outcomes. Some educators acknowledge the promise of AI, even while confronting obstacles such as insufficient training and technological infrastructure (Nugroho *et al.,* 2024).

Boosting Research and Innovation through AI

In the era of digitalisation, AI continues to penetrate into all aspects of enterprise operations, becoming a key technology for enterprise data processing, decision-making, and product innovation. AI technology is not only able to quickly process massive amounts of data and extract valuable information but, also discover patterns and predict the future through deep learning and other methods (Ranga *et al.*, 2008). As a result, AI technology has become a powerful tool to enhance enterprises' innovation ability. The ability of an enterprise to innovate is one of the core competitiveness of enterprises. Innovation ability covers many aspects, such as technological innovation, management innovation, and product innovation, and it affects the market position, profitability and sustainable development of enterprises (Pavlović *et al*., 2022). With the continuous development of science and technology, enterprises must constantly update their innovation ability and adapt to changes in market demand to be invincible in fierce market competition.

Artificial intelligence has become a catalyst for advancing research capabilities across Nigerian universities, particularly in the STEM fields. Machine learning algorithms facilitate sophisticated data analysis, predictive modelling, and pattern recognition, enabling breakthroughs in health, agriculture, and climate science. For instance, in healthcare, AI assist in diagnostics and personalised treatment planning (Edeh & Madu, 2022), while in agriculture, AI-driven systems optimise crop management and pest control (Oladejo & Musa, 2020). Climate researchers utilise AI to improve weather forecasting and environmental monitoring (Abdullahi *et al.*, 2023). Institutions such as Covenant University and the University of Ibadan have established AI-focused research centres and innovation hubs to promote interdisciplinary collaboration and technology entrepreneurship (Adeleke *et al.*, 2022a). These centres support projects ranging from robotics to natural

language processing, positioning Nigerian universities as growing contributors to global AI research. Moreover, AI tools are increasingly being used to automate literature reviews, enhance data visualisation, and streamline experimental procedures, thereby accelerating research productivity (Okafor & Chukwuma, 2022). Nigerian universities are not only enhancing academic output but also encouraging innovation ecosystems that support startup incubation and industry partnerships by fostering an environment that integrates AI with research contributing to socio-economic development (Adeleke *et al.*, 2022b).

AI Educational Technology Platforms for Science Teaching

Examples of how AI has been extensively used in educational technology platforms are as follows:

i. Online Mentor

AI serves as a virtual mentor and is being used extensively in various online education technology platforms particularly those that are online. Mentoring involves a more experienced individual (the mentor) helping a less experienced individual (the mentee) reach a learning goal (Klamma *et al.*, 2020). Like a teacher or tutor, AI can comment on students' practice problems and learning exercises before suggesting content that needs to reviewed.

ii. Virtual Mentor

A virtual mentor (VM) is a multimedia-integrated e-learning environment that prioritises intelligence, interaction, and personalisation (Zhang, 2016). Virtual mentors are similar to AI technology by simply put, voice assistants rely more on speech functions as a hub for communication and engagement. Voice assistants can converse with consumers in natural language and integrate AI through cloud computing (Terzopoulos & Satratzemi, 2019).

iii. Voice Assistant

Voice assistant technology has also been included in many Edutech platforms to facilitate the practical and speedy discovery of resources and knowledge. One of the most well-known and frequently used AI tools across various industries, including education, is the voice assistant. Several well-known voice assistants include Microsoft's' Cortana, Apple's Siri, and Google Assistant. Students can use voice Assistant to search for resources, reference questions, books, and articles by merely speaking or saying terms. According to Canbek and Mutlu (2016), AI assistants, such as the ones mentioned above, use natural language in digital communication to help humans and computers communicate.

iv. Smart Content

Smart items, an AI tool makes it easier and faster to distribute and locate programmable digital books and other material items. Today's public libraries, colleges, and schools all have digital libraries that serve as common instances of how this technology is being used. AI can swiftly and systematically locate and classify the books we are looking for. Book recommendations and other pertinent information to your search will be provided. An overview of different learning resources, such as digital textbooks and interfaces that may be customised to meet our needs, is called "smart content."

v. Presentation Translator

The Presentation Translator is an AI-based solution that renders subtitles in real-time mode and students can hear or read in their native language wit AI speech recognition. This technology has similarities to Voice Assistant, which relies on voice to perform its functions. It's just that Presentation Translator has a usability

specification to explain or present a text from a different language into the desired language. A person can read and understand journals, articles, or books from any language more easily and quickly.

vi. Global Courses

Artificial intelligence technology has been widely used in education, among other sectors. In a nutshell, students or users of Global Courses can look up and enrol in online courses from around the world. The course platform can determine topics that interest someone based on the keywords you have previously entered. Currently, someone can try some open and free courses with a range of engaging, interactive, and structured features and content (Zhang, 2021).

vii. Automatic Assessment

AI is frequently used for automated testing and question rectification. Teachers and tutors can designed and administer quizzes and examinations more easily and practically design and administer quizzes and examinations more easily and practically when features like these are used. It is no longer necessary for tutors and teachers to manually create and edit questions. Teachers and tutors can design and more easily and practically design and administer quizzes and examinations when features like these are used. Teachers will have more time to monitor students' development and concentrate on enhancing their teaching methods if these procedures are automated.

viii. Personalised Learning

There are several similarities between personalised learning and other AI technology applications. Essentially, this AI technology enables consumers or students to receive personal assistant-like services. AI technology significantly improves quality and makes learning patterns more useful and efficient. Numerous studies and implementations by different Edutech platforms have also demonstrated this, and it is true that using AI technology can significantly improve the calibre and efficacy of learning. Through personalised learning, each student can advance and grow according to accordance their own learning preferences and aptitudes as well as their own mastery rate of the content (Mufdalifah, 2017).

ix. Educational game

Games intended to teach while still being enjoyable are known as educational games. All types of games designed to give players an educational or learning experience are referred to as educational games. The Khan Academy Kids and Duolingo are two examples of instructional games. Quick Brain and Puzzle Kids Memory, focus, accuracy, attention, thinking speed, and logic skills can all be enhanced by playing this game. According to Yunanto (2017), gamification is a design theory that must be applied when creating a game. According to this theory, one of the essential elements that the game must have is the application of artificial intelligence (AI). This study aims to quickly and accurately construct an artificial intelligence (AI) in an educational English game. The heuristic of similarity is the foundation of AI technology. Heuristics for solving problems based on human habits, including deriving a solution from routine behaviour.

x. Intelligent Tutoring System

An intelligent tutoring system (ITS) is a teaching system that can adjust to students' capacities and is often referred to as Intelligent Computer-Aided Instruction. ITS is one of the advancements in artificial intelligence expert systems for learning. The ITS for Nun Sukun or Tanwin legal learning, the ITS for circular learning, the ITS based on augmented reality (AR) for dimensional geometry material, and other ITS are examples of ITS. The Intelligent Tutoring System (ITS) is a computer software that offers pupils individualized instruction and

feedback without requiring human participation (Abu Ghali *et al.*, 2018). The system moves students from an easier to a more challenging level while considering their individual qualities. A group of students of all ages were given access to the intelligent tutoring system so that they could test it out and see how it affected them.

Challenges of AI Implementing in Science Education

For the effective adoption of artificial intelligence (AI) in scientific education in Nigerian higher institutions, it is crucial to solve many obstacles and impediments. The ubiquitous infrastructural restrictions in several educational institutions nationwide are a major obstacle. Lack of sufficient access to technology, such as PCs or tablets, impedes the efficient implementation of AI-powered instructional aids (Aina *et al.*, 2023). In addition, the irregular provision of electricity and insufficient internet access in many schools present substantial challenges, hindering the smooth use of AI applications and obstructing the educational progress of students.

The necessity for through teacher training and ongoing professional development is an essential component in incorporating AI into science education (Al-Zyoud, 2020). With the rise of innovative technologies in educational settings, educators must possess the necessary knowledge and skills to effectively leverage these tools. Present educational programmes frequently fall short of providing adequate training materials, resulting in inadequately equipped teachers (Guo & Liu, 2022). Educators often lack the essential knowledge required to effectively adopt these emerging technologies which can negatively impact the learning environment.

Promoting the allocation of more resources towards education infrastructure, fostering partnerships with both public and commercial sectors, and creating AI apps that can function without an internet connection or with limited bandwidth are viable methods to address these infrastructure difficulties. Another crucial obstacle is the preparation and competence of teachers in integrating AI into the educational system. Several educators may lack sufficient training in using AI tools in the classroom, impeding their capacity to successfully harness new technology. Resistance to change, which originates from a lack of familiarity or scepticism over the efficacy of AI, is another obstacle. The limited access to continuous professional development opportunities worsens the problem, hindering instructors from enhancing their abilities and remaining up-to-date with breakthroughs in AI-driven teaching. To tackle these issues, it is necessary to execute extensive training programmes, cooperate with educational institutions for ongoing professional growth, and create mentoring programmes to allow the exchange of information among educators (Adeyemi, 2020).

Conclusion

The study concluded that AI can revolutionise science instruction by offering fresh approaches to student engagement and improving learning outcomes. Teachers should consider integrating AI technology into their curricula, especially in the STEM and higher education fields. However, the possible dangers and ethical questions that come with using AI in education must be understood by educators. On the other hand, it is crucial for educators to be aware of the potential risk and ethical issues associated with using AI in the science classrooms.

Recommendations

The following recommendations were made at the end of this study:

1. The exploration analysis of AI in science education needs the technology's expanding significance in improving science education, and teachers should be trained towards it.
2. The ethical and practical consequences of AI in education should be taken into consideration when using AI.
3. AI in science education is a collective work of academics, educators, and policymakers.

4. The AI should support a range of learning styles and abilities. These AI-powered solutions improve learning outcomes and advanced diversity.
5. A-driven data analysis tools also provide insights into student performance which help teachers improve their lesson plans and curriculum to maximise learning outcomes.

References

Abdullahi, S., Bello, M., & Yusuf, K. (2023). AI applications in climate modeling: A Nigerian perspective. *Environmental Informatics Journal*, 18(2), 112-125.

Abu Ghali, M. J., Abu Ayyad, A., Abu-Naser, S. S., & Abu Laban, M. (2018). *An Intelligent Tutoring System for Teaching English Grammar*. http://dspace.alazhar.edu.ps/xmlui/handle/123456789/289

Acisli Celik, S., & Ergin, I. (2022). Opinions of middle school students on the concept of science and the use of robotic systems. *International Journal of Technology in Education*, 5(1), 154-170. https://doi.org/10.46328/ijte.232.

Adeyemi, O. A. (2020). Integrating Artificial Intelligence into STEM Education in Nigerian Secondary Schools. *Journal of Educational Technology Research,* 15(2), 112-130.

Ahmad, S. F., Alam, M. M., Rahmat, M. K., Mubarik, M. S., & Hyder, S. I. (2022). Academic and Administrative Role of Artificial Intelligence in Education. Sustainability, 14(3), 1101. https://doi.org/10.3390/su14031101

Aina, M.A., Gbenga-Epebinu, M.A., Olofinbiyi, R.O., Ogidan, O.C., and Ayedun, T.O. (2023) Perception and Acceptance of Medical Chatbot Among Undergraduates in Ekiti State University, Nigeria, *British Journal of Education*, 11(11), 1-14

Al Darayseh, A. (2023). Acceptance of artificial intelligence in teaching science: Science teachers' perspective. Computers and Education: Artificial Intelligence, 4, 100132. https://doi.org/10.1016/j.caeai.2023.100132.

Alam, A., Hasan, M. & Raza, M..M. (2022). Impact of artificial intelligence (AI) on education: changing paradigms and approaches. Towards Excell.;14(1):281–9. https://doi.org/10.37867/te140127

Aldosari, S. A. M. (2020). The future of higher education in the light of artificial intelligence transformations. *International Journal of Higher Education,* 9(3), 145-151.

AlKanaan, H. M. N. (2022). Awareness regarding the implication of artificial intelligence in science education among pre-service science teachers. International Journal of Instruction, 15(3), 895-912. https://doi.org/10.29333/iji.2022.15348a

Alonso, J.M (2020). Teaching explainable artificial intelligence to high school students. Int J Comput Intell Syst.;13(1):974–787. https://doi.org/10.2991/IJCIS.D.200715.003

Al-Zyoud, H.M.M (2020). The role of artificial intelligence in teacher professional development. Univ J Educ Res.;8(11B):6263–72. https://doi.org/10.13189/UJER.2020.082265

Awad, S.O.I., Mohamed, Y. & Shaheen, R. (2022). Applications of Artificial Intelligence in Education. *Al-Azkiyaa - Int J Lang Educ*.;1(1):71–81. https://doi.org/10.33102/alazkiyaa.v1i1.10.

Canbek, N. G., & Mutlu, M. E. (2016). On the track of Artificial Intelligence: Learning with Intelligent Personal Assistants. *Journal of Human Sciences*, *13*(1), 592–601.

Chen, L., Chen, P. & Lin, Z. (2020). Artificial Intelligence in Education: A Review. IEEE Access 8: 75264–75278.

Deveci Topal, A., Dilek Eren, C., & Kolburan Gecer, A. (2021). Chatbot application in a 5th grade science course. Education and Information Technologies, 26(5), 6241-6265. https://doi.org/10.1007/s10639-021-10627-8

Dignum, V. (2021). The role and challenges of education for responsible AI. London Review of Education, 19(1). https://doi.org/10.14324/LRE.19.1.01

Dimitriadou, E., & Lanitis, A. (2023). A critical evaluation, challenges, and future perspectives of using artificial intelligence and emerging technologies in smart classrooms. *Smart Learning Environments,* 10(1), 1-26. https://doi.org/10.1186/s40561-023-00231-3

Edeh, M. O., & Madu, J. N. (2022). Exploring interdisciplinary AI curriculum integration in Nigerian universities. *African Journal of Science, Technology & Mathematics Education*, 10(2), 123–136.

Ezzaim A, Dahbi A, Haidine A, Aqqal A. (2024). The Impact of Implementing a Moodle Plug-in as an AI-based Adaptive Learning Solution on Learning Effectiveness: Case of Morocco. *Int. J. Interact. Mob. Technol*., ;18(01):133–49. https://doi.org/10.3991/ijim.v18i01.46309.

Gibson, D., Kovanovic, V., Ifenthaler, D., Dexter, S., & Feng, S. (2023). Learning Theories for AI Promoting Learning Processes. BJET, 1–22. https://doi.org/10.1111/bjet.13341

Guo, X. & Liu, X. (2022). A Study of Strategies to Improve the Quality of Teacher Trainees from Teacher Training .The Example of the Teacher Training Program at Liaoning Normal University. *Learn Educ.;*10(5):189–90. https://doi.org/10.18282/l-e.v10i5.2732

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education,* 57(4), 542-570. https://doi.org/10.1111/ejed.12533

Huang, A. Y., Lu, O. H., & Yang, S. J. (2023). Effects of artificial intelligence–enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. *Computers & Education*, 194, 104684. https://doi.org/10.1016/j.compedu.2022.104684

Huang, X. (2022). Application of artificial intelligence APP in quality evaluation of primary school science education. *Educational Studies.* https://doi.org/10.1080/03055698.2022.2066462

Huang, X., & Qiao, C. (2022). Enhancing computational thinking skills through artificial intelligence education at a STEAM high school. Science & Education. https://doi.org/10.1007/s11191-022-00392-6

Jain, S., & Jain, R. (2019). Role of artificial intelligence in higher education—An empirical investigation. *IJRAR International Journal of Research and Analytical Reviews*, 6(2), 144z-150z.

Johnson, A. M., Jacovina, M. E., Russell, D. G., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. In Adaptive educational technologies for literacy instruction (pp. 13-30). Routledge.

Klamma, R., Lange, P. de, Neumann, A. T., Hensen, B., Kravcik, M., Wang, X., & Kuzilek, J. (2020). Scaling Mentoring Support with Distributed Artificial Intelligence. *Intelligent Tutoring Systems*, 38–44. https://doi.org/10.1007/978-3-030-49663-0_6

Luan, H., Geczy, P., Lai, H., Gobert, J., Yang, S. J., Ogata, H., Baltes, J., Guerra, R., Li, P., & Tsai, C. C. (2020). Challenges and future directions of big data and artificial intelligence in education. *Frontiers in Psychology*, 11, 580820. https://doi.org/10.3389/fpsyg.2020.580820

Mahroof, A., Gamage, V., Rajendran, K., Rajkumar, S., Rajapaksha, S. & Wijendra, D. (2020). An AI based chatbot to self-learn and self-assess performance in ordinary level chemistry. In Proceedings of the 2nd International Conference on Advancements in Computing (pp. 216-221). IEEE. https://doi.org/10.1109/ICAC51239.2020.9357131

Mehta, P., Chillarge, G.R., Sapkal, S.D., Shinde, G.R., Kshirsagar, P.S.,(2023) "*Inclusion of Children with Special Needs in the Educational System, Artificial Intelligence (AI)*" Advances in Educational Technologies and Instructional Design, IGI Global, 156–185

Miller, S. (2024). Unveiling the Synergy: Exploring Advances in Applied Artificial Intelligence and Narrow AI (No. 11651). EasyChair. https://easychair.org/publications/preprint_download/d1PB

Mufdalifah, M. (2017). Personalized Learning dan Multimedia Berbasis Komputer Masih Perlukah Guru? *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran): Kajian Dan Riset Dalam Teknologi Pembelajaran*, *1*(1), 50–57.https://doi.org/10.17977/um031v1i12014p050

Nagao, K. (2019). Artificial Intelligence in Education. *In Artificial Intelligence Accelerates Human Learning* (pp. 1 17). doi:10.1007/978-981-13-6175-3_1

Nguyen, M. T., Truong, L. H., Tran, T. T., & Chien, C.-F. (2020). Artificial intelligence based data processing algorithm for video surveillance to empower industry 3.5. *Computers & Industrial Engineering,* 148(106671), 106671. doi:10.1016/j.cie.2020.106671

Nugroho O.F, Hikmawaty L, Juwita S.R (2024). Artificial Intelligence Technology Embedded in High School Science Learning: A Study of Teacher Perception. Pedagonal: J Ilm Pendidik;8(2):132–43. https://doi.org/10.55215/pedagonal.v8i2.16

Okafor, P., & Chukwuemeka, O. (2020). Emerging AI research themes in Nigerian universities. *Journal of Computer Science Research*, 7(4), 210-220.

Oladejo, O., & Musa, S. (2020). Precision agriculture and AI: Enhancing productivity in Nigeria. *Journal of Agricultural Science and Technology,* 8(1), 33-47.

Pavlović, M., Banić, M., Simonović, M., & Nikolić, V. (2022). AI powered obstacle distance estimation for onboard autonomous train operation. *Tehnički vjesnik*, 29(2), 611-619.

Polat, H. (2023). Transforming Education with Artificial Intelligence: Shaping the Path Forward. ISTES BOOKS, 3-20. Retrieved from https://book.istes.org/index.php/ib/article/view/26

Rahman, M. M., & Watanobe, Y. (2023). ChatGPT for education and research: Opportunities, threats, and strategies. *Applied Sciences*, 13(9), 5783.

Ranga, L. M., Miedema, J., & Jorna, R. (2008). Enhancing the innovative capacity of small firms through triple helix interactions: challenges and opportunities. *Technology Analysis & Strategic Management*, 20(6), 697-716.

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education,* 26(2), 582-599.

Sadiku, M. N., Ashaolu, T. J., Ajayi-Majebi, A., & Musa, S. M. (2021). Artificial Intelligence in Social Media. *International Journal of Scientific Advances*, v2, i1.

Saveliev, A., & Zhurenkov, D. (2021). Artificial intelligence and social responsibility: the case of the artificial intelligence strategies in the United States, Russia, and China. Kybernetes, 50(3), 656-675.

Su, K. D. (2022). Implementation of innovative artificial intelligence cognitions with problem-based learning guided tasks to enhance students' performance in science. *Journal of Baltic Science Education,* 21(2), 245257. https://doi.org/10.33225/jbse/22.21.245

Swiecki, Z., Khosravi, H., Chen, G., Martinez-Maldonado, R., Lodge, J. M., Milligan, S., Selwyn, N., & Gašević, D. (2022). Assessment in the age of artificial intelligence. Computers and Education: Artificial Intelligence, 3, 100075. https://doi.org/10.1016/j.caeai.2022.100075

Taş, N. (2021). Artificial Intelligence in Education: Literature Review. *International Conference on Studies in Education and Social Sciences (ICSES)*. Antalya: ISTES.

Terzopoulos, G., & Satratzemi, M. (2019). Voice Assistants and Artificial Intelligence in Education. *Proceedings of the 9th Balkan Conference on Informatics*, 1–6. https://doi.org/10.1145/3351556.3351588

Van der Vorst, T., & Jelicic, N. (2019). Artificial Intelligence in Education: Can AI bring the full potential of personalized learning to education? https://www.econstor.eu/bitstream/10419/205222/1/van-der-VorstJelicic.pdf

Verma, S., Sharma, R., Deb, S., & Maitra, D. (2021). Artificial intelligence in marketing: Systematic review and future research direction. *International Journal of Information Management Data Insights,* 1(1), 100002. doi:10.1016/j.jjimei.2020.100002

Wu, T., & Tegmark, M. (2019). Toward an artificial intelligence physicist for unsupervised learning. *Physical Review E,* 100(3), 033311. https://doi.org/10.1103/PhysRevE.100.033311

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C.-W., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M. & Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. The Innovation, 2(4), 100179. https://doi.org/https://doi.org/10.1016/j.xinn.2021.100179

Yeo, S. K., Su, L. Y. F., Cacciatore, M. A., Zhang, J. S., & McKasy, M. (2022). The differential effects of humor on three scientific issues: Global warming, artificial intelligence, and microbiomes. *International Journal of Science Education,* Part B, 13(1), 59-83. https://doi.org/10.1080/21548455.2022.2123259

Yunanto, A. A. (2017). *Kecerdasan Buatan Pada Game Edukasi Untuk Pembelajaran Bahasa Inggris Berbasis Pendekatan Heuristik Similaritas* [Unpublished Thesis, Institut Teknologi Sepuluh Nopember]. https://repository.its.ac.id/2072/

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education,*16(39). https://doi.org/10.1186/s41239-019-0171-0

Zhai, X. (2023). ChatGPT and AI: The Game Changer for Education (March 15, 2023). Available at SSRN: https://ssrn.com/abstract=4389098

Zhai, X., He, P., & Krajcik, J. (2022). Applying machine learning to automatically assess scientific models. *Journal of Research in Science Teaching*, 59(10), 1765-1794. https://doi.org/10.1002/tea.21773

Zhang, D. (2016). Virtual Mentor and the Lab System-Toward Building an Interactive, Personalized, and Intelligent E-Learning Environment. *Journal of Computer Information Systems*, *44*(3), 35–43.

Zhang, H., Xiao, B., Li, J., Hou, M., & Zhong, S. (2021). An Improved Genetic Algorithm and Neural Network Based Evaluation Model of Classroom Teaching Quality in Colleges and Universities. Wireless Communications and Mobile Computing, 2021, 1-7. https://doi.org/10.1155/2021/2602385