

Transforming Higher Education for Sustainable Supply Chain Talent Through Generative AI-Enabled Pedagogical Frameworks

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Introduction

The global supply chain landscape faces unprecedented challenges in achieving sustainability goals while meeting the evolving demands of modern commerce. According to the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (quality education) and SDG 8 (decent work and economic growth), there exists an urgent need to prepare future supply chain professionals with competencies that address environmental, social, and economic sustainability (Salinas-Navarro et al., 2022). The emergence of generative artificial intelligence (AI) technologies presents a transformative opportunity to revolutionize how higher education institutions prepare students for sustainable supply chain careers.

Traditional supply chain education has primarily focused on operational efficiency and cost optimization, often overlooking the critical importance of sustainability integration. However, the current business environment demands professionals who can navigate complex sustainability challenges while leveraging advanced technologies to create value. Chiu (2024) emphasizes that generative AI has the potential to fundamentally transform educational approaches by providing personalized, adaptive learning experiences that can address diverse learning styles and professional requirements.

The integration of generative AI into supply chain education represents a paradigm shift from conventional pedagogical methods to dynamic, technology-enhanced learning frameworks. Kumar et al. (2024) argue that AI-driven educational innovations can significantly enhance the quality and accessibility of higher education, particularly in specialized fields like supply chain management. This technological advancement coincides with the growing recognition that sustainable supply chain practices require interdisciplinary knowledge, systems thinking, and innovative problem-solving capabilities.

This paper explores how generative AI-enabled pedagogical frameworks can transform higher education programs to better prepare students for careers in sustainable supply chain management. By examining current educational challenges, AI implementation strategies, and practical outcomes, this study provides insights into creating more effective and relevant educational experiences that align with industry sustainability requirements.

Reimagining Supply Chain Education Through AI-Enhanced Learning

Current Educational Challenges

Higher education institutions face significant challenges in preparing students for the complexities of modern sustainable supply chain management. Traditional curriculum structures often compartmentalize knowledge, creating silos between sustainability concepts, technology applications, and practical supply chain operations. This fragmented approach fails to develop the integrated thinking required for addressing real-world sustainability challenges.

The rapid pace of technological advancement in supply chain management further complicates educational delivery. Students need exposure to emerging technologies such as blockchain, Internet of Things (IoT), and artificial intelligence applications, while simultaneously understanding their sustainability implications. Conventional educational methods struggle to keep pace with these technological developments, often leaving graduates unprepared for industry expectations.

Generative AI as an Educational Catalyst

Generative AI technologies offer unprecedented opportunities to address these educational limitations through personalized and adaptive learning experiences. Gezdir and Bhattacharjya (2025) demonstrate that large language models can significantly enhance supply chain training programs by providing interactive, contextual learning environments that adapt to individual student needs. These technologies can simulate complex supply chain scenarios, allowing students to explore sustainability trade-offs and decision-making processes in risk-free virtual environments.

The application of generative AI in education extends beyond simple content delivery to include intelligent tutoring systems, automated assessment tools, and collaborative learning platforms. These technologies can generate customized case studies, create scenario-based learning exercises, and provide real-time feedback on student performance, thereby enhancing engagement and learning outcomes.

Framework Development for Sustainable Supply Chain Education

The development of effective AI-enabled pedagogical frameworks requires careful consideration of learning objectives, technological capabilities, and sustainability principles. A comprehensive framework should integrate experiential learning methodologies with AI-powered tools to create immersive educational experiences that mirror real-world supply chain challenges.

Salinas-Navarro et al. (2022) highlight the importance of experiential learning in sustainability education, emphasizing that students learn most effectively when engaging with authentic problems and contexts. Generative AI can enhance these experiential learning opportunities by creating dynamic simulations, generating diverse scenarios, and providing intelligent guidance throughout the learning process.

The framework should encompass four key components: adaptive content delivery, intelligent assessment systems, collaborative learning environments, and real-world application platforms. Each component leverages generative AI capabilities to create personalized learning pathways that address individual student needs while maintaining focus on sustainability objectives.

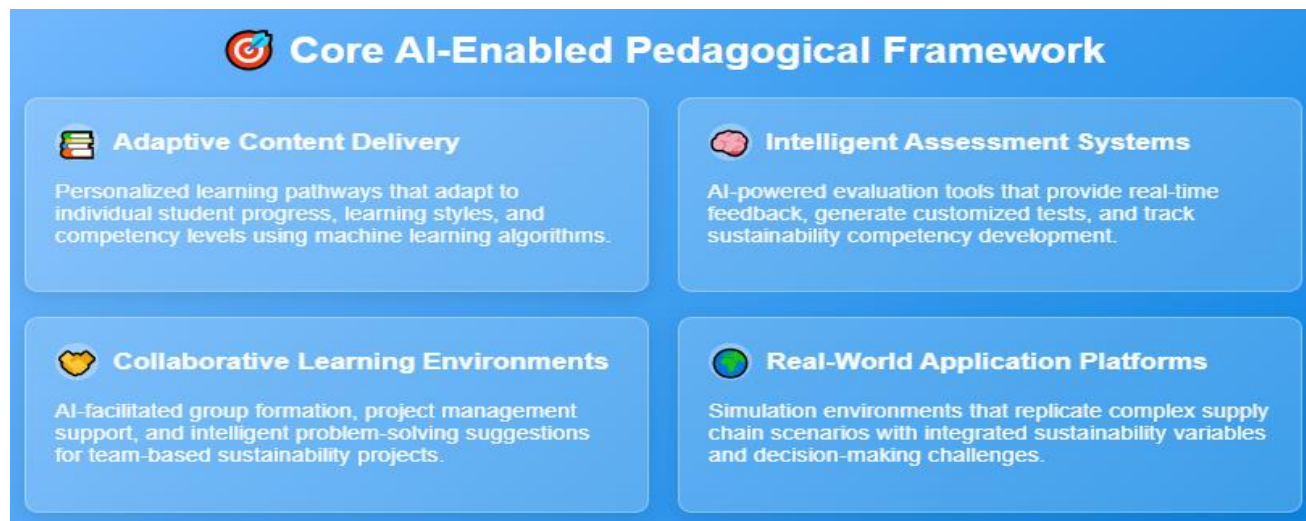


Fig 1: - AI-Enhanced Supply Chain Education Framework

Implementation Strategies and Practical Applications

Adaptive Learning Pathways

Implementation of generative AI in supply chain education begins with creating adaptive learning pathways that respond to individual student progress and preferences. These pathways utilize machine learning algorithms to analyze student performance, identify knowledge gaps, and recommend appropriate learning resources. By personalizing the educational experience, institutions can ensure that all students develop necessary competencies regardless of their starting knowledge level.

The adaptive approach extends to assessment methodologies, where AI systems can generate customized evaluation tools that test specific competencies while providing immediate feedback. This real-time assessment capability enables continuous improvement and helps students understand their progress toward sustainability-focused learning objectives.

Simulation-Based Learning Environments

Generative AI enables the creation of sophisticated simulation environments that replicate complex supply chain scenarios. These simulations can incorporate sustainability variables such as carbon footprint calculations, ethical sourcing decisions, and circular economy principles. Students can experiment with different strategies and observe the long-term consequences of their decisions without real-world risks.

Li et al. (2024) demonstrate that generative AI applications in supply chain contexts can significantly improve performance outcomes when properly implemented. Educational simulations can leverage these insights to create realistic learning environments that prepare students for actual industry challenges while emphasizing sustainable practices.

Collaborative Intelligence Platforms

The integration of generative AI facilitates collaborative learning experiences where students can work together on complex sustainability projects. AI-powered platforms can facilitate group formation based on complementary skills, provide project management support, and offer intelligent suggestions for problem-solving approaches. These collaborative environments mirror modern workplace dynamics while emphasizing teamwork and communication skills essential for sustainable supply chain management.

Benefits and Outcomes

Enhanced Learning Effectiveness

Students engaged in AI-enhanced supply chain education demonstrate improved learning outcomes compared to traditional educational approaches. The personalized nature of AI-driven instruction ensures that each student receives appropriate challenge levels and support, leading to better retention and application of sustainability concepts. Real-time feedback mechanisms enable immediate course corrections and continuous improvement throughout the learning process.



Fig 2: Benefits & Outcomes

The integration of generative AI also increases student engagement through interactive and immersive learning experiences. Virtual reality simulations, intelligent chatbots, and adaptive content delivery maintain student interest while providing deep learning opportunities that traditional lectures cannot match.

Industry Alignment

AI-enhanced educational programs better align with industry needs by incorporating current technologies and sustainable practices into the curriculum. Graduates enter the workforce with practical experience using AI tools and a deep understanding of sustainability applications in supply chain management. This alignment reduces the traditional gap between academic preparation and industry requirements.

Scalability and Accessibility

Generative AI technologies enable educational institutions to scale high-quality sustainability education to larger student populations without proportional increases in faculty resources. AI-powered tutoring systems can provide individual attention to students, while automated assessment tools reduce grading burdens on instructors. This scalability makes comprehensive sustainability education more accessible to diverse student populations.

Challenges and Considerations

Implementation Barriers

Despite significant potential benefits, implementing generative AI in higher education faces several challenges. Technical infrastructure requirements, faculty training needs, and initial investment costs can create barriers for institutions seeking to adopt these technologies. Additionally, ensuring data privacy and maintaining academic integrity in AI-enhanced learning environments requires careful planning and ongoing monitoring.



Fig 3: Challenges & Considerations

Ethical Considerations

The use of AI in education raises important ethical questions about algorithmic bias, data ownership, and the role of human instructors in the learning process. Institutions must address these concerns through transparent policies, diverse development teams, and ongoing evaluation of AI system performance across different student populations.

Kumar et al. (2024) emphasize the importance of maintaining human oversight in AI-driven educational systems to ensure that technological tools enhance rather than replace meaningful human interaction in the learning process.

Future Research Directions and Conclusion

Phase 1
Empirical evaluation of learning outcomes in AI-enhanced programs
Phase 2
Development of standardized assessment metrics for sustainability competencies
Phase 3
Investigation of long-term career impacts for graduates of AI-integrated programs
Phase 4
Cross-cultural applications and global adoption strategies research

Fig 4: Future Research Directions

This exploration of generative AI applications in sustainable supply chain education reveals significant opportunities for transforming higher education practices. The integration of AI-enabled pedagogical frameworks can address current educational limitations while preparing students for careers in increasingly complex and sustainability-focused supply chain environments. Future research should focus on empirical evaluation of learning outcomes in AI-enhanced programs, development of standardized assessment metrics for sustainability competencies, and investigation of long-term career impacts for graduates of AI-integrated educational programs. Additionally, research into cross-cultural applications of these frameworks could inform global adoption strategies for sustainable supply chain education.

The transformation of higher education through generative AI represents a critical step toward developing the sustainability-focused talent needed for future supply chain challenges. By embracing these technological innovations while maintaining focus on human-centered learning principles, educational institutions can create more effective, engaging, and relevant preparation for sustainable supply chain careers. As organizations increasingly recognize the importance of sustainable practices, the demand for qualified professionals will continue to grow. Educational institutions that successfully integrate generative AI technologies into their curriculum will be better positioned to meet this demand while contributing to global sustainability objectives outlined in the United Nations Sustainable Development Goals.

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