Chapter 26
Bridging Data-Driven Learning and Generative AI: A Framework for Sustainable Education Through Metacognitive Resource Utilization

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ABSTRACT

This chapter presents a framework to enhance sustainable education by bridging data-driven learning and generative artificial intelligence (AI) with metacognitive resource utilization. The framework offers educators a structured approach to integrate innovative pedagogical strategies grounded in the intersection of educational theory and emerging technologies. Through a comprehensive review of literature, the study identifies gaps and theoretical frameworks relevant to sustainable education. The proposed framework emphasizes the importance of promoting metacognitive skills alongside sustainability principles, empowering students to become active agents in addressing global challenges. However, challenges such as inequalities in access to resources and the need for comprehensive educator support are acknowledged. Although these challenges persist, the framework marks a notable advancement in nurturing critical thinking, problem-solving abilities, and conscientious citizenship among students. Further research and fine-tuning are imperative to guarantee its efficacy and accessibility across varied educational environments.

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INTRODUCTION

In the digital transformation era, the convergence of data-driven methodologies and AI presents a revolutionary opportunity to redefine the landscape of education (Alwahedi et al. 2024). By harnessing the power of data analytics and generative AI, educators can unlock new possibilities for personalized learning, adaptive instruction, and cognitive enhancement. In this context, the synergy between data-driven learning and generative AI offers a promising framework for sustainable education, where using metacognitive resources becomes paramount in shaping the learning experience (Bedington et al. 2024). Data-driven learning, characterized by its reliance on empirical evidence and quantitative analysis, has emerged as a cornerstone of contemporary educational practices. By leveraging data analytics, educators can gain valuable insights into student learning patterns, preferences, and performance metrics, enabling targeted interventions and instructional adjustments. From adaptive learning platforms to predictive modeling of student outcomes, data-driven methodologies empower educators to tailor their pedagogical strategies to meet learners' diverse needs (Chiu 2024) effectively.

Complementing data-driven learning, generative AI represents a paradigm shift in how educational content is created, personalized, and disseminated. Generative AI algorithms, equipped with natural language processing and deep learning capabilities, can simulate human-like reasoning and creativity, generating personalized learning materials, instructional content, and assessment tools. This transformative technology enhances the efficiency and scalability of educational delivery and fosters learner engagement, creativity, and critical thinking skills (Dai, Liu, and Lim 2023).

At the intersection of data-driven learning and generative AI lies the concept of MRU – the strategic deployment of cognitive processes to monitor, control, and optimize one's learning strategies. Metacognition, encompassing self-awareness, self-regulation, and reflective thinking, plays a crucial role in fostering deep learning, knowledge retention, and lifelong learning habits. By integrating metacognitive strategies into data-driven and AI-enabled educational environments, educators can empower learners to take ownership of their learning journeys, adaptively navigate complex tasks, and cultivate higher-order thinking skills (Gupta et al. 2024; Holmström and Carroll 2024).

However, while the fusion of data-driven learning and generative AI holds immense promise for sustainable education, it also poses significant challenges and ethical considerations. Issues such as data privacy, algorithmic bias, and the commodification of education demand careful attention to ensure that technological innovations serve the best interests of learners and educators (Hsu, Tan, and Stantic 2024). Moreover, the democratization of access to AI-driven educational resources must be accompanied by efforts to bridge digital divides and promote equitable educational opportunities for all learners.

The significance of the study in its exploration of cutting-edge educational methodologies to address the evolving needs of learners and educators in a rapidly changing world (Dadhich et al. 2022). By investigating the integration of data-driven learning and generative AI into educational frameworks, this research seeks to revolutionize traditional approaches to teaching and learning. Enhancing metacognitive resource utilization through this integration promises to empower learners to become more self-aware, reflective, and adaptable in their learning journeys. By leveraging the capabilities of AI and data analytics, educators can personalize learning experiences, provide targeted support, and identify areas for improvement, thereby fostering a more sustainable and effective educational ecosystem. Having considered the above prominent studies, the following research question can be formulated.

RQ.1: How can a framework integrating data-driven learning and generative AI be effectively designed and implemented to enhance metacognitive resource utilization in sustainable education practices?

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