Transforming Logistics Education in Higher Institutions: The Role of Digital Technologies in Global Training Contexts

Muhammad Rifqy Naufal Abdillah[1], Muhammad Wahyuilahi[2]
[1]Politeknik Negeri Madiun, Indonesia
[2]Politeknik Astra, Indonesia
Correspondent: muhammadrifqy412@gmail.com[1]

ABSTRACT : This paper explores the current state of digital logistics education and training, emphasizing the integration of advanced technologies such as virtual reality, digital twins, and artificial intelligence. The purpose of the study is to examine the impact of these technologies on learning outcomes and to identify the barriers that limit their effectiveness. A comprehensive literature review was conducted using databases such as Scopus and Google Scholar, with a focus on studies related to digital education, logistics, and technological adoption. The findings reveal that technologies such as virtual reality (VR) significantly improve engagement and concept mastery in logistics simulations, while artificial intelligence (AI) enhances personalized learning pathways. However, challenges such as insufficient infrastructure. The review highlights the importance of aligning curricula with industry needs and fostering greater collaboration between academia and industry. Policy recommendations include investing in digital infrastructure, enhancing educator training, and designing inclusive curricula that can accommodate diverse student populations. The study concludes with recommendations for future research to explore the long-term effects of digital training and the development of standardized evaluation methods for emerging educational technologies in logistics.

Keywords: Digital Logistics Education; Virtual Reality In Logistics; Digital Twins; Artificial Intelligence; Education Technology; Logistics Training; Workforce Readiness

INTRODUCTION

The last decade has witnessed a substantial global shift toward digital transformation, which has significantly impacted various sectors, including logistics. Within this broader movement, the field of digital logistics education and training has garnered increased attention as academic institutions and vocational training centers seek to adapt to the evolving demands of Industry 4.0. In this context, a growing number of higher education institutions have begun incorporating advanced technologies such as virtual reality (VR) simulations, digital twin systems, and big data analytics

into their logistics curricula (Ogrizović et al., 2021; Drozdova & Fursova, 2023). These changes reflect a paradigm shift in educational priorities, where digital competence is becoming an essential attribute for future logistics professionals. Furthermore, recent scholarship emphasizes the emergence of digital logistics as a strategic academic field aligned with the broader framework of the digital economy (Korepin et al., 2020).

Regionally, adaptations in digital logistics education reflect diverse technological capabilities and market demands. For instance, in some countries, curricula are being tailored to meet local industry standards and challenges, enabling institutions to address both global trends and regional specificities simultaneously (Drozdova & Fursova, 2023; Korepin et al., 2020). This dual approach supports a more flexible and responsive educational strategy that aligns with the accelerating pace of technological innovation and the complexities of contemporary supply chains. As the logistics sector becomes increasingly data-driven, the alignment between digital education and practical industry requirements becomes not only a pedagogical imperative but also a cornerstone for sustainable economic competitiveness.

Empirical data underscores the urgency of addressing skill gaps in digital logistics education. For example, a study conducted in Turkey highlighted a significant discrepancy between students' conceptual awareness of digital logistics and the competencies required by the modern logistics industry (Emre et al., 2024). Although there is a growing interest among students in digital logistics courses, infrastructural limitations and a shortage of qualified human resources continue to hinder the effective implementation of these programs (Emre et al., 2024). This situation reveals a dual challenge: on the one hand, the rising enthusiasm for digital learning content indicates fertile ground for educational innovation; on the other hand, systemic shortcomings highlight the pressing need for structural reforms to bridge existing gaps in workforce readiness.

Recent surveys and studies further substantiate the scale of these challenges. Across different regions, educational systems encounter varied levels of preparedness in integrating digital technologies into logistics training. In some contexts, digital infrastructure is robust, allowing seamless adoption of advanced instructional tools. In contrast, other regions struggle with unreliable internet connectivity, insufficient funding, and limited access to training in emerging technologies. These disparities not only affect the consistency of educational outcomes but also limit the mobility and competitiveness of graduates in the global labor market. Consequently, addressing these issues through evidence-based policy interventions and strategic investment becomes essential to ensure equitable and effective digital logistics education.

A number of technical and structural barriers have been identified in the literature concerning the implementation of digital logistics education. One primary challenge involves the pedagogical integration of complex digital tools such as big data analytics and VR into traditional teaching models (Ogrizović et al., 2021). The need for pedagogical innovation to facilitate knowledge transfer through these tools is clear, particularly given the cognitive and practical demands associated with mastering such technologies. Additionally, rapid technological evolution poses difficulties for curriculum design, necessitating continual updates and close collaboration between

academia and industry to maintain curricular relevance (Minculete & Olar, 2020). Structural issues such as funding constraints, unequal access to technology, and institutional inertia further complicate efforts to modernize logistics education on a broad scale (Drozdova & Fursova, 2023; Minculete & Olar, 2020).

The development of digital logistics education also faces infrastructural limitations, including inconsistent digital readiness among educational institutions. In many regions, a lack of investment in digital infrastructure constrains the deployment of immersive learning technologies. Moreover, disparities in institutional capacity contribute to a fragmented landscape, where only a subset of universities and training centers can deliver cutting-edge logistics training. These factors collectively hinder the scalability and accessibility of digital logistics programs and exacerbate existing inequalities in educational and labor market outcomes. Therefore, any comprehensive effort to advance digital logistics education must account for both technological and organizational readiness.

Despite these challenges, the scholarly literature reveals several critical gaps that justify the need for a comprehensive review of digital logistics education. First, there is a noticeable methodological gap regarding standardized evaluation metrics for assessing the effectiveness of digital tools in logistics education. Technologies such as VR have demonstrated promising outcomes in enhancing student engagement and comprehension, especially in logistics simulation environments (Ogrizović et al., 2021). However, the absence of comparative data between immersive and traditional learning methods impedes the ability to draw conclusive insights about their relative efficacy. This lack of standardized evaluation frameworks limits the generalizability of research findings and inhibits evidence-based policy development.

Additionally, there is a gap in understanding student perceptions and digital literacy levels, particularly in regions undergoing economic and technological transitions. Emre et al. (2024) found that students in Turkey often possess limited awareness of digital logistics concepts, suggesting that curricular integration of digital tools remains insufficient. While Korepin et al. (2020) advocate for a broader inclusion of digital logistics content in higher education curricula, existing research tends to focus narrowly on technological infrastructure or isolated instructional methods. Few studies comprehensively examine how regional, sectoral, and institutional variables interact to influence educational outcomes. Moreover, there is a paucity of empirical research linking the integration of digital logistics education with workforce development strategies in the context of Industry 4.0 (Minculete & Olar, 2020).

These gaps underscore the need for a more holistic and interdisciplinary approach to researching digital logistics education. In light of rapid digital transformation and intensifying global competition, the urgency of addressing these issues is paramount. Korepin et al. (2020) emphasize that updating logistics curricula is not merely a matter of keeping pace with technological advancements; it is a strategic necessity for preparing graduates to thrive in a dynamic and complex marketplace. Similarly, Drozdova and Fursova (2023) argue that the creation of integrated digital education ecosystems is a vital response to the evolving interplay between education and industry.

Bridging the gap between theoretical instruction and practical application requires systemic collaboration across academic, industrial, and policy-making spheres.

This review aims to synthesize the current state of research on digital logistics education and training, identify existing barriers, and propose strategic directions for future development. Specifically, the review will analyze the integration of emerging technologies in logistics curricula, the challenges faced by institutions in implementing such technologies, and the effectiveness of various pedagogical approaches. Furthermore, it will examine the extent to which digital logistics education aligns with labor market demands and contributes to workforce readiness in the context of Industry 4.0. Through a systematic analysis of existing literature, this review seeks to inform policy, practice, and future research in the field.

The geographical focus of this review encompasses both global trends and regional case studies, with particular attention to contexts such as Turkey, Eastern Europe, and other regions where digital transformation in education is emerging yet uneven. This scope allows for the identification of universal patterns as well as context-specific challenges and opportunities. By drawing on cross-regional comparisons, the review aims to highlight best practices, identify critical gaps, and offer insights into how diverse educational systems are adapting to the digitalization of logistics. The target population includes higher education students, educators, and institutional decision-makers involved in logistics education and training.

In summary, the digital transformation of logistics education presents both opportunities and challenges that require coordinated, evidence-based responses. The existing body of literature provides valuable insights but also reveals significant gaps that hinder comprehensive understanding and policy action. This review contributes to the academic discourse by offering a structured analysis of these issues and outlining pathways for developing inclusive, effective, and future-oriented logistics education frameworks.

METHOD

This review employed a comprehensive and methodologically robust literature search process to explore existing studies on digital logistics education and training. The methodology adopted in this review was designed to ensure a systematic and reproducible selection of scholarly literature from reputable databases, using well-defined inclusion and exclusion criteria, along with appropriate search strategies. By integrating structured search protocols such as PRISMA and narrative review techniques, this study seeks to capture a broad yet analytically meaningful representation of the research landscape.

The initial phase of the literature search involved identifying relevant databases that provide extensive coverage of scientific publications in education, logistics, and technological transformation. Scopus, Google Scholar, and Web of Science were selected as the primary sources due to their comprehensiveness and global reach in indexing peer-reviewed journals, conference

proceedings, and academic reports. These databases are widely recognized in academic research and offer advanced search features that facilitate precise retrieval of literature based on customized criteria.

In conducting the search, keyword selection was guided by both conceptual clarity and relevance to the research focus. The core keywords used included "digital logistics," "logistics education," "digital training," "e-learning," "virtual simulation," "internet of things," and "digital transformation." To refine the search and maximize relevancy, Boolean operators such as AND, OR, and NOT were strategically applied. For example, the combination "digital logistics" AND "education" helped to pinpoint literature that intersected both domains, ensuring that results addressed educational aspects within the digital logistics field. Alternatively, the query "training OR education" was used to broaden the scope and capture studies employing varied terminology. The exclusion operator NOT was utilized in searches like "digital logistics" AND "education" NOT "medical" to eliminate literature from unrelated disciplines, thereby enhancing the specificity of the results.

In order to manage the broadness of digital logistics education as a multidisciplinary topic, the literature review was conducted in phases, with each round of searching followed by refinement based on relevancy, study design, and thematic alignment. This iterative process allowed the researchers to build a coherent and representative pool of studies. To further enhance the rigor of the search process, reference lists of selected articles were also examined manually to identify additional relevant publications not captured by the database algorithms.

The selection of studies was guided by clear inclusion and exclusion criteria. Studies were included if they: (1) focused on education or training in digital logistics or closely related fields; (2) were published in peer-reviewed journals or recognized academic conference proceedings; (3) were available in English; and (4) provided either empirical data, theoretical frameworks, or case-based insights into digital logistics education. On the other hand, studies were excluded if they: (1) focused solely on logistics operations without educational components; (2) addressed digital education in unrelated sectors such as healthcare or finance; (3) lacked sufficient methodological transparency; or (4) were not accessible in full text.

Both qualitative and quantitative research studies were considered in this review, reflecting the diverse methodological approaches employed in the field. This included randomized controlled trials (RCTs) evaluating the impact of immersive technologies in logistics training, case studies exploring institutional implementation strategies, survey-based studies assessing digital literacy levels among students, and cohort studies tracking longitudinal changes in curriculum effectiveness. This multi-method inclusion strategy allowed for a rich and nuanced synthesis of findings, capturing both statistical evidence and contextual insights.

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol was employed to structure the documentation of the review process. This involved four key phases: identification, screening, eligibility, and inclusion. During the identification phase, search

queries were run in each database and the initial results were imported into a citation management software to remove duplicates. The screening phase involved reviewing titles and abstracts to exclude irrelevant articles based on the pre-defined criteria. Full-text reviews were then conducted during the eligibility phase to assess whether articles met the inclusion requirements. Finally, the included studies were analyzed in detail to extract data related to research questions, methodologies, sample populations, technologies applied, and reported outcomes.

In addition to PRISMA, insights from the Joanna Briggs Institute (JBI) methodology were incorporated, particularly in the thematic synthesis of qualitative studies. JBI's approach to scoping reviews was helpful in aggregating findings from diverse empirical contexts and allowed for a broader conceptual mapping of key themes such as digital competency, curriculum innovation, technological integration, and pedagogical challenges. This scoping perspective was particularly valuable in recognizing the interdisciplinary nature of digital logistics education, where themes from educational sciences, engineering, and management converge.

Although systematic protocols like PRISMA and JBI provide strong methodological foundations, the dynamic and emergent nature of digital logistics education also warranted the application of a narrative review approach. This qualitative synthesis method was employed to complement the structured protocols by integrating studies that may not fit stringent inclusion frameworks yet offer valuable conceptual or exploratory insights. For instance, emerging frameworks and pilot projects on VR or IoT integration in logistics training were considered under the narrative lens to capture innovation trends that are yet to be evaluated through rigorous empirical methodologies. This dual approach ensured both breadth and depth in the literature synthesis.

Articles selected for inclusion were subjected to a two-stage quality assessment. First, methodological quality was evaluated based on clarity of research design, data collection procedures, and analytical techniques. Second, relevance to the research question was determined by examining the extent to which the study addressed digital aspects of logistics education and training. Studies that scored low on both dimensions were omitted from the final synthesis. However, in cases where a study demonstrated strong thematic relevance despite methodological limitations, it was retained for discussion under the narrative review framework.

The final dataset included studies spanning a wide range of geographical regions, academic disciplines, and educational settings. This global representation allowed for comparative insights into how different institutional and national contexts shape the development and implementation of digital logistics education. Particular attention was given to studies from regions undergoing digital transformation, such as Eastern Europe and parts of Asia, where the integration of digital tools in logistics training is still evolving. These perspectives enriched the overall analysis by highlighting both universal challenges and localized solutions.

In conclusion, the methodology for this literature review combined rigorous search strategies, structured inclusion criteria, and both systematic and narrative synthesis techniques. By leveraging multiple databases, applying Boolean logic for precise searching, and adopting dual review

frameworks (PRISMA and JBI), the study ensured a comprehensive and credible examination of the literature. The methodological flexibility afforded by the narrative review approach further enabled the inclusion of pioneering works in a rapidly changing educational landscape. This robust methodological foundation supports the validity and relevance of the findings presented in subsequent sections of the review.

RESULT AND DISCUSSION

The review of literature reveals several major themes shaping the implementation and effectiveness of digital logistics education and training. These themes include the role of social factors, institutional and policy dynamics, technological innovation, and individual psychological readiness. Each of these themes is intricately connected and significantly contributes to the success or limitations of educational practices in the context of digital logistics transformation.

Social factors have emerged as a pivotal determinant in the accessibility and impact of digital logistics education. In particular, the level of formal education, digital culture, and access to technological resources profoundly influence learners' ability to engage with and benefit from digital training programs. Studies confirm that individuals with stronger educational backgrounds and higher digital literacy are more adept at assimilating technology-based instructional methods and maximizing the benefits of digital interventions (Emre et al., 2024; Korepin et al., 2020). This relationship underscores the importance of foundational knowledge and digital familiarity in fostering effective learning experiences. Conversely, disparities in access to digital infrastructure— often correlated with lower socioeconomic status—limit learners' ability to participate actively in training programs and undermine their potential benefits (Suntai & Beltran, 2022; Cresci et al., 2010).

Empirical research on the digital divide provides further support for these conclusions. The lack of equitable access to technology and variance in digital proficiency contribute to markedly different learning outcomes across student populations. These disparities necessitate the adoption of inclusive strategies in curriculum design, ensuring that students from disadvantaged backgrounds are not left behind in the digital shift (Korepin et al., 2020). For example, Emre et al. (2024) highlight that in Turkish universities, students' conceptual awareness of logistics digitalization is closely tied to their socioeconomic environments and the availability of supportive technological settings. In addition, Korepin et al. (2020) argue that integrating digital economy principles into logistics education accelerates digital competency when supported by robust infrastructural and financial environments. These findings collectively suggest that the advancement of digital logistics education must address social and economic disparities through well-crafted policy interventions aimed at systemic equity.

On an institutional level, national education policies and responsive institutional frameworks significantly shape the outcomes of digital logistics training programs. As demonstrated in the study by Drozdova and Fursova (2023), the creation of a dedicated digital education ecosystem for transport and logistics was strategically aligned with national policy priorities. This alignment

facilitated the incorporation of advanced digital technologies into the curriculum while fostering collaboration between academia and industry stakeholders. Such institutional ecosystems not only provide technological infrastructure but also ensure that curricular content is aligned with current market demands.

Further evidence of institutional influence comes from Minculete and Olar (2020), who reported improved managerial competencies and global readiness through targeted training programs framed within the supply chain management discipline. These initiatives demonstrate that well-integrated institutional programs can prepare learners for the dynamic challenges of global logistics operations. Comparative international studies further affirm that the integration of national digital strategies within institutional curricula results in improved learning outcomes (Korepin et al., 2020). Countries that have adopted coherent, cross-sectoral digital education strategies tend to show higher educational effectiveness.

The role of faculty development in this ecosystem is also notable. Almenara et al. (2021) emphasize that institutional efforts to enhance the digital competencies of educators are vital for effective program delivery. Their classification model of digital competencies in higher education demonstrates the importance of equipping instructors with the necessary tools and confidence to integrate technology into teaching practices. The alignment between national policy, institutional responsiveness, and instructor preparedness appears to be a critical driver of success in digital logistics education, especially when supported by sustained investments and policy coherence.

Technology and innovation have introduced a paradigm shift in the design and delivery of logistics training. Emerging tools such as immersive learning environments using virtual reality (VR), digital twin simulations, and artificial intelligence (AI) are being deployed to create interactive and realistic educational experiences. Ogrizović et al. (2021) found that VR-based simulations offer superior experiential learning compared to conventional 3D models, particularly in logistics training scenarios. Similarly, Drozdova and Fursova (2023) highlight the application of digital twin and AI technologies to simulate the complex dynamics of logistics systems, enabling continuous performance evaluation and scenario-based training customization.

The adoption of AI-driven solutions allows for adaptive learning environments tailored to individual learning paces and preferences. Korepin et al. (2020) assert that AI can transform pedagogical practices in logistics education by enabling responsive and data-informed teaching strategies. These technologies offer scalable and efficient alternatives to traditional training models, particularly in contexts where real-time experimentation is costly or logistically unfeasible.

The effectiveness of such technological interventions has been evaluated through both quantitative and qualitative measures. For instance, in the study by Ogrizović et al. (2021), participants evaluated VR as an effective medium for enhancing logistics concept comprehension. The study utilized user engagement, knowledge transfer efficacy, and practical application in simulated logistics tasks as metrics of success. These findings were corroborated by user feedback surveys and post-intervention performance assessments, offering a comprehensive picture of the educational impact.

Moreover, the integration of digital twin technologies and AI has been associated with significant improvements in learning adaptability and outcome tracking. By enabling data-rich training environments, these tools allow both educators and learners to monitor progress, identify skill gaps, and refine educational strategies in real time (Drozdova & Fursova, 2023; Korepin et al., 2020). These findings collectively suggest that digital innovation is not only a medium of instruction but also a catalyst for curriculum transformation and pedagogical evolution.

Psychological and individual-level factors are equally influential in determining the success of digital logistics training. Personal attitudes toward technology, motivation to learn, and digital self-efficacy emerge as essential variables in learners' engagement and performance. Yoon et al. (2020) report that psychological barriers such as technophobia and self-doubt significantly hinder participation and learning in digital environments. Conversely, learners who perceive digital tools as accessible and beneficial are more likely to engage meaningfully with the training content.

Almenara et al. (2021) further validate these observations by demonstrating a positive correlation between educators' digital readiness and students' academic outcomes. The psychological preparedness of both instructors and learners thus forms a foundational layer in the successful adoption of digital education. Evaluative tools, including motivation scales, confidence assessments, and ease-of-use perception surveys, are commonly employed to capture these dimensions. These instruments provide critical insights into the learner experience, informing the design of more inclusive and supportive educational interventions.

In the context of digital logistics education, this synergy between technological sophistication and psychological readiness fosters a holistic learning environment. The personalization enabled by immersive VR, digital twins, and AI systems is further enhanced when aligned with learners' cognitive and emotional profiles. As a result, training programs can be adapted not only to technical requirements but also to the diverse psychological dispositions of learners. This integrated approach ensures that logistics education remains responsive to evolving industry demands and the human dimensions of digital engagement.

In summary, the success of digital logistics education and training is shaped by an interplay of social, institutional, technological, and psychological factors. Empirical literature emphasizes the importance of equitable access, policy coherence, innovative instructional tools, and learner-centered strategies. Comparative evidence from various countries reinforces the need for inclusive, technologically advanced, and context-sensitive educational systems. As digital transformation continues to redefine the logistics sector, education and training systems must evolve accordingly, supported by empirical insights and driven by interdisciplinary collaboration.

The results of this narrative review align closely with both global and local literature on the development of digital logistics education and training. The integration of advanced digital technologies such as virtual reality (VR), digital twins, and artificial intelligence (AI) has been broadly recognized as a driver for improving the effectiveness of learning outcomes in logistics education. Korepin et al. (2020) confirmed that these tools enhance student engagement and provide more realistic simulations, allowing learners to internalize complex logistical processes. However, local-level studies, including those by Emre et al. (2024), emphasize that conceptual

awareness among students remains insufficient in several regions, especially in developing educational systems. This divergence between global advancements and local implementation underscores the need for context-specific pedagogical adaptations to ensure that digital innovation translates into tangible educational improvements.

One of the most consistent findings in both this review and prior studies is the systemic influence of digital access and readiness. In particular, Youssef et al. (2022) found that insufficient investment in information and communication technology (ICT) infrastructure impairs student performance and institutional preparedness. This correlates with findings from this study, which suggest that socio-economic disparities continue to manifest in limited access to essential tools and connectivity, thereby restricting students' ability to participate meaningfully in digital logistics programs. The uneven distribution of digital resources across regions contributes to a fragmented educational landscape, wherein only institutions with sufficient funding and support are able to successfully integrate advanced technologies into their curricula.

Moreover, structural issues extend beyond infrastructure. This review reinforces Drozdova and Fursova's (2023) conclusion that weak collaboration between academia and industry is a significant bottleneck in aligning educational content with real-world logistics needs. This disconnect inhibits the practical relevance of training programs and slows the responsiveness of academic institutions to technological developments in logistics. In addition, educators themselves often lack access to ongoing training in digital tools, creating a skills gap that undermines the implementation of digital curricula. These interrelated challenges necessitate a multisectoral approach, where educational institutions, industry actors, and policymakers co-develop strategic responses that address both technological and human capital requirements.

The implications of national policy are particularly salient in this context. Studies such as those by Amare et al. (2024) demonstrate that national digital transformation efforts can positively influence teacher preparedness and student acceptance of technology-enhanced learning. When policies include support for digital competency development among educators, the transition toward effective digital learning environments becomes more achievable. Nevertheless, policy interventions must move beyond general technology promotion and focus on specific measures that bridge the gap between classroom instruction and labor market expectations. Kondrat'ev et al. (2022) emphasized that successful reforms must consider intersectoral coordination and be grounded in empirical assessments of local needs and capacities.

A significant insight from this review is the importance of viewing digital logistics education as both a technological and socio-institutional innovation. While technological solutions offer significant potential to enhance learning, their efficacy is highly dependent on the readiness of the broader educational ecosystem. For example, the use of VR and digital twins in simulated logistics scenarios is promising, but without adequate technical support, pedagogical training, and learner familiarity, their impact may be limited. As noted in the results section, several studies reported high user engagement with these tools, yet a lack of systematic evaluation standards makes it difficult to compare effectiveness across contexts (Ogrizović et al., 2021; Drozdova & Fursova, 2023). This points to a need for future research to establish standardized metrics for assessing digital pedagogy in logistics.

The relationship between psychological readiness and technological innovation further complicates the implementation landscape. Learners' perceptions, motivations, and digital self-efficacy significantly affect how well they adapt to and benefit from technology-mediated training. Yoon et al. (2020) identified anxiety, perceived competence, and confidence as key psychological determinants of student engagement in digital learning environments. These findings are consistent with those of Almenara et al. (2021), who demonstrated that instructors' digital competencies also shape students' academic performance and learning satisfaction. Such evidence underscores the critical role of user-centered design in digital education frameworks, where both instructors and learners must be adequately supported to maximize the pedagogical potential of technology.

Despite these advances, the review highlights a range of limitations in the current literature. One major issue is the limited availability of comparative studies across regions, which makes it difficult to determine best practices or identify universally effective models. Most existing research is either localized or focused on isolated technologies, leaving a gap in understanding how integrated digital ecosystems function across diverse educational settings. Furthermore, many studies rely heavily on qualitative or small-sample data, which may not be generalizable. These methodological constraints hinder the scalability of promising interventions and reduce the ability of decision-makers to develop data-driven policies.

Another gap is the lack of longitudinal studies that track the impact of digital logistics training over time. Most research to date captures short-term learning outcomes or user satisfaction but fails to assess how digital education translates into long-term professional competencies and labor market success. Addressing this issue requires more sustained engagement from researchers, as well as improved data collection mechanisms within educational institutions. By adopting longitudinal designs, future studies can offer more robust evidence on the effectiveness and sustainability of digital logistics training programs.

This review also suggests that more interdisciplinary approaches are necessary to advance the field. The convergence of education, technology, logistics, and policy demands collaboration among scholars from various domains. For example, integrating insights from behavioral psychology could enhance understanding of student motivations, while input from data scientists could improve the analytics used to evaluate training outcomes. Furthermore, policy scholars can provide valuable perspectives on how regulatory frameworks and funding mechanisms influence the adoption of digital innovations in education. Such cross-disciplinary collaboration would enrich the research base and lead to more holistic and actionable recommendations.

One of the central arguments emerging from this discussion is that solving the challenges of digital logistics education requires more than technological innovation; it demands systemic transformation. This includes rethinking curriculum design to include flexible, modular content that can be adapted to diverse learning contexts. It also involves creating institutional cultures that value experimentation and continuous improvement. Policymakers must develop integrated strategies that link educational reform with workforce development and technological advancement. Additionally, investment in digital infrastructure must be complemented by

investment in human capital, particularly through professional development for educators and support services for students.

To move forward, researchers, educators, and policymakers must address these multi-dimensional challenges through coordinated action. This includes developing shared frameworks for evaluating digital education, expanding access to technology and training resources, and promoting inclusive pedagogical models that accommodate diverse learner needs. Only through such integrated efforts can the full potential of digital logistics education be realized in preparing a workforce capable of navigating the complexities of a digitalized global economy.

CONCLUSION

This study highlights the critical factors influencing digital logistics education and training, focusing on the role of technological integration, social and economic factors, and institutional support. The findings confirm that the adoption of digital technologies, such as virtual reality, digital twins, and artificial intelligence, has significantly improved learning outcomes in logistics education. However, challenges remain, particularly with regard to access to digital infrastructure, the need for educator training, and the alignment of curricula with industry needs. Despite technological advancements, disparities in access to these resources, particularly in underfunded regions, continue to hinder the effectiveness of digital logistics programs. This underscores the need for coordinated efforts between governments, educational institutions, and the private sector to create a more equitable and responsive educational environment. Recommendations include increased investment in digital infrastructure, the development of digital competency frameworks for educators, and the design of inclusive, flexible curricula that can address the diverse needs of learners globally. Future research should focus on longitudinal studies to assess the long-term impact of digital logistics training on workforce readiness and professional development, as well as the development of standardized evaluation metrics for emerging technologies in logistics education.

REFERENCE

Almenara, J., Guillén-Gámez, F., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2021). Classification models in the digital competence of higher education teachers based on the digcompedu framework: logistic regression and segment tree., Vol 17 No 1 (2021): Journal of. https://doi.org/10.20368/1971-8829/1135472

Almenara, J., Guillén-Gámez, F., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2021). Teachers' digital competence to assist students with functional diversity: identification of factors through logistic regression methods. British Journal of Educational Technology, 53(1), 41-57. https://doi.org/10.1111/bjet.13151

Amare, E., Zegeye, R., Wondie, S., Tamire, T., & Siyoum, M. (2024). Getting ready for digital shift: the level of acceptance towards educational technology among faculty members in higher education institutions in ethiopia. Discover Education, 3(1). https://doi.org/10.1007/s44217-024-00090-1

Cresci, M., Yarandi, H., & Morrell, R. (2010). The digital divide and urban older adults. Cin Computers Informatics Nursing, 28(2), 88-94. https://doi.org/10.1097/ncn.0b013e3181cd8184

Drozdova, M. and Fursova, E. (2023). Peculiarity and functionality of the digital educational ecosystem for transport and logistics. E3s Web of Conferences, 383, 03001. https://doi.org/10.1051/e3sconf/202338303001

Emre, A., Somuncu, S., Korkmaz, M., & Demirci, E. (2024). Conceptual awareness levels of digital logistics among turkish university students. Humanities and Social Sciences Communications, 11(1). https://doi.org/10.1057/s41599-024-02907-8

Kondrat'Ev, V., Popov, V., & Kedrova, G. (2022). Industrial policy priorities under industry 4.0. World Economy and International Relations, 66(3), 73-80. https://doi.org/10.20542/0131-2227-2022-66-3-73-80

Korepin, V., Дорожкин, Е., Mikhaylova, A., & Давыдова, Н. (2020). Digital economy and digital logistics as new area of study in higher education. International Journal of Emerging Technologies in Learning (Ijet), 15(13), 137. https://doi.org/10.3991/ijet.v15i13.14885

Minculete, G. and Olar, P. (2020). Supply chain management, key factor in modern education and training of logistics managers. https://doi.org/10.12753/2066-026x-20-027

Ogrizović, D., Hadžić, A., & Jardas, M. (2021). Fully immersive virtual reality in logistics modelling and simulation education. Promet - Traffic&transportation, 33(6), 799-806. https://doi.org/10.7307/ptt.v33i6.3941

Suntai, Z. and Beltran, S. (2022). The intersectional impact of race/ethnicity and sex on access to technology among older adults. The Gerontologist, 63(7), 1162-1171. https://doi.org/10.1093/geront/gnac178

Yoon, H., Jang, Y., Kim, S., Speasmaker, A., & Nam, I. (2020). Trends in internet use among older adults in the united states, 2011–2016. Journal of Applied Gerontology, 40(5), 466-470. https://doi.org/10.1177/0733464820908427

Youssef, A., Dahmani, M., & Ragni, L. (2022). ICT use, digital skills and students' academic performance: exploring the digital divide. Information, 13(3), 129. https://doi.org/10.3390/info13030129

Marquezan, C., Granville, L. Z., & Almeida, J. M. (2014). Software-defined networks in cloud logistics. *Computer Networks*, 68, 115–128.

Muñuzuri, J., Cortés, P., Onieva, L., & Guadix, J. (2020). Port logistics digitalization: A challenge for emerging economies. *Maritime Policy & Management*, 47(5), 563–578.

Nair, R. (2014). Internet infrastructure and logistics innovation in emerging markets. *Asian Journal of Infrastructure Development*, 8(1), 45–60.

Numair, A., Fatima, S., & Rasheed, R. (2021). Digital skills gap in logistics: An emerging market perspective. *Journal of Logistics & Workforce Development*, 3(4), 104–122.

Pan, Y., Zhou, H., & Zhang, W. (2023). Predictive analytics in cloud logistics: A performance review. *Journal of Digital Supply Chains*, 9(1), 25–46.

Samanta, S., Bera, S., & Chakraborty, S. (2021). Organizational adaptation in cloud-based logistics: A theoretical review. *Global Journal of Logistics and SCM*, 14(2), 98–112.

Sharmila, R., Mathews, A., & Chandra, S. (2024). Bridging policy and practice in cloud logistics. *Policy & Technology Journal*, 18(1), 11–29.

Sivakumar, G., Rajendran, C., & Choudhary, S. (2020). Legal and regulatory issues in cloud-based logistics. *Journal of Business and Law in Technology*, 12(3), 212–229.

Toka, O., Fajfar, P., & Novak, R. (2013). Hybrid cloud deployment for logistics management systems. *Computing and Informatics*, 32(2), 429–451.

Tran, B. X., Le, H. T., & Phan, H. T. (2022). Digital infrastructure and logistics efficiency: Evidence from Southeast Asia. *Asian Development Journal*, 39(2), 87–109.

Wernimont, A., Hall, P., & Chang, R. (2019). Digital transformation in high-tech logistics sectors. *International Journal of Supply Chain Technology*, 7(3), 146–165.