Chapter 6
Transforming Science Education Through Generative AI Through Adaptive Learning, Ethical Practices, and Inclusive Curriculum Design

Dipta Gomes
https://orcid.org/0000-0003-3019-6051
American International University-Bangladesh, Bangladesh

Saikat Baul
American International University-Bangladesh, Bangladesh

Jubayer Ahamed
https://orcid.org/0000-0003-2076-9194
American International University-Bangladesh, Bangladesh

Dip Nandi
American International University-Bangladesh, Bangladesh

ABSTRACT

This chapter explores the integration of GenAI into STEM education with a primary focus on Science education. It examines how GenAI can revolutionize teaching and learning by providing adaptive learning environments, personalized assessments, and real-time feedback that cater to the diverse needs of students also ensuring the

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ethical challenges associated with the implementation of GenAI, including concerns around bias, transparency, data privacy, and academic integrity. The chapter emphasizes the importance of balancing technological innovation with ethical practices to ensure equitable access and responsible use of GenAI tools. Looking ahead, the chapter outlines key future directions, including the refinement of adaptive learning tools and the need for AI literacy programs for educators. The chapter concludes by highlighting the potential of GenAI to transform science education while ensuring that it is used in ways that promote fairness, inclusivity, and accountability.

1. INTRODUCTION

The landscape of modern education is rapidly being reshaped through generative artificial intelligence (GenAI) by providing dynamic, creative, and adaptive learning environments (Law, 2024). GenAI can be defined as a collection of algorithms that can utilize data like text, audio, video, and images to construct new content for further findings and investigation (Mittal et al., 2024). In the context of science-related subjects, where conceptual understanding, data analysis, and inquiry-based learning are crucial, GenAI offers transformative opportunities. Its capacity to generate personalized content, real-time feedback, and customized learning pathways positions it as a powerful tool for addressing diverse learner needs and promoting deeper engagement. (Zhai, 2023). Despite huge enhancements of the dynamics in its growing influence, there remains a gap in consolidated frameworks and structured guidance for integrating GenAI into science education in ethical, inclusive, and pedagogically sound ways (Baidoo-Anu & Ansah, 2023). This proposed book chapter aims to fill this gap by exploring both theoretical and practical dimensions of GenAI's role in science education through four core strands which includes Adaptive/ITS with knowledge tracing, AI-driven formative assessment and feedback, GenAI–enabled scientific reasoning and data visualization and Ethics and governance in higher education. Here the chapter also demonstrates evidence-based design patterns and tertiary science case studies that translate theoretical insights into actionable classroom strategies for personalized, inclusive, and authentic learning experiences.

Core Concepts

The application of GenAI in science education is grounded in several well-established learning theories that emphasize active, student-centric, and adaptive instruction: