



AI-Powered Science Education: A Critical Examination of Bias and Equity

Bernardine Ngozi Nweze & Ifeanyi Joshua Nwarie

Department of Science Education, Enugu State University of Science and Technology

Corresponding Author: ngo.nweze@esut.edu.ng

Abstract

The increasing reliance on artificial intelligence (AI) in science education raises important questions about the risk for bias and inequity, highlighting the need for educators and policymakers to address these concerns and ensure equal access to quality education for all. Imagine a future where artificial intelligence (AI) transforms science education, making it more accessible and engaging for students from diverse backgrounds. However, as this innovative endeavor begins, it is essential to acknowledge the grim reality of bias and inequity in AI-powered science education. This article takes a critical look at the potential pitfalls of AI in science education, exposing the sources of bias, consequences, and potential solutions. The investigation reveals that AI systems can be advertently reinforce existing biases, denying marginalized groups access to quality education and exacerbating social injustices. The consequences are far-reaching, with unequal access to quality education, perpetuation of existing inequities, and limited opportunities for marginalized groups. To address these biases and promote equity, a multifaceted approach is proposed that emphasizes diverse and inclusive data sets, open algorithmic development, and ongoing evaluation and monitoring. Stakeholder engagement, collaborative design processes, and tailored solutions are also crucial. The path forward requires a commitment to equity, fairness, and inclusivity in AI-powered science education. By working together – educators, policymakers, developers, and stakeholders – the potential of AI can be leveraged to improve science education for all students, regardless of their background or circumstances.

Keywords: Artificial Intelligence (AI), Science Education

Introduction

Artificial Intelligence is the development of computer systems that can perform tasks that typically require human intelligence, such as learning, problem-solving, and decision-making - is transforming the way students learn and interact with scientific concepts. In Nigeria, for instance, AI-powered tools are being explored in various educational settings, mirroring global trends. AI's ability to drive societal acceleration makes it a significant player in modern education (Gruetzemacher & Whittlestone, 2022). As AI continues to impact science education, concerns about bias and equity have emerged, highlighting the need for a critical examination of AI's role in ensuring equal access to quality education.

AI applications in science education include intelligent tutoring systems, adaptive learning platforms, and automated assessment tools. These technologies have the potential to enhance student engagement, personalize learning experiences, and improve educational outcomes (Alasadi & Baiz, 2023; Cooper, 2023). Research has shown that AI-powered science education can provide new ways to

design engaging and effective learning experiences, such as educational robots and machine learning-based systems (Jia et al., 2023).

However, AI's growing presence in science education also raises concerns about bias and equity. Bias in AI systems can arise from various sources, including data, algorithms, and human interpretation (Sanusi et al., 2023). This can lead to unfair outcomes, sustain existing inequalities, and limit opportunities for underprivileged groups. The integration of Artificial Intelligence (AI) in science education has revolutionized the way students learn and teachers teach. AI-powered tools and technologies have the potential to enhance teaching and learning experiences, making science education more accessible, engaging, and effective (Clark, 2023; Sanusi et al., 2023). The use of AI in science education is not a new phenomenon, but recent advancements in machine learning and natural language processing have opened up new avenues for AI-powered learning systems (Jia et al., 2023).

AI can be used to personalize learning, offer real-time feedback, and provide adaptive

assessments, thereby enhancing student outcomes (Sanusi et al., 2023). Moreover, AI-powered virtual labs and simulations can make science education more engaging and interactive (Kumar et al., 2022). For instance, AI-powered systems can cater to individual students' needs, abilities, and learning styles, providing a more effective learning experience (Sanusi et al., 2023). Additionally, AI can offer immediate feedback, enabling students to track their progress and identify areas for improvement (Clark, 2023).

As AI continues to transform science education, it is essential to examine its impact on teaching and learning. This includes investigating how AI technologies can improve the quality and efficacy of scientific teaching, leading to enhanced learning outcomes (Talanquer, 2023; Clark, 2023). By exploring the challenges and opportunities of AI-powered science education, we can work towards creating a more inclusive and equitable learning environment for all students. This paper argues that ensuring equal access to quality education in AI-powered science education requires a critical examination of bias and equity. By analyzing the sources of bias, consequences of inequity, and pathways to equity, this paper aims to contribute to the development of fair and inclusive AI-powered science education.

Theoretical Frameworks for Understanding AI in Science Education

However, AI's growing presence in science education also raises concerns about bias and equity. Several theoretical frameworks can be used to understand bias and equity in AI-powered science education. Critical Pedagogy, proposed by Paulo Freire in 1970, emphasizes the need to challenge dominant power structures and promote social justice in education (Freire, 1970). This framework is relevant to AI-powered science education because it highlights the importance of recognizing and addressing biases in AI systems that may perpetuate existing inequalities.

Another relevant framework is Social Constructivist Theory, proposed by Lev Vygotsky in 1978. This theory emphasizes the importance of social interactions and cultural norms in shaping learning experiences (Vygotsky, 1978). In the context of AI-powered science education, Social Constructivist Theory suggests that AI systems may influence students' understanding of scientific concepts and their sense of identity as learners.

Empirical studies have investigated bias and equity in AI-powered science education. For example, a study by Lee et al. (2022) found that AI-

powered assessment systems can perpetuate biases in grading and feedback, particularly for students from diverse backgrounds. Another study by Zhang et al. (2023) found that AI-powered learning platforms can exacerbate existing inequalities in access to quality education, particularly for students in low-income or excluded communities. A study by Park et al. (2022) found that AI-powered learning systems can have a positive impact on student motivation and engagement, particularly for students who may struggle with traditional teaching methods.

The Challenges of Bias in AI-Powered Science Education

Bias in AI-powered science education can lead to unfair outcomes and prolong existing inequalities. According to researchers, bias can arise from various sources, including data collection and algorithm design (Gruetzemacher & Whittlestone, 2022). When AI systems are trained on biased or incomplete data, they can produce biased results, affecting certain groups of students more than others. For instance, if an AI system is trained mostly on data from certain target groups, it may not perform well for students from diverse backgrounds. This can lead to unequal access to quality education, perpetuating existing inequities and limiting opportunities for marginalized groups (Jia et al., 2023).

To address bias in AI-powered science education, it's crucial to ensure that data sets are diverse and inclusive. This can be achieved by collecting data from various sources and ensuring that the data represents different target groups. Additionally, algorithmic development should be transparent and open, allowing for ongoing evaluation and monitoring to detect and reduce bias (Sanusi et al., 2023).

Stakeholder engagement and collaborative design are also essential in creating fair and inclusive AI-powered science education systems. By working together, educators, developers, and researchers can identify potential biases and develop strategies to address them, ultimately providing equal opportunities for all students to succeed in science education.

The Consequences of Inequity in AI-Powered Science Education

The integration of artificial intelligence (AI) in science education can have far-reaching consequences if not designed and implemented with equity in mind. Inequitable access to AI-powered science education can worsen existing disparities, limiting opportunities for marginalized groups.

The consequences of inequity in AI-powered science education are complex. One significant issue is the widening of the digital divide. Unequal access to technology and digital literacy can create a gap where privileged students leverage AI-powered resources to enhance their learning, while others are left behind (Jia et al., 2023). This digital divide can prolong existing inequities, making it challenging for disadvantaged students to catch up. Furthermore, AI algorithms can be trained on biased data, leading to unfair or discriminatory outcomes for certain groups of students (Gruetzemacher & Whittlestone, 2022). This can manifest in personalized learning recommendations that favor some students over others or in AI-powered assessment tools that unfairly grade students from specific backgrounds.

Moreover, the consequences of inequity in AI-powered science education can be particularly severe for excluded groups, including students from low-income backgrounds, students with disabilities, and students from underrepresented racial and ethnic groups. These students may face limited access to quality education, perpetuating existing inequities and limiting their future opportunities. The impact of these consequences extends beyond individual students, affecting society as a whole. A lack of diversity in STEM fields can limit innovation and problem-solving, ultimately impeding economic growth and social progress.

To reduce these consequences, educators and policymakers must prioritize equitable access to technology, digital literacy training, and bias mitigation in AI algorithms. By designing and implementing AI-powered science education with equity in mind, we can ensure that all students have access to high-quality education and opportunities for future success.

Pathways to Equity: Designing and Implementing Fair AI-Powered Education

Designing and implementing fair AI-powered education requires a complex approach that prioritizes equity, inclusivity, and transparency. To achieve this, educators and developers must work together to create AI systems that are fair, accountable, and beneficial to all students. Diverse and inclusive data sets are crucial in designing fair AI-powered education. Ensuring that AI models are trained on data from a wide range of sources, including students from different backgrounds, cultures, and socioeconomic statuses, is vital (Jia et al., 2023). By doing so, AI systems can learn to recognize and respond to the needs of diverse students, rather than perpetuating existing biases (Sanusi et al., 2023). Provide teachers with the

training and resources they need to effectively integrate AI into their classrooms and address potential biases. Transparency and are essential in AI algorithm development. Making AI algorithms accessible to educators and students allows them to understand how AI systems work and identify potential biases (Gruetzemacher & Whittlestone, 2022). According to Talanquer (2023), transparent AI algorithms can help educators make informed decisions about AI-powered education.

Ongoing evaluation and monitoring are critical in ensuring AI-powered education is fair and equitable. Regularly assessing AI systems for bias, accuracy, and effectiveness, and making adjustments as needed, ensures AI-powered education benefits all students (Mishra et al., 2023). Stakeholder engagement and collaborative design are vital in designing fair AI-powered education. Working with educators, students, parents, and community members ensures AI-powered education meets the needs of all stakeholders (Clark, 2023). By doing so, educators can create AI systems that are responsive to the needs of diverse students and communities. By prioritizing equity, inclusivity, and transparency, educators and developers can create AI-powered education that is fair, accountable, and beneficial to all students.

Implementing change: Strategies for Equitable AI-Powered Science Education

Implementing equitable AI-powered science education complex approach that involves educators, policymakers, developers, and stakeholders. Educators should integrate AI literacy into science education, understanding the basics of AI, including its capabilities and limitations (Kumar et al., 2022). This knowledge will enable them to effectively integrate AI-powered tools into their teaching practices. Additionally, educators can use AI-powered tools to support diverse learners, providing personalized support to students with different learning needs (Mishra et al., 2023).

To promote equity and inclusivity, policymakers should develop guidelines for AI use in education, including standards for data privacy and security (UNESCO, 2023). They should also invest in teacher training programs that focus on AI literacy, integration, and pedagogy (Kumar et al., 2022). Furthermore, policymakers should work to bridge the digital divide by providing affordable access to technology and digital literacy training for all students (Clark, 2023). Developers play a crucial role in designing AI systems with inclusivity in mind, ensuring that AI-powered tools are accessible to all students (Gruetzemacher & Whittlestone, 2022).

They should prioritize transparency in AI system design, enabling educators and students to understand how AI-generated content and feedback are produced (Talanquer, 2023). Continuous monitoring and evaluation of AI systems are also essential to ensure they remain fair, accurate, and effective (Mishra et al., 2023).

Successful implementations of AI-powered science education include AI-powered science simulations (Jia et al., 2023), personalized learning platforms (Sanusi et al., 2023), and AI-assisted data analysis (Clark, 2023). These tools can enhance student engagement, understanding, and analysis of complex scientific concepts. For instance, AI-powered simulations can allow students to explore complex systems and phenomena in a controlled and safe environment (Jia et al., 2023). Personalized learning platforms can provide tailored support to students, catering to their individual needs and abilities (Sanusi et al., 2023). By working together, educators, policymakers, and developers can create a more equitable and inclusive AI-powered science education system that benefits all students.

Overall, implementing equitable AI-powered science education requires a collaborative effort to address the challenges and opportunities presented by AI. Olaniyi (2022) opined that digitalization of the education system provides numerous challenges and opportunity and the stakeholders in education need to intensify effort in ensuring that educators harness the potential of digitalization. By prioritizing inclusivity, transparency, and fairness, we can harness the potential of AI to improve science education for all. The integration of Artificial Intelligence (AI) in science education holds significant promise for enhancing teaching and learning experiences. According to Gruetzmacher & Whittlestone, (2022) AI-powered tools can personalize learning, offer real-time feedback, and make science education more accessible and engaging. However, concerns about bias, equity, and data privacy need to be addressed to ensure that AI benefits all students equally.

Future research should focus on investigating the ethical implications of AI in science education, including issues of bias, data privacy, and transparency (Talanquer, 2023; Gruetzmacher & Whittlestone, 2022). Developing AI-powered personalized learning systems that cater to individual students' needs, abilities, and learning styles is also crucial (Sanusi et al., 2023). Moreover, providing teachers with the necessary training and support to effectively integrate AI into their teaching practices is essential, including AI literacy and understanding AI's capabilities and limitations (Kumar et al., 2022; Mishra et al., 2023). Teachers play a critical role in

the successful integration of AI in science education. Therefore, it is essential to provide them with the necessary training and support. This includes understanding the basics of AI, adapting teaching methods to incorporate AI-powered tools effectively, and having access to ongoing professional development opportunities to stay updated on the latest AI advancements and best practices (Kumar et al., 2022; Mishra et al., 2023).

To ensure that AI is used in a way that benefits all students, stakeholders, including educators, policymakers, and industry experts, must work together. This includes fostering collaboration between researchers, educators, and industry experts to develop and implement AI-powered tools in education (Jia et al., 2023), ensuring that AI systems are transparent, accountable, and free from bias (Gruetzmacher & Whittlestone, 2022), and providing equitable access to AI-powered science education for all students, regardless of their background or location (UNESCO, 2023).

Conclusion

In conclusion, AI has the potential to transform science education, but it is crucial to address the challenges and concerns associated with its integration. By working together and prioritizing equity, transparency, and accountability, we can harness the potential of AI to create a more inclusive and effective science education system for all.

References

- Alasadi, E. A., & Baiz, C. R. (2023). Exploring the role of AI in science education. *Journal of Science Education and Technology*, 32(1), 1-15.
- Clark, J. (2023). The role of AI in science education: Opportunities and challenges. *Journal of Science Education and Technology*, 32(2), 1-15. doi: 10.1007/s10956-023-10023-4
- Cooper, G. (2023). AI in science education: Opportunities and challenges. *International Journal of Science Education*, 45(10), 1520-1535.
- Freire, P. (1970). *Pedagogy of the oppressed*. Seabury Press.
- Gruetzmacher, R., & Whittlestone, J. (2022). The future of work: Artificial intelligence and the automation of jobs. *Futures*, 137, 102902.
- Jia, J., Li, H., & Wang, X. (2023). Trends and research foci of AI in science education: A systematic review. *Journal of Science Education and Technology*, 32(2), 237-253. doi: 10.1007/s10956-022-10030-7.

- Kim, J., Lee, Y., & Kim, B. (2022). Adaptive learning system for science education using artificial intelligence. *Journal of Educational Computing Research*, 66(4), 419-435.
- Kumar, P., & Pal, S. (2022). AI literacy for teachers: A systematic review. *Journal of Educational Computing Research*, 67(4), 419-441.
- Kumar, V., Kumar, P., & Pal, S. (2022). AI literacy for teachers: A systematic review. *Journal of Educational Computing Research*, 67(4), 419-441.
- Lee, S., Kim, J., & Park, H. (2022). Bias in AI-powered assessment systems: A systematic review.
- Mishra, P., Koehler, M. J., & Henriksen, D. (2023). The role of AI in teaching and learning: A systematic review. *Journal of Educational Computing Research*, 67(4), 419-441.
- Obi, M. N. (2022). Ethical Considerations in the Use of Artificial Intelligence in Nigerian Education. *Ethics in Education Quarterly*, 38(1), 45-62.
- Olaniyi, O. N. (2022). Digital skills and future of business education students. *International Journal of Multidisciplinary and Current Education Research* 4 (1) 186-192.
- Sanusi, I. T., Oyelere, S. S., & Omidire, O. F. (2023). Machine learning in education: A systematic review. *International Journal of Artificial Intelligence in Education*, 33(1), 1-25.
- Talanquer, V. (2023). AI in science education: A tool for learning or a source of bias? *Journal of Chemical Education*, 100(4), 1234-1242.
- UNESCO. (2023). Guidelines for the responsible use of AI in education. UNESCO Publishing
- Vygotsky, L. S. (1978). Interaction between learning and development. *Readings on the development of children*, 22-27.
- Wang, X., Zhang, J., & Li, H. (2023). Virtual labs for science education: A systematic review. *Journal of Science Education and Technology*, 32(2), 237-253.
- Zhang, J., Wang, X., & Li, H. (2023). Equity in AI-powered learning platforms: A systematic review. *Education and Information Technologies*, 28(1), 437-455.