European International Journal of Pedagogics (ISSN: 2751-000X)

Received: 26 March 2026 | Accepted: 23 April 2026 | Published: 09 May 2026

DOI: 10.55640/eijp-06-05-05

RESEARCH ARTICLE

Methodology for Preparing Future Engineers for Professional Activities Based on Digital Logistics Systems

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VOLUME: Vol.06 Issue05 2026

PAGE: 21-26

Abstract

This thesis develops a methodological model for preparing future engineers for professional activities based on digital logistics systems. The study highlights ways to integrate logistics 4.0, digital education, WMS, TMS, ERP, IoT, RFID, GPS monitoring, business analytics, and simulation tools into the educational process. The proposed methodology is aimed at bringing theoretical knowledge closer to real logistical processes, strengthening project tasks in self-study, and developing students' competencies in data management, decision-making, security, and professional communication. As a result, it will be possible to train engineers who know digital technologies, think systematically, and are capable of analyzing logistics processes in production conditions.

KEYWORDS

Digital logistics, Logistics 4.0, WMS, TMS, ERP, IoT, RFID, professional competence, engineering education, simulation, self-study.

INTRODUCTION

At the current stage, transportation, production, and supply chain processes are managed based on digital platforms. Acceptance of orders, inventory control, planning of warehouse operations, optimization of transportation routes, real-time monitoring of cargo movement, and evaluation of final KPI indicators are moving into a single integrated information environment. Therefore, in higher education, preparing future engineers not only for theoretical logistics concepts but also for working in digital logistics systems has become a pressing issue.

In the context of Uzbekistan, this issue is also directly related to state policy. The "Digital Uzbekistan - 2030" Strategy defines tasks for the accelerated digital development of economic sectors, the social sphere, and public administration, including the development of digital education and digital infrastructure [1]. Consequently, the content of engineering education must be updated in accordance with the requirements of the digital economy.

International experience also indicates the digital transformation of logistics as one of the main directions of development. In the World Bank's LPI data, supply chain speed, connectivity, and reliability are considered important indicators for assessing logistics efficiency [2]. According to the LPI 2023 findings, end-to-end digitalization is significantly reducing port delays, especially in emerging economies [3]. This situation requires the systematic integration of knowledge and skills in digital logistics into the higher education process.

Purpose and objectives of the research

The aim of the research is to develop a methodology for preparing future engineers for professional activity based on digital logistics systems and to substantiate the didactic conditions for its application in the educational process.

To achieve this goal, the following tasks have been defined: determining the role of digital logistics systems in professional training; defining the composition of competencies necessary for a future engineer; Development of training modules based on the use of WMS, TMS, ERP, IoT, RFID, GPS monitoring, and analytical platforms; linking independent study and practical sessions with the project-simulation method; proposing a system of criteria and indicators for assessing competencies.

Content of digital logistics systems

Digital logistics is a system aimed at coordinating material flow, information flow, and financial flows based on real-time data. Its main components include resource planning via ERP, warehouse process management via WMS, transportation and route control via TMS, cargo and vehicle tracking via IoT/RFID/GPS, and data analysis via BI/AI. Systematic analyses on Intelligent Warehouse show that Industry 4.0 solutions - IoT, RFID, visual technologies, automated vehicles, and real-time backup data - play a crucial role in warehouse processes [4].

Training in digital logistics systems develops broader competencies in students than simple "computer usage" skills. In this process, students learn to collect, sort, and analyze data, assess logistics costs, plan warehouse capacity, select transport routes, identify risks and delays, and justify digital system results as engineering solutions.

Table 1. Digital logistics systems and the professional competencies being formed

Digital system	Main function	A skill formed in a student	Sample practical assignment
ERP	Enterprise resource planning in a unified system	linking material and financial flows	building an order-reserve-cost chain
WMS	Manage warehouse acceptance, placement, and shipment	calculating reserves, positioning, and rotational speed	Compiling a warehouse plan based on ABC/XYZ analysis
TMS	Transportation planning and route optimization	assessment of distance, time, fuel, and delay	selecting the most optimal delivery route
IoT/RFID/GPS	Real-time tracking of cargo and vehicle status	monitoring, identification and security control	Modeling cargo movement using an RFID tag
BI/AI analytics	Visual analysis and forecasting of data	KPIs, dashboard, forecast, decision-making	preparing a dashboard on logistics costs

Methodological model and didactic approach

The core idea of the methodology is to integrate the sequence "theory + digital tool + real problem + project result + assessment" into the educational process. In this case, the teacher is not a person who provides information, but a methodological leader who organizes the process, poses a problem, guides the selection of digital tools and evaluates the result. The student, on the other hand, becomes an active subject who analyzes the digital logistics problem, develops a solution, and defends the decision, rather than merely returning ready-made information.

Scientific literature notes that practical projects and laboratory prototypes are effective in teaching Logistics 4.0 concepts. For example, Belmonte et al. proposed an approach to using WMS and low-cost laboratory prototypes in teaching engineering students Logistics 4.0 skills [5]. Pacheco-Velazquez et al. have shown that in Industry 4.0 logistics, simulation platforms create a safe experimental environment, developing decision-making and complex systems thinking [6].

The proposed methodological model consists of the following stages: 1) selection of a real logistics problem in professional activity; 2) identifying the necessary digital tools for the problem; 3) divide students into small groups and give them a project assignment; 4) data collection and entry into the digital platform; 5) analysis of KPI results; 6) comparison of alternative options; 7) defense of the final decision; 8) rubric-based evaluation and feedback.

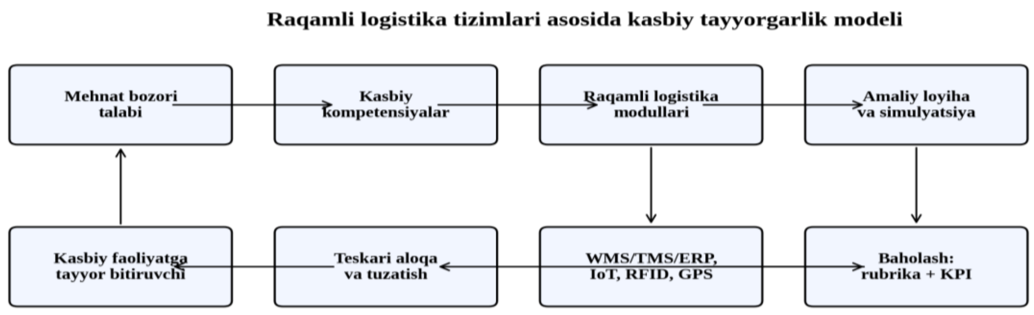

Figure 1. Professional training model based on digital logistics systems

Educational modules and practical assignments

The methodology is organized based on a five-module structure. The first module is dedicated to the concepts of digital logistics and information flows. The second module covers modeling of WMS and warehouse processes.

Table 2. Content of training modules on digital logistics

Module	Topic content	Digital tool	Independent work	Result
1.	Digital logistics and information flows	ERP Conceptual Framework	drawing the company's order chain	process map
2.	Warehouse operations and inventory control	WMS, QR/RFID	marking warehouse zones	warehouse model
3.	Transportation and route optimization	TMS, GPS	Compare 3 routes	the most optimal option
4.	Supply chain integration	ERP + WMS + TMS	data exchange schedule	integration scheme
5.	Analytics and decision making	Excel/Power BI/AI	Create KPI dashboard	reporting and protection

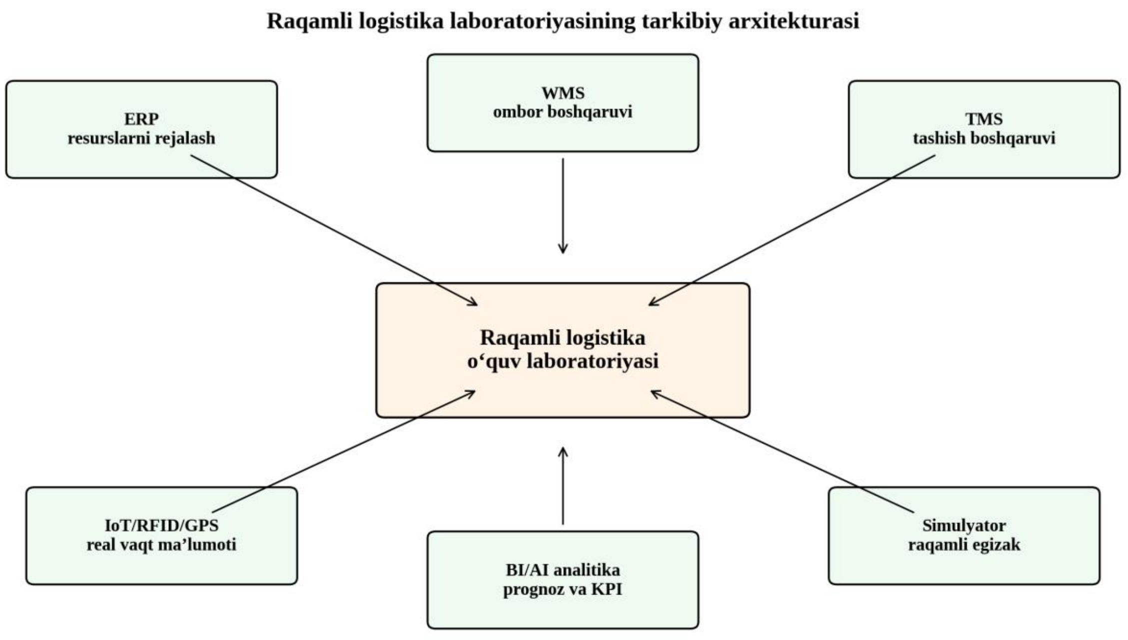

Figure 2. Structural architecture of the digital logistics training laboratory

The third module will focus on TMS, GPS monitoring, and optimization of transport routes. The fourth module teaches ERP and supply chain integration. The fifth module will focus on BI/AI, dashboards, and decision-making mechanisms. At the end of each module, the student will complete a small practical project.

Criteria for assessing professional competence

Based on digital logistics, the result of training should not be limited to a simple test. Because in this process, multi-component results are formed, such as knowledge, practical skills, the use of digital tools, teamwork, and decision justification. Therefore, the rubric, project defense, practical assignment, electronic portfolio, and KPI indicators are used together in the assessment. UNESCO also notes the importance of using AI, big data, and digital platforms to adapt VET systems to labor market requirements [7].

The proposed valuation formula is expressed as follows: KTF = 0.25Kraq + 0.20Kana + 0.20Klog + 0.15Kloy + 0.10Kkom + 0.10Krisk. Where KTF is the final percentage of professional training; Kraq - the use of digital systems; Kana — analytical thinking; Klog - understanding the logistics process; Chloe - project result; Kkom - communication and teamwork; Risk is an indicator of information security and an ethical approach.

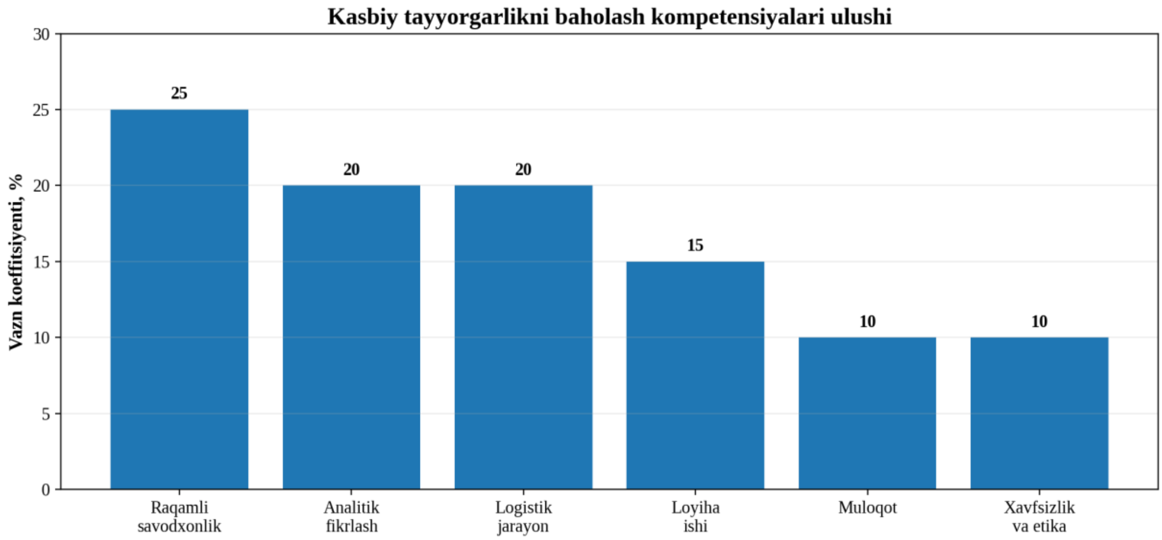

Figure 3. Proportion of assessments for the proposed competencies

Table 3. Competencies Assessment Rubric

Criterion	Low level	Intermediate	High level
Use digital system	works only with ready-made instructions	performs main operations independently	adapts the system to the problem
Analytical thinking	can't explain the result	analyzes the main KPIs	makes a decision by comparing alternative options
Project work	the solution is incomplete	the solution partially meets practical requirements	the solution is close to production conditions
Communication	the report is messy	the report is clear	reporting, defense, and proof are perfect

Conditions for the implementation of the Methodology

To effectively implement the methodology, the share of practical hours related to digital logistics in curricula will be increased first and foremost. Secondly, a virtual or real educational laboratory will be organized at the department. Thirdly, in cooperation with enterprises, case studies will be prepared based on real data. Fourth, students' independent work is performed not as a simple abstract, but in the form of a small digital project. Fifth, the results are evaluated through the competence rubric.

This approach is particularly useful for engineers studying in the fields of transport, highways, construction, manufacturing, and supply chains. Because the professional activity of an engineer is no longer limited to technical drawings or calculations; he must also deal with real-time data, logistics costs, rational use of resources, and environmental and safety requirements. Therefore, digital logistics systems enhance an engineer's systematic thinking and professional flexibility.

Expected results

The introduction of the proposed methodology into the educational process leads to the following results: increasing the digital literacy of future engineers; strengthening a systematic approach to logistics processes; developing practical decision-making skills in warehousing, transportation, and supply chains; increasing the effectiveness of independent learning; creating an educational environment close to professional activity based on project and simulation; and accelerating the adaptation of graduates to the labor market. The IntechOpen source also emphasizes the need to include practical technological training, simulation, and real project work in logistics higher education curricula [8].

CONCLUSION

• Digital logistics systems are an important methodological tool in engineering education that connects theoretical knowledge with real production processes.

• WMS, TMS, ERP, IoT, RFID, GPS monitoring, and BI/AI analytics tools comprehensively develop digital, analytical, and organizational competencies in students.

• Since the proposed methodology is organized based on practical projects, simulations, case studies, and electronic portfolios, it increases the effectiveness of independent learning.

• When assessing professional training, it is advisable to use rubrics, KPIs, project defense, and practical result indicators alongside the test.

• The Digital Logistics Laboratory creates a safe, controlled, and close to a real professional environment for future engineers.

• The practical significance of the methodology lies in the fact that it serves to prepare graduates in accordance with the requirements of the digital economy, transport and logistics enterprises, and the production supply chain.

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