ISSN: 3067-8358
Research Article
Journal of Global Perspectives on Society, Culture, and Development

Empowering Vocational Education Through Generative AI: Building Green Skills and Digital Resilience for the Future Workforce

Ercan Küçükarslan

Mamak İlçe Milli Eğitim Müdürlüğü, Ankara, Türkiye

*Corresponding author: Ercan Küçükarslan, Mamak İlçe Milli Eğitim Müdürlüğü, Ankara, Türkiye.

Submitted: 29 October 2025 **Accepted:** 03 November 2025 **Published:** 10 November 2025

https://doi.org/10.63620/MKJGPSCD.2025.1030

Citation: *Küçükarslan, E. (2025). Empowering Vocational Education Through Generative AI: Building Green Skills and Digital Resilience for the Future Workforce. J of Glob Perspect Soc Cult Dev, 1(4), 01-04.*

Abstract

This paper examines the transformative potential of Generative Artificial Intelligence (GenAI) for vocational education and training (VET), with a focus on green skills and digital resilience. Drawing on empirical evidence from pilot implementations in Türkiye, particularly the AI4ALL Erasmus+ project, this study explores how GenAI can enhance curriculum design, adaptive learning, and teacher capacity building while addressing sustainability goals. The paper offers insights into methodological approaches, findings on personalization and sustainability integration, and concludes with policy recommendations for ethical and scalable GenAI adoption in VET systems.

Keywords: Generative AI, Vocational Education, Green Skills, Digital Transformation, Erasmus+, AI4ALL.

Introduction

Artificial Intelligence (AI) is rapidly redefining education worldwide, with Generative AI (GenAI) offering significant potential to transform vocational education and training (VET). As economies navigate the twin transitions of digitalisation and sustainability, there is an increasing urgency to align VET systems with evolving labor market demands for digital competence and green skills [1, 2].

Within this context, the AI4ALL Erasmus+ Strategic Partnership project (2021-1-PT01-KA220-VET-000033127) provides a central case study for this paper. AI4ALL aimed to democratize access to AI literacy and digital tools for VET learners and educators through the development of an open-source, multilingual platform designed for self-assessment and adaptive learning aligned with the DigComp framework [3]. This study explores how GenAI-enabled platforms such as AI4ALL can contribute to modernizing VET practice, advancing sustainability-focused curricula, and supporting the professional development of teachers in an ethically grounded, inclusive manner.

The Key Objectives of This Paper are to Examine

- How GenAI technologies can be integrated into VET curricula to meet emerging skills needs;
- The role of GenAI in enhancing learner engagement, digital competence, and sustainability awareness;
- The challenges and opportunities inherent in adopting GenAI solutions in diverse VET environments.

The Research is Guided by the Following Questions

1. How can GenAI support VET learners and educators in developing digital and green competencies?
2. What pedagogical innovations arise from GenAI-enabled platforms like AI4ALL?
3. What barriers exist for equitable, scalable, and ethical GenAI adoption in VET contexts?

By addressing these questions, this paper aims to contribute to the emerging literature on the digital transformation of VET and underscore the relevance of AI4ALL as an empirical case for advancing innovation, inclusion, and sustainability in vocational education.

Methodology

This study adopts a qualitative, exploratory research design to investigate the application of Generative AI (GenAI) in vocational education and training (VET). This approach is appropriate for

examining emerging educational innovations where theoretical frameworks and empirical evidence are still evolving [4]. Given the novelty of GenAI in VET, a qualitative method enabled rich, context-sensitive insights into the practicalities, challenges, and opportunities of implementation at institutional and classroom levels. The AI4ALL Erasmus+ project serves as the primary empirical case. AI4ALL aimed to democratize access to AI literacy and digital skills by piloting a multilingual, open-source AI management platform aligned with the European Dig Comp framework. The project provided a robust structure for examining GenAI in action, as it involved multi-country pilot testing, iterative development, and multi-stakeholder feedback cycles.

Primary Data Collection

Primary data were gathered from pilot initiatives coordinated by the Mamak District Directorate of National Education, Ankara, reflecting Türkiye's contribution to the AI4ALL partnership. A variety of qualitative data collection methods ensured depth and triangulation:

- Participant observation captured real-time educator and learner engagement with the AI4ALL platform in vocational classrooms. Observations focused on interaction patterns, ease of platform use, integration into teaching practice, and learner responsiveness [5].
- Semi-structured interviews were conducted with 12 VET instructors, 4 project managers, and 18 learners. Interview guides explored participants' experiences, perceived benefits, barriers encountered, and suggestions for improvement. This method allowed participants to share reflective accounts in their own words, facilitating a nuanced understanding of local contexts and conditions.
- Document analysis examined project deliverables including interim and final reports, feedback surveys, meeting minutes, and monitoring data, particularly drawing from the consolidated insights of the AI4ALL final report [5]. This enabled the inclusion of cross-national findings from other partner countries (Portugal, Italy, France, Greece, Spain) to contextualize local results within broader European experiences. Secondary Data and Analytical Framework Secondary data complemented the primary dataset by incorporating an analytical review of academic literature on AI in education DigComp framework documentation, and key European policy strategies promoting green and digital skills. These materials helped position the findings within relevant theoretical frameworks and policy objectives.

A thematic analysis approach was employed for data coding and interpretation, ensuring a systematic process of identifying recurring patterns and salient themes. Codes were generated inductively from the empirical material and subsequently organized into thematic clusters that reflected key areas of GenAI application:

- GenAI-enabled curriculum co-design, especially in sustainability-focused modules;
- Microlearning personalization, including AI-driven content sequencing and adaptive pathways;
- Teacher professional development, emphasizing digital competence acquisition and ethical AI awareness;
- Integration of green skills content into VET instruction, aligned with labor market and policy priorities.

Ensuring Rigor and Validity

The study applied triangulation across data types (observation, interviews, documents), participant groups (teachers, managers, learners), and contexts (Türkiye and partner countries), enhancing the internal validity of findings [6]. Reflective memos and peer debriefings were used throughout the analysis to mitigate researcher bias. Limitations included the exploratory scope of pilot studies, which may not generalize across all VET contexts, and varying levels of participant familiarity with AI tools, which influenced adoption experiences. Nevertheless, this multi-source, practice-based methodology ensures that findings reflect both local and European-level perspectives on GenAI's potential and challenges in transforming VET and provides a grounded understanding of how ethical, inclusive, and sustainable digital transformation can be realized in practice.

Findings and Discussion

The findings from this study illustrate how Generative AI (GenAI) enables multi-level transformation in vocational education and training (VET), particularly when deployed through a structured platform like AI4ALL. GenAI has the capacity to impact not only individual learning pathways but also institutional practice and policy alignment.

Curriculum Co-Design

GenAI tools significantly facilitated the development of modular, context-sensitive curricula, especially in addressing sustainability topics such as renewable energy, waste management, and circular economy principles. This mirrors OECD (2021) recommendations advocating for flexible, green-skills-oriented curricula in VET. Through AI4ALL, teachers could co-create content rapidly, increase relevance and localization, and adapt materials to sectoral needs, such as smart agriculture and energy-efficient construction.

Moreover, GenAI's natural language generation capabilities supported instructors in drafting lesson plans and assessment questions, reducing administrative workload and freeing time for learner-centered instruction. This pedagogical potential aligns with Zawacki-Richter, Marín, and Bond (2019), who argue that AI can enhance instructional innovation when integrated thoughtfully into curriculum design.

Microlearning and Personalization

A defining feature of AI4ALL was its adaptive microlearning approach, where content was delivered in digestible, interactive segments tailored to learner profiles. AI-driven personalization engines adapted learning sequences based on learners' progress, motivation, and performance, aligning with findings from Minn (2022) that personalized learning pathways improve learner engagement and knowledge retention.

Notably, pilot participants across Türkiye and partner countries reported that the platform's recommendation system effectively addressed different starting levels of digital competence, literacy, and confidence. This personalized scaffolding enabled previously underserved learners to progress at their own pace while maintaining motivation.

Teacher Capacity Building

Teacher development emerged as a critical enabler of successful

implementation. AI4ALL incorporated embedded professional development tools, including tutorials, interactive workshops, and digital competence self-assessments aligned with [7]. Teachers reported significant improvements in their ability to apply AI in instructional design and to critically reflect on AI's ethical dimensions, echoing the need for educator upskilling highlighted. These modules emphasized awareness of algorithmic bias, data protection, and privacy considerations, ensuring that teachers could anticipate unintended consequences such as biased content delivery or excessive learner monitoring. Importantly, this teacher training fostered both digital confidence and ethical sensitivity—necessary preconditions for sustainable adoption.

Green Skills Integration

GenAI was particularly effective in promoting green skill acquisition through scenario-based learning and interactive simulations that incorporated AI-generated environmental datasets. Learners engaged in practical exercises such as conducting virtual energy audits, optimizing irrigation systems, and analyzing waste management processes—thus gaining hands-on experience in sustainability-related problem-solving. These instructional practices support systems thinking competencies, which the European Green Deal and GreenComp frameworks identify as central to green jobs. The AI4ALL platform demonstrated a strong alignment between green transition policy goals and pedagogical innovation, enabling VET institutions to prepare learners for the labor market's evolving sustainability demands.

Challenges Identified

Despite these positive developments, several persistent challenges were reported by educators and learners across the pilots:

- Algorithmic bias: As Roh, Heo, and Whang (2021) emphasize, pre-trained AI systems occasionally embedded cultural assumptions that were not locally relevant or inclusive, necessitating careful oversight and manual content adaptation.
- Digital literacy gaps: Variation in digital readiness among teachers impacted uniform adoption, consistent with findings from Deursen and van Dijk (2014), who note that disparities in foundational digital skills can affect both uptake and pedagogical outcomes.
- Infrastructure disparities: Unequal access to reliable internet and updated devices remained a significant barrier to equitable implementation, reinforcing concerns highlighted by regarding the risk of exacerbating digital divides through technologically enhanced education.
- In addition, teachers expressed the need for ongoing professional support and community learning opportunities, highlighting that one-off training sessions were insufficient to build deep digital pedagogical competence or ethical awareness.

Overall, these findings closely align with feedback gathered in the AI4ALL final report, confirming that while GenAI holds strong potential to modernize VET and develop both digital and green competencies, robust, inclusive, and context-sensitive implementation strategies are essential. Successful adoption depends on not only technological infrastructure but also thoughtful policy alignment, sustained educator capacity-building, ethical oversight frameworks, and a commitment to digital equity. These findings suggest that future deployments of platforms like AI4ALL must adopt a whole-institution approach, ensuring that leadership, educators, and learners are collectively engaged in the design, implementation, and evaluation of GenAI-enhanced VET programs.

Conclusions

Generative AI (GenAI) presents unprecedented opportunities to revitalize vocational education and training (VET) by embedding sustainability, personalization, and innovation at both pedagogical and institutional levels. The findings from this study, drawn from the AI4ALL project, underscore how GenAI can serve as a critical enabler for modernizing curricula, enriching teacher practices, and empowering learners with essential green and digital skills.

Through platforms such as AI4ALL, GenAI has shown significant potential to accelerate both green skill development and digital resilience, aligning VET practices with broader policy frameworks such as the European Green Deal, the Digital Education Action Plan, the DigComp framework, and Türkiye's National AI [8, 9]. The AI4ALL pilots demonstrated that AI-supported instructional design allows for modular, adaptable curricula that can be rapidly localized and customized to sectoral needs — a capability that is increasingly important in preparing VET graduates for fast-changing labor markets.

This study confirms that successful GenAI integration requires more than just technological deployment. While AI-enabled tools can help educators design differentiated learning pathways and build digital competence system-wide, the results emphasize that these outcomes depend on educator preparedness, equity of access, institutional readiness, and robust ethical oversight. The human factors — teacher confidence, learner engagement, and leadership support — are equally critical to success. Policy Recommendations

Based on this Research, Several Clear Policy Recommendations Emerge

- The development of ethical AI integration frameworks aligned with EU and national policies, ensuring that GenAI adoption upholds fairness, transparency, and learner privacy.
- Investment in robust professional development programs for VET educators, building their digital competence, ethical awareness, and capacity to critically evaluate AI-supported pedagogies.
- Support for open-source, scalable platforms like AI4ALL, which can adapt flexibly to the needs of diverse learner populations while ensuring accessibility and inclusivity;
- Establishment of participatory governance mechanisms that engage educators, learners, policymakers, and civil society in co-creating frameworks for AI adoption in education, reflecting a shared understanding of priorities and challenges.

These recommendations reflect a growing consensus across the AI in education literature that inclusive, context-aware implementation is essential for achieving meaningful, equitable impact.

Future Directions

Looking ahead, future research must address key gaps in our understanding of GenAI's long-term impacts on learner outcomes, employability, and career progression. In addition, there

is an urgent need to study how GenAI influences educator roles and professional identity, particularly as teachers transition from content delivery to facilitation and guidance in AI-enhanced learning environments [10, 11].

This study also highlights the importance of examining how platforms such as AI4ALL can interoperate with emerging credentialing systems, including micro-credentials and Europass, and integrate with career guidance services to provide a seamless pathway from education to sustainable employment. Such interoperability would ensure that learners benefit from personalized, AI-supported learning pathways that remain relevant beyond formal education and into dynamic labor markets increasingly shaped by digital transformation and sustainability imperatives [12].

A critical priority is to ensure that GenAI-supported innovations remain human-centered and aligned with the values of inclusion, equity, and sustainability, consistent with UNESCO's (2022) guidance and the objectives of the European Green Deal [13].

In summary, this research confirms that while GenAI can play a transformative role in the modernization of VET systems, its successful adoption depends on carefully coordinated policies, educator empowerment, infrastructure readiness, and an unwavering focus on ethical and equitable education outcomes.

References

1. European Commission. (2020). Digital Education Action Plan 2021–2027: Resetting education and training for the digital age. Publications Office of the European Union. https://education.ec.europa.eu/focus-topics/digital-education/action-plan
2. OECD. (2021). Greening technical and vocational education and training (TVET): A practical guide. OECD Publishing. https://unevoc.unesco.org/up/gtg.pdf
3. European Commission. (2021). DigComp 2.2: The Digital Competence Framework for Citizens with new examples of knowledge, skills and attitudes. Publications Office of the European Union. https://joint-research-centre.ec.europa.eu/digcomp_en
4. Zawacki-Richter, O., Marín, V. I., Bond, M. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? International Journal of Educational Technology in Higher Education, 16(1), 39.
5. Al Braiki, B., Harous, S., Zaki, N., Alnajjar, F. (2020). Artificial intelligence in education and assessment methods. Bulletin of Electrical Engineering and Informatics, 9(5), 2085-2093.
6. European Commission. (2023). European Green Deal and the Pact for Skills: Skills for the green transition. https://ec.europa.eu/social/main.jsp?catId=1517&langId=en
7. Selwyn, N. (2019). Should robots replace teachers? AI and the future of education. Polity Press. https://research.monash.edu/en/publications/should-robots-replace-teachers-ai-and- the-future-of-education
8. UNESCO. (2022). AI and education: Guidance for policy-makers. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000376709
9. Ghomi, M., Redecker, C. (2019). Digital Competence of Educators (DigCompEdu): Development and evaluation of a self-assessment instrument for teachers' digital competence. ResearchGate. https://doi.org/10.5220/0007679005410548
10. Türkiye Ministry of Industry and Technology. (2021). National Artificial Intelligence Strategy (2021–2025). Presidency of the Republic of Türkiye Digital Transformation Office. https://dig.watch/resource/the-national-artificial-intelligence-strategy-2021-2025
11. Deursen, A. J. A. M., van Dijk, J. A. G. M. (2014). Measuring digital skills: From digital skills to tangible outcomes. University of Twente. http://dx.doi.org/10.13140/2.1.2741.5044
12. Minn, S. (2022). AI-assisted knowledge assessment techniques for adaptive learning environments. Computers and Education: Artificial Intelligence, 3, 100050. https://doi.org/10.1016/j.caeai.2022.100050
13. Roh, Y., Heo, G., Whang, S. E. (2021). A survey on data collection for machine learning: A big data–AI integration perspective. IEEE Transactions on Knowledge and Data Engineering, 33(4), 1328-1347.