Chapter 1
Future Trends and Challenges for AI and Sustainability in TVET

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ABSTRACT

Integrating Artificial Intelligence (AI) and sustainability into Technical and Vocational Education and Training (TVET) is essential for preparing a future-ready workforce. This paper explores the convergence of AI and sustainability in TVET, examining emerging trends, challenges, and strategic approaches. AI technologies, such as machine learning and intelligent tutoring systems, enable personalized learning, while sustainability-driven curricula foster environmental stewardship. Key challenges include the digital divide, curriculum restructuring, and ethical considerations. A strategic framework focusing on curriculum development, technological integration, capacity building, and stakeholder collaboration is proposed to address these challenges. By fostering innovation and promoting lifelong learning, TVET institutions can build a technologically advanced, environmentally responsible global workforce.

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1. INTRODUCTION

The rapid advancements in Artificial Intelligence (AI) and sustainability have ushered in a new era of opportunities and challenges across industries, reshaping the educational landscape and workforce requirements. In this context, Technical and Vocational Education and Training (TVET) stands as a pivotal force in equipping individuals with the skills and knowledge necessary for a dynamic and sustainable future. This chapter delves into the transformative interplay between AI and sustainability and its implications for TVET institutions. As a technological phenomenon, AI is revolutionizing industries by automating processes, enhancing decision-making, and fostering innovation. The integration of AI extends beyond mere efficiency improvements; it introduces new paradigms in how tasks are performed and value is created. On the other hand, sustainability has emerged as a global imperative, driven by the urgent need to address environmental degradation, resource depletion, and socio-economic inequities. Together, AI and sustainability represent two transformative forces reshaping industries, societies, and economies. TVET, sitting at the intersection of education and industry, must rise to the occasion by integrating these elements into its framework (Liow, 2025).

The historical role of TVET has been to prepare individuals for employment, emphasizing practical skills and industry readiness. However, the 21st century demands a broader scope of competencies. The rise of Industry 4.0, marked by advanced technologies such as IoT, robotics, blockchain, and AI, is reshaping workplaces into interconnected, intelligent ecosystems. Simultaneously, sustainability goals, including the United Nations' Sustainable Development Goals (SDGs), require a workforce capable of addressing complex environmental and social challenges. These dual forces necessitate a paradigm shift in how TVET institutions design their curricula, deliver education, and engage with industries and policymakers. The integration of AI and sustainability into TVET is not merely an academic exercise; it is a necessity for fostering a resilient and future-ready workforce. AI technologies, such as machine learning, natural language processing, and predictive analytics, are becoming essential across sectors ranging from healthcare and manufacturing to agriculture and energy. For instance, AI-powered systems are enhancing precision agriculture by optimizing resource use and predicting crop yields, thereby contributing to food security and sustainability. Similarly, green technologies, such as renewable energy systems and sustainable building materials, are driving industries toward eco-friendly practices. TVET institutions must equip learners with the technical expertise and critical thinking skills needed to navigate these innovations. However, the integration of AI and sustainability into TVET is not without challenges. One significant hurdle is the digital divide, which exacerbates educational inequities. Access to digital tools and the internet remains uneven, particularly in developing countries, limiting opportunities for students and educators alike. Additionally, the rapid pace of technological change requires TVET institutions to adopt agile and responsive strategies. Traditional educational models, which often view learning as a one-time event, must evolve to accommodate lifelong learning and continuous upskilling. This shift is crucial for workers to remain relevant in an ever-changing job market (Magagula & Awodiji, 2024).

Another critical aspect of this integration is data privacy and the ethical use of AI. As AI technologies are increasingly employed in education and training, concerns about data security and algorithmic bias come to the forefront. Ensuring compliance with data protection regulations, such as the General Data Protection Regulation (GDPR), and fostering ethical AI practices are essential for building trust and credibility in AI-driven educational systems. TVET institutions must also address policy and institutional challenges, as many lack the resources and frameworks needed to implement these changes effectively. Collaboration with governments, industries, and international organizations will be key to overcoming