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CURRENT PROBLEMS AND PROSPECTS OF INFORMATION TECHNOLOGY IMPLEMENTATION IN HIGHER EDUCATION INSTITUTIONS OF CONSTRUCTION AND TRANSPORT

MAMMADOV M., doctor of Economic Sciences, professor, Azerbaijan University of Architecture and Construction, Ayna Sultanova st., 11, Baku, Azerbaijan.

E-mail: m.m.asirli@ mail.ru, ORCID 0000-0002-5327-2507.

TAGHİYEVA T., PhD, teacher, Azerbaijan State Oil and Industry University, Azadlig avenue, 34, Baku, Azerbaijan.

E-mail: turantagiyeva1225@gmail.com, ORCID 0000-0003-3982-1319.

TALIBZADEH S., Head of ICT Department, doctoral student, Azerbaijan University of Architecture and Construction, Ayna Sultanova st., 11, Baku, Azerbaijan.

E-mail: sw@azmiu.edu.az, ORCID 0000-0002-4591-6325.

MAMMADOV T., higher education student, University of Minnesota, 15th Ave. S.E., 319, Minneapolis, MN 55455, United States of America.

E-mail: tomik20072072@gmail.com, ORCID 0009-0001-7961-6291.

Abstract. *The implementation of information technologies (IT) in higher education institutions of construction and transport has emerged as a critical factor in enhancing educational quality, institutional efficiency, and graduate competitiveness. Despite the significant potential of digital solutions, universities in these sectors face multiple challenges, including outdated IT infrastructure, limited financial resources, insufficient digital competencies among faculty and students, and resistance to organizational change. Specialized professional training in construction and transport further requires advanced modeling tools, simulation platforms, and sector-specific digital resources, which complicates the adoption of innovative IT solutions. Global experiences demonstrate the effectiveness of IT governance frameworks such as COBIT, ITIL, and CMMI in standardizing processes, increasing transparency, and ensuring continuous improvement. Emerging technologies–including big data analytics, learning analytics, virtual and augmented reality (VR/AR), building information modeling (BIM), digital twins, cloud services, and artificial intelligence (AI)-based tools–offer substantial opportunities to improve academic outcomes and operational efficiency. In the Azerbaijani context, progress has been observed in LMS adoption, blended learning, and administrative digitization; however, persistent barriers include uneven regional infrastructure, limited budgets, and scarce empirical evidence on IT governance in technical universities. Addressing these issues requires integrated strategies combining technological investment, faculty development, organizational reforms, and industry–university partnerships. Priority measures include establishing pilot projects for ITIL/COBIT implementation, developing specialized digital laboratories, embedding sector-specific digital competencies into curricula, and aligning national initiatives with global frameworks such as the UN Sustainable Development Goals and the EU Digital Education Action Plan. The study underscores the need for systematic evaluation of IT maturity and governance in construction*

and transport higher education, highlighting the importance of evidence-based approaches to digital transformation. Effective IT adoption in these specialized institutions necessitates a holistic approach that integrates infrastructure modernization, human capacity building, governance enhancement, and sectoral alignment to ensure sustainable development and prepare graduates for the demands of the digital economy.

Key words: *information technology implementation, higher education, construction universities, transport universities, digital transformation, IT governance, digital competencies, educational technologies, Industry 4.0/5.0, learning analytics.*

Introduction. In recent years, the implementation of information technologies (IT) in higher education has become a key factor in ensuring the quality and competitiveness of educational services. Systematic research demonstrates that the integration of IT into teaching, learning, and management processes contributes to improving accessibility, flexibility, and efficiency of education. However, despite the significant potential of digital solutions, the process of IT implementation in higher education institutions, particularly in the construction and transport fields, faces a number of complex challenges.

Among the most pressing issues are outdated information and communication infrastructure, insufficient financial resources, limited digital competencies of academic staff and students, and resistance to organizational change. These barriers slow down the digital transformation of universities and restrict their ability to fully benefit from modern technological opportunities. In addition, the persistence of traditional "legacy" systems in many institutions creates compatibility problems and complicates the integration of innovative platforms. As a result, inefficiencies arise in administrative and academic processes, reducing overall institutional productivity.

It is important to note that similar problems were observed in the early stages of digital transformation in developed countries, where consistent and targeted measures were implemented to modernize infrastructure, strengthen digital skills, and adapt management systems. In the context of construction and transport education, the challenges become even more specific, as professional training in these fields requires advanced modeling tools, simulation platforms, and specialized digital resources. Therefore, overcoming existing barriers and adopting innovative IT solutions are necessary conditions for ensuring the sustainable development of higher education institutions, improving the

quality of professional training, and meeting the requirements of the modern labor market.

Analysis of recent researches and publications. The digital transformation of higher education has become a central focus in recent years, particularly in response to global demands for flexibility, quality, and competitiveness. Reports such as the OECD Digital Education Outlook 2023 highlight that while significant progress has been made in establishing digital education ecosystems, persistent challenges remain in infrastructure, governance, teacher and student digital competencies, and equitable access [1]. Furthermore, comparative surveys of OECD member states reveal that many national strategies lack clear frameworks for assessing digital readiness and implementation, which complicates systematic evaluation of progress [2].

In the field of construction and transport education, several sector-specific studies provide important insights. Longitudinal research on e-learning in construction management demonstrated that digital platforms improve student knowledge and engagement, although blended learning remains preferable for most students [3]. At the same time, systematic reviews show that virtual reality (VR) and simulation technologies enhance understanding of complex construction processes and professional practices, but their adoption is constrained by resource limitations and integration challenges [4]. Another promising area is the use of digital twins in higher education programs related to engineering, construction, and transport. Literature reviews confirm that, although implementation in these fields is less advanced than in manufacturing, digital twin technologies can improve operational efficiency, forecasting, and sustainability outcomes [5].

Moreover, theoretical and applied studies in transport highlight that virtual modeling of infrastructure facilities facilitates diagnostics, planning, and system management, but requires significant institutional and technical readiness [6].

Despite these opportunities, universities often face financial limitations, outdated or incompatible IT systems, uneven access to digital resources, and low levels of digital literacy among staff and students [7, 8]. Integration of IT requires systemic organizational change – restructuring pedagogical approaches, governance models, and staff training systems [9]. Without addressing these structural challenges, even

advanced digital tools such as LMS, VR, or digital twins cannot achieve their full potential [10].

The rapid development of information and communication technologies (ICT) and, more recently, artificial intelligence (AI), has generated a substantial body of research on the implementation of educational technologies in higher education. Broad syntheses indicate that successful adoption depends not only on hardware and software, but also on pedagogical redesign, stakeholder perceptions, institutional strategies, and measurable post-implementation metrics [11]. These findings form a conceptual backbone for analysing sectoral (construction and transport) specifics.

Frameworks of Education 4.0 and its core components – competencies, learning methods, ICT and infrastructure – are particularly relevant for engineering disciplines, where curricular change must align with industry digitalisation (BIM, digital design, IoT, data analytics). Literature stresses that technological tools are necessary but not sufficient; curricula, teacher competence and assessment practices must be retooled to exploit digital affordances and to develop students' applied digital skills required by Industry 4.0/5.0 [12]. Sector-specific reviews confirm uneven progress: in built-environment and construction education, reviews point to growing use of VR/AR, BIM and simulation tools, while identifying a persistent gap between industry expectations and student capabilities in digital design, automation and programming skills [13; 14]. Siddiqui et al. argue that HEIs should integrate hands-on digital competencies (BIM, GIS, coding for automation, data analytics) into core modules rather than leaving them as electives or short courses [14]. Similarly, systematic examinations of emerging technologies in built-environment courses find positive effects on engagement and employability but emphasise the need for scaffolded implementation and faculty development to avoid superficial tool use [13].

Transportation engineering education literature echoes these messages: the discipline is increasingly data-driven (traffic telemetry, ITS, transport modelling) and requires curricula that combine classical engineering fundamentals with digital and managerial competences. Reviews call for expansion of data literacy, programming, and exposure to industry software within degree programmes, along with stronger partnerships between universities and transport agencies to provide

authentic learning experiences [15; 16]. These studies highlight a core tension: rapid industry change versus relatively slow curricular and institutional adaptation.

Adoption studies also document persistent institutional barriers: limited faculty digital literacy, insufficient strategy and funding, inadequate IT infrastructure, resistance to pedagogical change, and lack of reliable metrics to evaluate impact [11; 17]. Moreover, the rise of AI in education introduces opportunities (adaptive learning, automated assessment, intelligent tutoring) and ethical, capacity and governance challenges that HEIs must manage through policy and training. Comprehensive reviews of educational-technology adoption emphasise stakeholder perceptions (students, faculty, administrators) as critical determinants of long-term success [11].

Turning to Azerbaijan, a growing but still maturing literature describes national digitalisation efforts and the experience of local universities. Case studies from Azerbaijan State University of Economics and multi-author surveys in national technical universities document active steps toward LMS adoption, blended learning, and administrative digitisation, while also reporting obstacles: uneven internet access across regions, the need for targeted faculty retraining, and the absence of coherent national metrics for digital learning quality [17; 18]. Recent analyses of Azerbaijan's higher-education digital transformation note promising policy initiatives and pilot projects but call for stronger alignment between national digital strategies, university curricula (particularly in construction and transport faculties), and employer needs in infrastructure and transport sectors [19].

Synthesising global and Azerbaijani findings yields several implications for construction and transport HEIs in Azerbaijan and similar contexts. First, curriculum reform must embed practical digital skills (BIM, transport data analytics, simulation, programming) within core modules rather than as add-ons [14; 15]. Second, faculty professional development and institutional change management are essential prerequisites; without them, investments in technology risk remaining underutilised [11; 17]. Third, national-level coordination and funding models that incentivise university–industry collaboration will accelerate meaningful transitions and graduate employability [19]. Finally, the governance of AI and data within teaching – including

ethical, assessment and quality assurance frameworks – should be integrated into institutional digital strategies from the outset [20].

The literature converges on a multi-dimensional view: technology is an enabler, but impact in construction and transport education depends on curricular integration, faculty capacity, infrastructure, stakeholder buy-in, and national policy alignment. For Azerbaijani HEIs, the immediate prospects are positive given national digital initiatives, but realizing benefits for the construction and transport sectors requires deliberate curricular redesign, consistent faculty development programs and closer university–industry partnership models. In summary, current research indicates that while IT adoption can significantly enhance educational outcomes, institutional efficiency, and graduate competitiveness, the effective implementation of digital technologies in higher education – especially in construction and transport – depends on a combination of technological investment, institutional reforms, staff capacity-building, and the development of sector-specific digital ecosystems. These findings justify the need for comprehensive studies on the current problems and prospects of IT implementation in specialized higher education institutions.

The formulation of the objectives of the article. The purpose of the article is to identify the main problems and barriers hindering the implementation of information technologies in higher education institutions of construction and transport, to analyze international governance frameworks and global trends in digital transformation, and to assess the prospects for their adaptation to the Azerbaijani context in order to enhance efficiency, transparency, and competitiveness of universities.

Statement of the main material of the research. The analysis begins with financial constraints as a critical factor shaping the digital transformation process in higher education institutions of construction and transport, followed by human resource challenges, technological and organizational limitations, and the necessity for strategic governance measures. By structuring the results in this manner, the study provides a comprehensive view of the problem and lays the groundwork for identifying feasible solutions adapted to the Azerbaijani context.

The financing of IT implementation remains a major issue: many construction and transport universities do not have sufficient budgets to

allocate the required funds for updating IT systems. Digital transformation in technical education requires considerable initial investment, which creates difficulties for state-funded institutions in securing the necessary resources. In particular, the lack of adequate financial support from various sources and the short-term (annual) nature of budget planning hinder the modernization of IT infrastructures.

There are also serious shortcomings in human resources. The lack of knowledge and skills required to use digital technologies effectively – i.e., insufficient digital literacy – has become a common problem for many universities worldwide. For instance, the weak preparation of pedagogical staff and managers in information systems complicates the adoption of new IT projects in construction and transport education. Additionally, resistance to innovative changes is observed in the higher education sector due to long-standing traditions. Some employees are reluctant to move beyond the current state, approach change with caution, or feel uncertain, all of which slow down the implementation of digital innovations. Such attitudinal and behavioral barriers have existed for decades and are considered among the most difficult challenges in carrying out digital transformation.

Other problems identified in studies include data fragmentation and integration challenges, incompatibility between outdated software and modern applications, and the necessity of continuous training for staff. Overall, international research indicates that for IT governance in higher education to meet modern requirements, comprehensive solutions are needed that address technical, financial, and human factors simultaneously. These solutions should include programs and strategies for international experience-sharing and for developing theoretical and methodological measures for the effective organization and management of IT in construction and transport universities.

In global practice, a number of benchmark frameworks for IT organization and governance have been developed, among which COBIT (Control Objectives for Information and Related Technologies) and ITIL (Information Technology Infrastructure Library) are especially widespread. Although these frameworks were initially designed for the corporate sector, they have been successfully applied in higher education institutions of construction and transport, producing effective results. Research shows that IT governance in technical universities most often

employs ITIL and COBIT. Specifically, ITIL is considered more practical at the operational level, frequently applied to standardize processes such as helpdesk and incident management. COBIT, in turn, is used as a reference model for IT governance and control mechanisms.

These frameworks provide construction and transport universities with methodologies for aligning IT goals with academic-business objectives, clarifying roles and responsibilities, and optimizing processes through documentation. For example, studies in technical higher education have demonstrated that implementing COBIT, ITIL, and ISO/IEC 17799 has increased transparency and accountability of IT processes, improved service quality, and enhanced risk management. Such standardized approaches help institutions align IT activities with strategic goals and ensure continuous improvement.

The theoretical foundations of IT governance also encompass change management and IT maturity models. Change management models – such as John Kotter's 8-step model – can be particularly useful for the implementation of digital innovations in higher education. Kotter's model emphasizes the need to establish a sense of urgency and build a strong guiding coalition, which is highly relevant in the university context where governance is collegial and decentralized. The success of IT initiatives therefore depends on the involvement of diverse stakeholders, from faculty members to administrative staff. As a result, change management frameworks are adapted to higher education, focusing on effective communication, stakeholder motivation, phased training, and continuous support during digital transformation projects.

IT maturity models are also important tools, enabling institutions to assess their current IT capabilities and plan future development. One widely known model is the Capability Maturity Model Integration (CMMI) [21], which has recently been adapted to IT governance. Studies of IT maturity in universities indicate that institutions with higher maturity levels manage IT more effectively, demonstrate stronger alignment between IT strategies and institutional missions, and make more strategic, evidence-based decisions. Such models provide a roadmap for universities to advance from the "initial" stage of IT governance to an "optimized" stage.

At the same time, global trends that shape IT in higher education - such as artificial intelligence, digital transformation, online and virtual

learning, expansion of cloud services, big data analytics, and cybersecurity - are widely studied and discussed. These factors influence the future trajectory of higher education systems, and many Azerbaijan universities are already taking strategic steps in these directions. UNESCO's latest reports indicate that higher education demonstrates the highest levels of digital technology adoption compared to other education levels [22]. For instance, the global e-learning market, which was valued at nearly 299.67 USD billion in 2024, is projected to reach 842.64 billion USD by 2030 [23]. The COVID-19 pandemic further accelerated digital transformation, creating a natural experiment that led to rapid adoption of online and hybrid learning models.

Massive Open Online Courses (MOOCs) have also transformed the global education environment. Statistics confirm this explosive growth: while MOOCs had no users in 2012, by 2021 their registered student base had reached at least 220 million learners [24]. Within only a decade, hundreds of millions of people gained access to higher education through online courses.

Cloud technologies are another rapidly growing trend in universities. Research indicates that approximately 79 % of higher education institutions already use Software as a Service (SaaS) in some form [25], nearly double the share from a few years ago. The primary motivation is cost efficiency, with analyses showing that cloud migration delivers average savings of around 21 % [26]. Universities increasingly rely on cloud platforms such as Microsoft 365 and Google Workspace for email and document management, reducing the need for large in-house IT teams. Nevertheless, research also highlights potential risks - such as data security and vendor dependence - that must be carefully managed.

The expansion of big data and learning analytics is another important development. According to an OECD report [1], effective use of big data analytics can help higher education institutions restructure their models, make evidence-based decisions, and improve both academic and administrative outcomes. In construction and transport universities, for example, many institutions now integrate student information systems, e-learning platforms, and library usage data into analytics dashboards, enabling early detection of at-risk students and improving academic advising. At the program level, analytics help

identify challenges in specific courses and evaluate labor market outcomes of graduates, which is particularly relevant for technical disciplines with strong links to industry.

In the Azerbaijan context, IT governance in higher education faces similar challenges as observed globally – outdated infrastructure, limited funding, insufficient human capital, and resistance to change. National development strategies, such as the Socio-Economic Development Strategy of the Republic of Azerbaijan for 2022–2026 [27], emphasize the priority of digital skills and IT infrastructure development in higher education. Strategic initiatives under the Digital Azerbaijan framework also aim to reduce the digital divide by expanding broadband access, particularly in rural areas.

Recent local studies [18; 19] provide a critical overview of digital transformation in Azerbaijan higher education, including construction and transport universities. They highlight both progress – such as the implementation of electronic university platforms, integration with European academic networks, and the growing role of online learning – and persistent barriers, including uneven regional infrastructure, limited budgets, and lack of empirical research on IT governance frameworks like COBIT and ITIL in local technical universities.

Despite significant global progress in digital transformation in higher education, implementation in construction and transport universities in Azerbaijan faces notable challenges. Country-specific studies remain limited, and empirical evidence on how IT governance frameworks, digital transformation strategies, and institutional IT maturity are applied in local technical universities is scarce. This gap underscores the need for targeted research and practical initiatives to identify effective approaches for IT adoption, improve institutional efficiency, enhance educational quality, and align university programs with industry requirements in the construction and transport sectors.

Conclusions. The study demonstrates that the implementation of information technologies in higher education institutions of construction and transport is a complex, multidimensional process that involves financial, human, technological, and organizational challenges. Major barriers include limited and short-term funding, outdated IT infrastructure, insufficient digital competencies among faculty and students, and resistance to innovations rooted in traditional academic practices.

International experience highlights the effectiveness of IT governance frameworks such as COBIT, ITIL, and CMMI, which contribute to process standardization, increased transparency and accountability, and continuous improvement of IT services. The adoption of modern technologies – including big data, learning analytics, VR/AR, BIM, digital twins, cloud services, and AI-based tools – creates significant opportunities to enhance the quality of professional training and the efficiency of institutional management in construction and transport universities.

At the same time, the Azerbaijani context demonstrates country-specific constraints, such as uneven regional infrastructure, limited financial resources, and insufficient empirical evidence on IT governance frameworks in local technical universities. Addressing these challenges requires targeted strategies that combine technological investments with institutional reforms.

Priority measures should include the development of national pilot projects on ITIL/COBIT implementation in higher education, the establishment of specialized digital laboratories for construction and transport disciplines, the promotion of public–private partnerships to ensure sustainable financing, and the integration of digital skills into curricula at all levels of training.

Aligning digital transformation strategies with global frameworks such as the UN Sustainable Development Goals and the EU Digital Education Action Plan would strengthen the international competitiveness of Azerbaijani universities. Particular emphasis should be placed on the sectoral needs of construction and transport education: for construction, the systematic integration of BIM and cloud-based collaboration platforms; for transport, the application of digital twins, simulation systems, and VR-based training tools.

Identified research gaps include the absence of comprehensive metrics for assessing digital maturity in higher education institutions of Azerbaijan and the lack of large-scale empirical studies evaluating the effectiveness of IT governance models in construction and transport universities. Future research should therefore focus on developing evaluation tools, conducting pilot studies, and analyzing the impact of digital transformation on learning outcomes, industry collaboration, and graduate employability.

Overall, effective IT implementation in construction and transport higher education institutions is not limited to technological modernization but requires the combination of organizational adaptation, faculty development, sustainable financing, and industry–university partnerships.

Only such an integrated approach can ensure sustainable development, enhance graduate competitiveness, and align the higher education system with the needs of the digital economy and modern labor market.

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АКТУАЛЬНІ ПРОБЛЕМИ ТА ПЕРСПЕКТИВИ ВПРОВАДЖЕННЯ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ У ВИЩИХ НАВЧАЛЬНИХ ЗАКЛАДАХ БУДІВНИЦТВА ТА ТРАНСПОРТУ

МАМЕДОВ М., доктор економічних наук, професор, Азербайджанський університет архітектури і будівництва, вул. Айна Султанова, 11, м. Баку, Азербайджан.

E-mail: m.m.asirli@mail.ru, ORCID 0000-0002-5327-2507.

ТАГІЄВА Т., PhD, викладач, Азербайджанський державний університет нафти і промисловості, просп. Азадлиг, 34, м. Баку, Азербайджан.

E-mail: turantagiyeva1225@gmail.com, ORCID 0000-0003-3982-1319.

ТАЛІБЗАДЕ С., завідувач кафедри ІКТ, докторант, Азербайджанський університет архітектури і будівництва, вул. Айна Султанова, 11, м. Баку, Азербайджан.

E-mail: sw@azmiu.edu.az, ORCID 0000-0002-4591-6325.

МАМЕДОВ Т., здобувач вищої освіти, Університет Міннесоти, 15-те Авеню С.Е., 319, Міннеаполіс, МН 55455, США.

E-mail: tomik20072072@gmail.com, ORCID 0009-0001-7961-6291.

Анотація. *Впровадження інформаційних технологій (ІТ) у закладах вищої освіти будівельного та транспортного профілю є критично важливим чинником підвищення якості освіти, ефективності управління та конкурентоспроможності випускників.*

Незважаючи на значний потенціал цифрових рішень, університети цих секторів стикаються з низкою проблем, серед яких застаріла IT-інфраструктура, обмежене фінансування, недостатній рівень цифрової компетентності викладачів і студентів та опір організаційним змінам. Спеціалізована професійна підготовка у будівництві та транспорті вимагає використання сучасних інструментів моделювання, симуляційних платформ та галузевих цифрових ресурсів, що ускладнює інтеграцію інноваційних IT-рішень. Міжнародний досвід демонструє ефективність впровадження фреймворків IT-управління, таких як COBIT, ITIL та CMMI, які дозволяють стандартизувати процеси, підвищувати прозорість і забезпечувати постійне вдосконалення. Сучасні технології, включаючи великі дані та аналітику навчання, віртуальну та доповнену реальність (VR/AR), інформаційне моделювання будівель (BIM), цифрові двійники, хмарні сервіси та інструменти на основі штучного інтелекту, створюють значні можливості для підвищення ефективності академічного та адміністративного процесів. В азербайджанському контексті спостерігається прогрес у впровадженні електронних навчальних платформ, змішаного навчання та адміністративної цифровізації; водночас зберігаються проблеми нерівномірної регіональної інфраструктури, обмеженого фінансування та недостатньої емпіричної бази щодо IT-управління у технічних університетах. Подолання цих викликів потребує комплексних стратегій, що поєднують інвестиції в технології, розвиток кадрового потенціалу, організаційні реформи та партнерство з промисловістю. Пріоритетними заходами є реалізація пілотних проєктів впровадження ITIL/COBIT, створення спеціалізованих цифрових лабораторій, інтеграція галузевих цифрових компетентностей у навчальні програми та узгодження національних ініціатив із міжнародними рамками, такими як Цілі сталого розвитку ООН та Дія Плану цифрової освіти ЄС. Дослідження підкреслює необхідність системної оцінки IT-зрілості і моделей управління в закладах вищої освіти будівельного та транспортного профілю. Ефективне впровадження IT у цих спеціалізованих установах потребує цілісного підходу, що об'єднує модернізацію інфраструктури, розвиток людського потенціалу, вдосконалення управління та секторну орієнтацію для забезпечення сталого розвитку та підготовки випускників до потреб цифрової економіки.

Ключові слова: *впровадження інформаційних технологій, вища освіта, будівельні університети, транспортні університети, цифрова трансформація, IT-управління, цифрові компетентності, освітні технології, Індустрія 4.0/5.0, аналітика навчання.*