

Practical Training Based on Robotics for Future Supply Chain Specialists

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ABSTRACT

Objective: This study investigates the role of robotics in logistics education by developing a practice-oriented training model that equips students with the technical and professional competencies required for future supply chain environments, addressing the increasing digitalization of logistics processes and the demand for automation. **Method:** A practice-driven design was applied to create a robotics-assisted learning framework for logistics students, incorporating warehouse robotics, simulation tools, and interactive platforms that support hands-on activities, with data collected through student performance assessments, structured observations, and surveys, while emphasizing experiential learning, problem-solving exercises, and teamwork activities aligned with real-world logistics operations. **Result:** Findings show that students engaged in robotics-based training developed stronger abilities to manage automated workflows, interpret logistics processes, and apply theoretical concepts in practice, while participants demonstrated higher engagement, increased motivation, and improved collaboration compared to traditional lecture-based formats. **Novelty:** The integration of robotics into logistics education provides a promising pathway for developing supply chain specialists who are adaptable to emerging technologies, fostering both technical skills and critical thinking, and enabling learners to actively contribute to the advancement of smart and efficient supply chain systems.

INTRODUCTION

In the era of digital transformation, the logistics sector is experiencing rapid automation, digitalization, and the adoption of intelligent technologies. Supply chain systems are increasingly relying on robotics, artificial intelligence (AI), and simulation models to ensure efficiency, precision, and sustainability. Consequently, higher education institutions are required to integrate innovative pedagogical tools to prepare future supply chain specialists who can adapt to these emerging trends.

The importance of robotics in logistics education lies in its ability to combine theoretical knowledge with practice-oriented learning. By utilizing robotic simulators, warehouse automation models, and interactive digital platforms, students can gain first-hand experience of complex logistics processes. Such an approach not only enhances technical competencies but also develops critical thinking, teamwork, and problem-solving skills, which are essential in real-world supply chain management [1], [2].

Several studies emphasize that robotics-assisted education significantly improves students' engagement and motivation compared to traditional lecture-based methods. For instance, interactive systems that employ simulation tools have been shown to increase learners' understanding of logistics workflows and enable them to apply theoretical knowledge more effectively [3], [4]. Other researchers highlight that robotics-

based curricula provide students with exposure to smart warehouse systems and automated material handling, preparing them for Industry 4.0 requirements [5], [6].

Moreover, the role of artificial intelligence in combination with robotics has been investigated for designing adaptive learning environments. Such systems can personalize the training process, offer real-time feedback, and evaluate students' knowledge dynamically [7], [8]. Buronova et al. [9] have explored the integration of AI with robotics in educational contexts, emphasizing its potential for enhancing both cognitive and practical skills of learners. This indicates that the synergy of robotics and AI-driven pedagogy can be particularly effective in logistics education.

In addition, international research has demonstrated that simulation-driven logistics training supports professional development by replicating real-world supply chain scenarios in virtual settings. These approaches foster active participation, collaborative problem-solving, and scenario-based learning, all of which contribute to preparing highly qualified specialists for the demands of smart supply chains [10]-[13]. Studies in Uzbekistan and Central Asia further underline the growing necessity of incorporating robotics into the national higher education curriculum, aligning it with global standards and the needs of the modern labor market [14], [15].

Therefore, this study aims to design and validate a robotics-based practical training framework tailored for logistics education. The system not only provides hands-on experience but also enhances students' readiness to work in automated supply chain environments. Through this approach, future specialists will be better equipped to contribute to the development of intelligent, technology-driven logistics systems.

RESEARCH METHOD

This research employed a practice-oriented methodology designed to integrate robotics into logistics education and evaluate its effectiveness in preparing students for future supply chain environments. The method was structured into four key stages: system design, implementation, data collection, and evaluation.

A robotics-assisted training framework was developed, combining warehouse automation models, robotic simulators, and interactive digital learning platforms. The framework aimed to replicate real-world logistics processes, including automated material handling, inventory management, and order fulfillment. The design emphasized experiential learning by allowing students to interact directly with robotic systems and simulation environments.

The proposed framework was piloted within logistics courses at the undergraduate level. A group of students was selected to participate in the experimental program, while another group continued with traditional lecture-based instruction to serve as a control group. During the implementation phase, students were engaged in practical tasks such as programming simple robotic workflows, operating simulation-based warehouse models, and solving scenario-driven supply chain challenges.

Multiple instruments were used to collect data:

- a. Classroom observations to monitor student engagement and interaction with robotic systems.
- b. Student feedback surveys to capture perceptions of learning effectiveness, motivation, and usability of the platform.
- c. Performance assessments including problem-solving tasks, teamwork activities, and knowledge application exercises to measure skill acquisition.

The collected data were analyzed using both quantitative and qualitative methods. Quantitative evaluation focused on comparing academic performance and task completion rates between the experimental and control groups. Qualitative evaluation involved thematic analysis of student feedback to identify strengths, challenges, and potential improvements in the system. This dual analysis provided a comprehensive view of how robotics integration influences learning outcomes in logistics education.

All participants were informed about the purpose of the study and provided consent prior to involvement. The study adhered to institutional research ethics guidelines, ensuring voluntary participation and confidentiality of data.

RESULTS AND DISCUSSION

The evaluation of the robotics-assisted training system revealed clear differences between the experimental group (students trained with robotics) and the control group (students trained through traditional lectures).

As shown in Figure 1 and Table 1, students in the experimental group achieved an average score of 85%, compared to 68% in the control group. Furthermore, teamwork and collaboration ratings were notably higher in the experimental group (4.5 out of 5) than in the control group (3.2 out of 5). These results confirm that robotics-based learning significantly improves knowledge acquisition and teamwork competencies.

Classroom observations indicated that students engaged in robotics-based activities showed stronger motivation and enthusiasm during problem-solving tasks. Feedback surveys revealed that participants appreciated the practical nature of the system, which allowed them to connect theoretical logistics concepts with real-world applications. Students also highlighted that the interactive platform improved their confidence in operating automated systems.

The findings are consistent with previous studies [9-12], which emphasize the benefits of integrating robotics and simulation into logistics curricula. The improved performance of the experimental group demonstrates that robotics not only enhances academic outcomes but also cultivates skills required in Industry 4.0 and future supply chain environments. These results underline the potential of robotics-based learning to serve as an effective pedagogical strategy in logistics education.

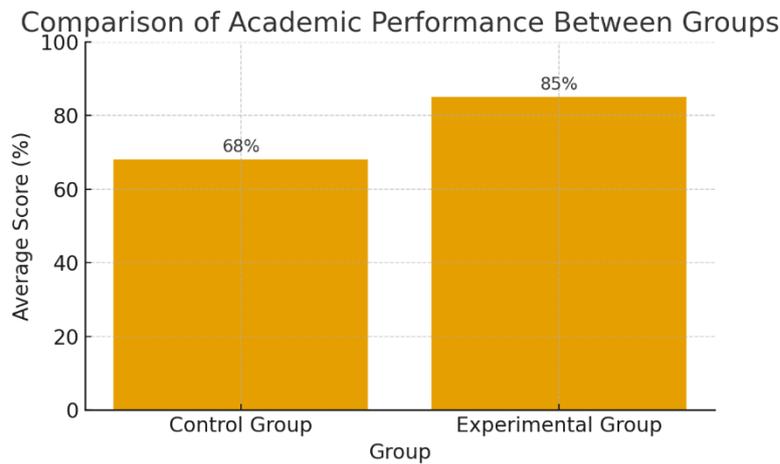


Figure 1. Comparison of Academic Performance Between Groups.

The bar chart shows higher performance of the experimental group in terms of average score.

Table 1. Academic Performance and Teamwork Comparison.

Group	Average Score (%)	Teamwork Rating (1-5)
Control Group	68	3.2
Experimental Group	85	4.5

CONCLUSION

Fundamental Finding : This study set out to investigate the effectiveness of robotics-assisted learning in logistics education, demonstrating that the integration of robotics and interactive simulation into the curriculum leads to higher academic performance, stronger engagement, and improved teamwork compared to traditional lecture-based instruction, while enhancing students’ theoretical understanding of logistics processes and equipping them with practical skills needed to operate and manage automated systems. **Implication :** The experimental results indicate that students gained valuable problem-solving abilities and collaborative competencies, essential for modern supply chain management, validating the proposed training framework as a model for aligning academic programs with technological advancements in Industry 4.0 and supporting digital transformation in logistics education. **Limitation :** Despite these benefits, the study is limited by the scale of the sample and the short-term observation period, which may not fully capture long-term impacts on professional competencies and adaptability in real-world supply chain environments. **Future Research :** Future studies should expand to larger student groups, integrate artificial intelligence for adaptive learning, and evaluate the long-term impact of robotics-based training on professional careers, ensuring that embedding robotics into logistics curricula provides a sustainable pathway for developing highly qualified specialists ready to contribute to intelligent and technology-driven supply chains.

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