THE ROLE OF ARTIFICIAL INTELLIGENCE IN PROMOTING CREATIVITY AND PRODUCTIVITY IN SCIENCE EDUCATION

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ABSTRACT

The incorporation of Artificial Intelligence (AI) in science education signifies a revolutionary change in teaching and learning approaches. With the use of artificial intelligence (AI), adaptive learning systems can tailor course material to each student's needs, recognising their strengths and shortcomings instantly and offering focused interventions to promote learning. AI tools like machine learning algorithms and natural language processing can analyse extensive educational datasets, furnishing educators with invaluable insights. AI facilitates personalised instruction by adapting to each student's learning preferences and pace via adaptive learning platforms, enabling customised and efficacious educational encounters. Incorporating AI in education empowers teachers to cater to the diverse requirements of their students and cultivate captivating and interactive learning settings. The paper therefore examined various AI powered tools and its application in science education, curriculum development, and classroom instruction. The paper also discussed AI- Enhanced Pedagogies for Creativity and Productivity and major drawbacks in utilization of AI in science education. It was recommended among others that there should be professional development opportunities, workshops, and continual support to instil confidence in educators for effectively utilising AI technologies to enhance student learning outcomes.

Keywords: *Artificial Intelligence, Science education, creativity, productivity, pedagogies*

Introduction

Today's technology has become an unavoidable part of the passage of time. Technology has not only changed people's lifestyles but has also changed how we work, learn, and interact. Various kinds of innovations appear all the time, making our activities and work more practical and effective. A more recent technological development is the emergence of the term artificial intelligence which is

abbreviated as AI (Artificial intelligence) which is currently starting to steal attention as a tool to act like humans. In its development, artificial intelligence has also penetrated the world of education.. Artificial Intelligence (AI) is the process of modelling human thinking and designing a machine so that it can behave like humans or other terms called cognitive tasks, namely how machines can learn automatically from programmed data and information ((Aina et al., 2023). Artificial intelligence technology refers to machines that can think, weigh the actions to be taken, and can make decisions as humans do. Artificial intelligence (AI) is currently being developed on a large scale so that this technology will imitate and even take over the work normally done by humans. Based on the definition of AI, it was created to be able to act like humans in the form of programs and robots. AI is used to make things easier for humans to do. Several technology companies have implemented AI including Amazon, Facebook, Microsoft, and Google. Artificial intelligence or (AI) is a technology where machines can learn and understand logic like humans. This technology is said to be able to help simplify human life which is very complex (Fitria, 2021a).

The role of Artificial Intelligence (AI) technology is increasingly evident in various sectors, including the education sector. The presence of AI technology has transformed the educational curriculum, especially in the fields of technology, science, mathematics, and engineering(STEME) The incorporation of Artificial Intelligence (AI) in science education signifies a revolutionary change in teaching and learning approaches. AI can also be implemented in the world of education. Teachers/lecturers can understand student needs more easily and more deeply (Fitria, 2021b).

With the use of artificial intelligence (AI), adaptive learning systems can tailor course material to each student's needs, recognising their strengths and shortcomings instantly and offering focused interventions to promote learning. In science education, where concepts can differ greatly in complexity and abstraction, personalisation is very helpful. Additionally, teachers can evaluate learning outcomes and trends at a finer level with the use of AI-driven data analysis tools, which facilitates the improvement of curriculum and instructional techniques to increase student retention and comprehension (Kamalov, Santandreu & Gurrib, 2023). AI's predictive powers can also identify future learning paths, giving teachers the opportunity to proactively address such issues before they

hamper a student's progress. These AI systems can assess student performance data, deliver real-time feedback, and alter course contents to better meet learning goals (Nur, 2021). Furthermore, AI tools can assist educators in recognising students' misconceptions, guiding them through intricate scientific ideas, and encouraging a thorough comprehension of scientific principles (Al Darayseh;2023). AI technologies can support teachers in pinpointing student misunderstandings, assisting students in navigating through intricate scientific ideas, and promoting a profound comprehension of scientific principles (Kotsis, 2024a). Embracing the integration of AI in science education enables educators to enrich the calibre of teaching, elevate student involvement, and ultimately equip the forthcoming cohort of scientists and trailblazers with the aptitude to excel in a progressively technology-driven society.

ARTIFICIAL INTELLIGENCE (AI) IN EDUCATION

Artificial Intelligence (AI) in education is the application of sophisticated technology, namely machine learning algorithms and computational models, to enhance the learning process, boost educational results, and customise instruction to meet the unique requirements of each student (Schueller et al., 2017). It includes a computer's ability to perform tasks that traditionally require human intelligence, such as knowledge acquisition, logical reasoning, problem-solving, and understanding natural language. Chowdhary (2020b) delineates AI into various subfields, including machine learning, neural networks, deep learning, and natural language processing. Within the framework of scientific education in Nigeria, AI can comprise a diverse array of applications, such as intelligent tutoring systems, adaptive learning platforms, and virtual simulations. These technologies have the objective of examining students' learning habits, offering individualised feedback, and generating dynamic educational experiences. AI in education encompasses the use of diverse techniques including natural language processing, computer vision, and data analytics to provide a dynamic and adaptable learning environment. It surpasses conventional teaching techniques by utilising computing power to adjust to the individual strengths and limitations of students, promoting a more customised and efficient educational experience.

The development of AI within the educational realm has substantially revolutionised the dynamics of teacher-student interactions in the classroom (Bates et al., 2020). AI can customise learning experiences, offer immediate feedback, and cater to individual student requirements. AI-powered virtual laboratories and simulations are transforming practical STEM education. These tools offer interactive and immersive experiences that allow students to conduct experiments and explore scientific concepts in a risk-free virtual environment. For instance, platforms like Labster and PhET Interactive Simulations enable students to perform virtual dissections, chemical reactions, and physics experiments, enhancing their understanding through hands-on learning (Bello et al; 2024). Through AI integration, educators can accurately pinpoint students' strengths and weaknesses, facilitating more personalised instruction and assistance. Moreover, AI tools can analyse extensive data to forecast student performance and furnish valuable insights for enhancing teaching methodologies. As AI progresses, it harbours immense potential to enrich the educational journey for educators and learners, paving the way for a more efficient and effective learning environment (Bond, 2024). Integrating AI in education can enhance classroom efficiency, promote greater student participation, and elevate academic performance across diverse student populations (Sharifuddin & Hashim, 2024). AI in science education has exciting opportunities to raise student interest, boost instructional effectiveness, change the way knowledge is acquired, and promote a deeper comprehension of scientific ideas (Almusaed, et al, 2023). AI is facilitating collaborative learning through intelligent platforms that connect students, educators, and experts globally. These environments promote peer-to-peer (P2P) learning, mentorship, and interdisciplinary projects. AI-driven tools can match students with complementary skills and interests, fostering teamwork and collective problem-solving. Examples include platforms like Piazza and Peergrade, which enhance communication and collaboration in STEM education .

A major hurdle in incorporating AI into education is the potential lack of personalisation in learning (Chen et al., 2020). AI systems operate on algorithms and data patterns, which may not accurately represent each student's unique learning styles and requirements. This lack of personalisation can lead to a standardised approach to education that may not fully engage all students

or address their individual needs. Moreover, the constraints of AI technology in terms of emotional intelligence and contextual comprehension present additional obstacles in educational settings (Singh & Chouhan, 2023). For instance, AI may struggle to interpret non-verbal cues or provide the emotional support that a human teacher can offer. Therefore, educators must carefully evaluate the implications of utilising AI in classrooms to ensure that the advantages outweigh the obstacles and limitations it brings.

AI –POWERED TOOLS FOR CREATIVITY AND PRODUCTIVITY IN SCIENCE EDUCATION

One of the most intriguing areas of AI application is in enhancing human creativity. While creativity has traditionally been viewed as a uniquely human trait, AI technologies are now demonstrating their potential to augment and even inspire creative processes. Creativity, being crucial skill in Science education fields, can be fostered by AI technologies through AI tools that support experimentation and discovery. As AI technology continues to evolve, its potential to enhance creativity and productivity in science education will keep growing, offering new opportunities for innovative teaching and learning. Some instances that explores how AI can enhance creativity and productivity across different domains by providing new tools, facilitating collaboration, offering inspiration, and automating routine tasks are provided below

Virtual Mentor

The function of AI which is currently quite widely applied to various educational technology platforms, especially those based online, is as a virtual mentor. Mentoring is a process in which a more knowledgeable person (the mentor) assists a less-knowing person (the mentee) in achieving a learning objective (Klamma et al., 2020). AI can provide feedback on students' learning activities and practice questions, then provide recommendations for material that needs to be re-studied like a teacher or tutor. One example is Blackboard (https://www.blackboard.com/teaching-learning/learningmanagement/ mobile-learning-solutions) which is an application that is widely used in universities in Europe and America. This AI tool is widely used by professors/lecturers to publish notes, homework, quizzes, and tests that allow students to ask questions and assignments for the assessment process. This application can identify the reasons behind students' misunderstanding and

can offer solutions that have been released by the lecturer and programmed beforehand. The Blackboard concept is actually inspired by the conventional whiteboard that is in every classroom and discussion room.

Voice Assistant (VA)

This AI technology has similarities with virtual mentors. Voice assistants incorporate AI using cloud computing and can communicate with the users in natural language (Terzopoulos & Satratzemi, 2019). Voice Assistant is also one of the most widely recognized and used AI technologies in various fields, including education. Examples of commonly known voice assistants are Google Assistant (Google), Siri (Apple), Cortana (Microsoft), and others. Voice Assistant allows students to search for materials, reference questions, articles, and books by simply speaking or mentioning keyword .

Voice Assistants allow interaction with various learning materials without communicating with the teacher. As a result, the educational platform can be used anywhere and anytime. That way, the students can learn independently without worrying about getting confused even without a teacher/tutor, because by using VA, everything and information that is not understood can be presented only by voice .

Smart Content

Smart Content is an AI technology that functions to share and find programmable digital book and material content more easily and quickly. Common examples of the application of this technology are found in various digital libraries today, both in schools, universities, and public libraries. AI can find and categorize the books we are looking for quickly and structured. Examples of smart content are **Cram101** to find and categorize digital books quickly and in a structured way. Then, **NetexLearning** offers a personalized cloud platform with virtual training, conferences, and more. This platform will recommend various multimedia such as books, videos, and various virtual training.

Presentation Translator

Presentation Translator is an AI-based solution that renders subtitles in real-time mode. With AI Speech Recognition, students can hear or read in their native language. This technology has similarities to Voice Assistant, which relies on voice to carry out its functions. It's just that Presentation Translator has a usability specification to explain or present a text from a different

language into the language you want. So users only need to listen to various kinds of speech texts, articles, or digital books without the need to read. So with AI Speech Recognition, users can hear in their native language. We can read and understand journals, articles, or books from any language more easily and quickly.

This technology also has an important role for those who have limitations in terms of language and vision. It has become one of the features that are always present on smartphones today, namely 'Voice Control'. Even today we can also type using only voice (voice typing), so this can be a solution for those of us who have problems typing long text. We just need to speak and then the sentence will be written into text automatically in the app.

Personalized Learning

Personalised learning facilitated by AI enables students to receive tailored instruction based on their unique needs and learning preferences. AI algorithms analyse data concerning a student's strengths, weaknesses, and progress to design a customised learning plan to optimise educational results (Tapalova & Zhiyenbayeva, 2022). This high level of customisation empowers educators to deliver precise support and interventions, ultimately leading to heightened student engagement and academic success, Examples of the application of Personalized Learning, are those that have been implemented by Khan Academy(https://www.khanacademy.org/),Duolingo(https://www.duolingo.com/), Ruangguru(https://www.ruangguru. com/), and more.Additionally, AI systems can adjust to the student's learning pace in real-time, ensuring that each student is challenged appropriately and provided with adequate support (Seo et al., 2021). By leveraging the capabilities of AI, educators can transform the learning experience for students, thereby enhancing the effectiveness and impact of education for every learner (Jian, 2023).

Virtual Laboratories and Simulations

AI-driven simulations provide immersive learning experiences that stimulate creativity.

Integrating virtual labs and simulations into science education can offer students a practical, hands-on learning opportunity that may otherwise be inaccessible due to constraints such as cost, safety, or logistical issues (Kapici et al., 2022). These digital resources enable students to engage in experiments, conduct observations, and analyse data in a virtual setting, enriching their

comprehension of intricate scientific principles. Moreover, virtual labs can be tailored to accommodate various learning styles and speeds, presenting them as a versatile and valuable educational tool for teachers (Groenewald et al., 2024). By incorporating these technologies into the curriculum, educators can design interactive and stimulating learning environments that foster critical thinking and problem-solving skills among students.

Automatic Assessment

AI is widely used for online automatic assessment and question correction purposes.

The use of features like this makes it easier for teachers and tutors to prepare and conduct

quizzes and tests easily and practically. Teachers and tutors no longer need to make questions and correct questions manually. One example of the application of Automatic Assessment is the quiz creation and automatic correction features provided by the Kejarcita platform (https://kejarcita.id/). This feature allows teachers to easily and practically create quizzes and tests. Teachers only need to choose the type of subject, level, number of questions, level of difficulty, and several other options. After that, the teacher only needs to share the quiz link with the students to do it directly online.

Adaptive Learning System (ALS)

Artificial intelligence plays an important role in adaptive learning systems with its advanced technology and capabilities. Machine learning algorithms are used to analyze large amounts of data. AI-powered adaptive learning systems consist of multiple interconnected components that work together to deliver a personalized learning experience. Learner modeling involves creating and maintaining individual learner profiles, as well as collecting data such as assessment scores, learning preferences, progress tracking, and even socio-emotional factors. By offering personalized content, real-time feedback, and targeted exercises; adaptive learning systems helps students grasp complex concepts more effectively and at their own pace. Prominent examples include platforms like DreamBox, Knewton, and Smart Sparrow, which tailors educational pathways to meet the unique needs of each learner(Meet; 2024)

Intelligent Tutoring System (ITS)

Intelligent Tutoring System (ITS) or commonly known as Intelligent Computer-Aided

Instruction is a system to provide teaching that can adapt to students' abilities. ITS is one of

the developments of an expert system on artificial intelligence in the field of learning.

Examples of Intelligent Tutoring System (ITS) are Intelligent Tutoring System (ITS) Based on Augmented Reality (AR) for Dimensional Geometry Material, Intelligent Tutoring System for Nun Sukun or Tanwin law learning, Intelligent Tutoring System (ITS) for circular learning, and various other ITS. (Abu Ghali et al., 2018) states that The IntelligentTutoring System (ITS) is a computer program that provides students with personalized education and feedback without the need for human intervention. The system adjusts to each student's unique characteristics and progresses them from an easier to a more difficult level.

AI- ENHANCED PEDAGOGIES FOR CREATIVITY AND PRODUCTIVITY IN SCIENCE EDUCATION

Project – Based learning (PBL)

Project based learning is a student-centered instructional approach that involves students working on real-world problems and projects, promoting deep learning, critical thinking, collaboration and communication and problem –solving skills. Incorporating project-based approaches is vital for engaging students with AI. Schools should provide access to AI-powered tools and platforms that allow students to experiment with coding, data analysis, and machine learning. Projects that involve real-world problems encourage students to apply AI concepts creatively and collaboratively.

Examples include developing AI models for environmental monitoring or creating chatbots for educational purposes (Johnson et al., 2016).

Inquiry – Based Learning(IBL).

Inquiry – Based Learning is a student- centered instructional approach that encourages students to explore, investigate and learn through active questioning, critical thinking and problem –solving. It also encourages flexibility and adaptability as students navigate unexpected results, challenges and setbacks. Examples of inquiry –based learning includes: Science investigations, Historical inquiry, Mathematical explorations and Environmental studies. By incorporating IBL into the class room,

educators can create engaging relevant and challenging learning experiences that prepare students for success in careers and life.

Collaborative Learning

Collaborative Learning is a teaching approach that involves students working together in small group to achieve common learning goals. AI facilitates collaboration and idea generation among students, fostering a creative learning environment. Collaborative platforms like Slack and Trello, enhanced with AI capabilities, streamline communication and project management, allowing students to share ideas and work together on science projects more effectively. AI-powered brainstorming tools, such as IBM Watson's Idea Generation, helps students generate and refine creative ideas through natural language processing and machine learning algorithms (Shneiderman, 2020). Creating collaborative learning environments where students can work on AI projects together fosters teamwork and enhances learning outcomes.

Flipped Learning

Flipped learning is defined as a pedagogical approach that direct instruction moves out of the class via technology and internet (e.g. videos, podcasts, online blogs or available online materials.) while in-class time includes practice and collaborative activities which promote active learning (Abeysekera & Dawson, 2015). Flipped learning can motivate students to learn more effectively, develop critical thinking skills, facilitate collaborative learning, and handle different learning styles(Eze; 2023). AI can support flipped classroom models by providing personalized instruction, feedback and support, enabling students to work at their own pace.

MAJOR DRAWBACKS IN UTILIZATION OF AI IN SCIENCE EDUCATION

Integrating AI into Science education presents numerous challenges despite its potential to revolutionize the field. While AI can enhance personalized learning, automate administrative tasks, and provide advanced data analytics, several significant barriers, outlined below, hinders its seamless integration into educational systems.

Equity and Access

Digital equity and accessibility concerns significantly influence the efficacy of integrating AI into science education at the elementary level (Holstein & Doroudi, 2021). The absence of access to essential technology and digital resources such as PCs or tablets can exacerbate the educational achievement gap among students, particularly those in marginalised communities. Furthermore, variances in digital literacy competencies can impede students' capacity to reap the benefits of AI integration in the educational setting. In addition, the irregular provision of electricity and insufficient internet access in many schools provide substantial challenges, hindering the smooth use of AI applications and obstructing the educational progress of students.

Teacher Training and Professional Development

Another crucial obstacle is to the preparation and competence of teachers in integrating AI into the educational system. Several educators may lack enough training in using AI tools in the classroom, impeding their capacity to successfully harness new technology. A further obstacle arises from resistance to change, which originates from a lack of familiarity or scepticism over the efficacy of AI. 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.

Data Privacy and Security

The incorporation of AI in education raises significant ethical problems. The collecting and storage of student data by AI systems give rise to issues regarding data privacy, hence requiring strong measures to ensure privacy protection (Adeyemi, 2020). Learners' personal information must be protected through secure storage, access controls, and anonymization practices. Informed consent must be obtained from learners, parents (in the case of minors) and other parties for the collection, use and disclosure of data.

The presence of biases in AI systems, which might inadvertently perpetuate pre-existing prejudices in the data used for training, poses an additional ethical dilemma. The responsible use of AI in education necessitates the formulation and implementation of rigorous data security rules, periodic assessments to detect and correct biases, and the formation of ethical norms and legislation.

Bias and Fairness

Bias and fairness issues in AI algorithms play a pivotal role in our present technological landscape. AI systems frequently undergo training on biased datasets, leading to inequitable outcomes for specific demographic groups (Varona & Suárez, 2022). This dilemma is notably rampant in domains like the criminal justice system, where AI algorithms are utilised in decision-making processes related to bail, sentencing, and parole. Studies have indicated that these algorithms may manifest racial and gender biases, resulting in unjust treatment (McKay, 2020).

Financial Constraints

Implementing AI technologies in education can be expensive, encompassing costs for software, hardware, training, and on-going maintenance. Many educational institutions, especially those already struggling with limited budgets, find it challenging to allocate sufficient funds for these purposes. Securing financial resources and demonstrating the long-term return on investment is crucial for the sustainable integration of AI.

Resistance to Change

Educational systems are traditionally slow to adopt new technologies, often due to institutional inertia and resistance to change. Stakeholders, including educators, administrators, and policymakers, may be sceptical about the efficacy of AI in education or concerned about the potential displacement of traditional teaching roles. Overcoming this resistance requires clear evidence of AI's benefits and a strategic approach to change management

CONCLUSION

The application of artificial intelligence (AI) in science education holds the potential to completely transform the way that scientific knowledge is comprehended, implemented, and shared. AI can enhance personalised learning experiences by adapting to individual student needs and providing targeted feedback. This adaptability can lead to improved student engagement and academic performance. AI tools such as virtual labs and simulations can provide hands-on learning experiences that are otherwise not feasible in traditional classroom settings. These tools offer a practical way for students to explore complex scientific concepts in a safe and interactive environment. Integrating AI in science teaching can help teachers streamline administrative tasks, allowing them to focus more on

delivering high-quality instruction and supporting student learning outcomes. By leveraging AI technology, educators can enhance their teaching practices and provide students with a more enriching learning experience.

Despite its transformative potential, integrating AI into Science education presents several challenges, including technological infrastructure disparities, the need for comprehensive teacher training, curriculum development, ethical and privacy concerns, financial constraints, resistance to change, and ensuring equity and inclusivity. To effectively implement AI in science education, teachers must receive adequate training and resources to leverage this technology to its full potential. Additionally, policymakers and stakeholders in education must work together to support initiatives that promote the integration of AI in the classroom. A call to action is needed to prioritise AI in science education to ensure that students are prepared for the challenges and opportunities of the future. As we continue to explore the possibilities of AI in the classroom, teachers need to stay informed, adapt to changes, and embrace the opportunities that this innovative technology presents. By doing so, we can ensure that our students receive a genuinely enriching and impactful educational experience.

RECOMMENDATIONS

The following recommendations, for integrating Artificial Intelligence (AI) into Science Education for enhancing creativity and productivity are proffered

1. Policy and infrastructure support are imperative for successfully integrating AI into science education. Policymakers' development of guidelines and regulations is crucial to facilitate the incorporation of AI tools in classrooms, while upholding student data privacy and security standards. Furthermore, ensuring adequate infrastructure support, such as dependable internet connectivity and access to suitable hardware, is vital for teachers to employ AI resources in their teaching methodologies effectively.
2. Integrate AI concepts across various subjects to create an interdisciplinary approach. For instance, incorporate data analysis and machine learning in mathematics, use AI-driven simulations in physics, and explore the ethical implications of AI in social studies.

3. The provision of training and support for educators plays a pivotal role in the successful introduction of novel technologies, including AI, in educational settings. Teachers must acquire the knowledge and skills to integrate AI tools seamlessly into their teaching practices. This necessitates offering professional development opportunities, workshops, and continual support to instil confidence in educators for effectively utilising AI technologies to enhance student learning outcomes.
4. Evaluating and monitoring AI tools in educational environments is crucial for assessing their efficacy and impact on teaching and learning outcomes . Educators need to regularly evaluate the performance of AI tools to ascertain if they align with the intended objectives and promote student engagement. This evaluation process entails collecting student feedback, observing the utilisation of tools in classrooms, and analysing student progress and performance data.
5. Address disparities in technological infrastructure by securing funding for necessary hardware, software, and stable internet connections, particularly in underfunded or rural areas
6. Encourage project-based learning (PBL) by having students work on real-world projects that apply AI tools to solve practical problems. This hands-on experience helps develop critical thinking, collaboration, and technical skills. Provide access to AI-powered tools and platforms that allow students to experiment with coding, data analysis, and machine learning, thereby encouraging creative exploration and problem-solving.
7. Continuous enhancement and adaptation are fundamental components of integrating AI into science education. With the evolution of technology and the emergence of new AI tools, educators must consistently assess and refine their instructional approaches to deliver the most effective and engaging education to students. Embracing a mind-set of continuous improvement enables educators to adjust their teaching strategies to leverage the capabilities of AI in enhancing student learning outcomes.

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