

# INNOVATION SCIENCE AND TECHNOLOGY

**ISSUE 10, PART I / OCTOBER 2026**

 **Acceptance of papers**



**Acceptance of  
papers**

Published monthly



**Topics**

economics,  
technology, social  
sciences



**EDITOR-IN-CHIEF:**

Mirzaliyev Sanjar Makhamatjon ugli

**DEPUTY EDITOR-IN-CHIEF:**

Makhmudov Nosir Makhmudovich  
DSc., Prof., Academician

**DEPUTY EDITOR-IN-CHIEF:**

Ochilov Bobur Bakhtiyor ugli – Senior  
lecturer at TSUI

THE SCIENTIFIC-POPULAR ELECTRONIC  
JOURNAL **"INNOVATION SCIENCE AND  
TECHNOLOGY"** HAS BEEN REGISTERED  
UNDER THE NUMBER **C-5669633** BY THE  
AGENCY FOR INFORMATION AND MASS  
COMMUNICATIONS (AOKA) OF THE  
REPUBLIC OF UZBEKISTAN, EFFECTIVE  
FROM OCTOBER 9, 2024.

**CONTACTS**

Phone: **+998 50 737 87 88**

Website: <https://ist-journal.uz>

Email: [innovationist2025@gmail.com](mailto:innovationist2025@gmail.com)

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

**Editorial board:**



**Sharipov Kongiratbay Avezimbetovich,**  
Doctor of Technical Sciences (DSc), Professor



**Abdurakhmanova Gulnora Kalandarovna,** Doctor of  
Economic Sciences (DSc), Professor



**Cham Tat Huei,**  
Doctor of Philosophy (PhD), Professor (Malaysia)



**Muhammad Imran Sadiq**  
Doctor of Philosophy in Economics (PhD), Professor,  
Malaysia



**Ahmed Aziz Ismail**  
Doctor of Technical Sciences (DSc),  
Professor (Egypt)



**Lee Chin**  
Doctor of Philosophy in Economics (PhD), (Malaysia)



**Asongu Simplicie**  
Doctor of Philosophy in Economics (PhD), Cameroon



**Rui Dang**  
Doctor of Chemistry (DSc), Professor, China



**Zahoor Ahmed**  
Doctor of Philosophy in Economics (PhD), Turkey



**Shujaat Abbas**  
Doctor of Philosophy in Economics (PhD), Russia



**Tina A Coffelt**  
Doctor of Philosophy in Educational Sciences (PhD),  
USA



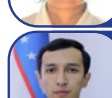
**Abdikarimova Dinara Rustamxanovna**  
Doctor of Economic Sciences (DSc), Professor

**Kurbonbekova Mohichehra Turobjonovna**  
Doctor of Economic Sciences (DSc), Professor

**Alimardonov Ilkhom Muzrabshokovich**  
Doctor of Economic Sciences (DSc), Professor



**Razakova Barno Sayfieva**  
Doctor of Philosophy in Economics (PhD)



**Khasanov Sarvar Ulugbek ugli**  
Doctor of Philosophy in Economics (PhD)



**Kholikova Rukhsora Sanjarovna**  
Associate Professor (PhD)



**Xoliyorova Shoxista Qahramon qizi**  
PhD in Economics, Assistant Lecturer at the Department TSUE

**Nasiba G'anjon qizi Sattorova**  
PhD, Senior Lecturer at the Department of Banking

# CONTENTS

|                                                                                                                                                           |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| IMPLEMENTATION OF THE IMPROVED METHODOLOGY IN PRACTICE AND ASSESSMENT OF ITS ECONOMIC EFFICIENCY .....                                                    | 8   |
| Eshniyazova Yulduz Yuldashbayevna                                                                                                                         |     |
| EXPERIMENTAL OPTIMIZATION OF DESIGN AND ENERGY PARAMETERS OF A GARLAND-TURBINE MOBILE MICRO HYDROPOWER PLANT FOR FREE-FLOWING WATER .....                 | 13  |
| Sultonov Sanjarbe, Zokirov Islomjon, Nurillaev Ahadullo, Abdullaev Shavkat                                                                                |     |
| METHODOLOGY FOR INCREASING THE EFFICIENCY OF CREDIT OPERATIONS IN COMMERCIAL BANKS .....                                                                  | 19  |
| Djumaniyazov Ikram Karimbaevich                                                                                                                           |     |
| COMPARATIVE ANALYSIS OF A COMPACT RESIDUAL CONVOLUTIONAL MODEL AND LINEAR REGRESSION FOR IMAGE SUPER-RESOLUTION .....                                     | 27  |
| Husan Arziqulov Normurod o'g'li                                                                                                                           |     |
| COMPARATIVE EVALUATION OF MACHINE LEARNING ALGORITHMS AND CLASS IMBALANCE HANDLING STRATEGIES FOR CREDIT CARD FRAUD DETECTION .....                       | 33  |
| Mahmudova Dilnoza Avaz qizi                                                                                                                               |     |
| DIGITAL TRANSFORMATION OF FINANCIAL RESOURCE MANAGEMENT IN PUBLIC SOCIAL SECTOR INSTITUTIONS .....                                                        | 39  |
| Khasanov Tulkin Axmatovich                                                                                                                                |     |
| WAYS TO ENSURE THE STABILITY OF THE CAPITAL BASE OF COMMERCIAL BANKS .....                                                                                | 45  |
| Isakov Isobek Janabay's son                                                                                                                               |     |
| CROSS-DAY EXPERIMENTAL EVIDENCE OF THERMAL-LOAD SHIFTING IN A SOLAR-DRIVEN HYDRONIC RADIANT FLOOR WITH MACROENCAPSULATED RT52 PHASE CHANGE MATERIAL ..... | 50  |
| Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova                                                                                                       |     |
| STUDY OF THE TRACTION DYNAMICS OF AN AGGREGATE CONSISTING OF A FRUIT-HARVESTING MACHINE AND ITS TWO-AXLE CONTAINER-CARRYING TRAILER PLATFORM .....        | 59  |
| Norchayev Davron, Sardor Nigmatjonov, Norchayev Jaloliddin, Norchayev Rustam                                                                              |     |
| PRIORITY DIRECTIONS FOR STRENGTHENING THE FINANCIAL STABILITY OF AGRICULTURAL ENTERPRISES .....                                                           | 67  |
| Kulmatov Zafar Jumanazarovich                                                                                                                             |     |
| METHODOLOGICAL APPROACHES TO DEVELOPING UNIVERSITY STUDENTS' DIGITAL COMMUNICATIVE COMPETENCE BASED ON EMOTIONAL INTELLIGENCE .....                       | 73  |
| Malikakhon Kamiljanova                                                                                                                                    |     |
| SIMULTANEOUS REMOVAL CHARACTERISTICS OF OIL AND HEAVY METAL IONS BY BIOFLOCCULANTS BASED ON THE CELLULOSE-DMAEMA/PEPA COMPOSITE .....                     | 80  |
| Xayitboeva Dilshoda, Ibragimov Nasrilla, Jumaev Anvarbek                                                                                                  |     |
| ECONOMIC ANALYSIS AND DEVELOPMENT STRATEGY OF THE WOOD-POLYMER COMPOSITES MARKET .....                                                                    | 84  |
| Abdumalikova Zarnigor, Ayubova Indira, Jumaev Anvarbek                                                                                                    |     |
| ENERGY UTILIZATION ANALYSIS OF AGRICULTURAL DRYING BASED ON INTEGRATED SOLAR THERMAL AND PHOTOVOLTAIC ENERGY SUPPLY .....                                 | 89  |
| Ibragimov Umidjon, Mirzayarova Sevara, Khujayorova Aziza                                                                                                  |     |
| RECENT ADVANCES IN THE SYNTHESIS OF NANOSTRUCTURED MATERIALS FOR ZINC-ION BATTERIES .....                                                                 | 96  |
| Diyorbek Absattorov, Dilnoza Erimbatova, Murodjon Samadiy                                                                                                 |     |
| ENTHALPY-MODEL SELECTION AND PRACTICAL IDENTIFIABILITY OF A MACROENCAPSULATED RT52 RADIANT FLOOR UNDER UNCERTAIN BRANCH FLOW .....                        | 101 |
| Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova                                                                                                       |     |
| ENTHALPY-MODEL SELECTION AND PRACTICAL IDENTIFIABILITY OF A MACROENCAPSULATED RT52 RADIANT FLOOR UNDER UNCERTAIN BRANCH FLOW .....                        | 101 |
| Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova                                                                                                       |     |

|                                                                                                                                                                |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| THE IMPORTANCE OF THERMAL ENERGY STORAGE SYSTEMS IN ENHANCING THE EFFICIENCY OF SOLAR DRYERS .....                                                             | 110 |
| <b>B. A. Hikmatov, M. S. Mirzaev,</b>                                                                                                                          |     |
| METHODOLOGY AND PRINCIPLES FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ADAPTIVE ECONOMIC MODELS OF HIGHER EDUCATION.....                                 | 117 |
| <b>O'lmasxo'jayev Zoirxo'ja Abbos o'g'li</b>                                                                                                                   |     |
| FORECASTING ECONOMIC EFFECTS OF GREEN INNOVATION IN MINING THROUGH COST REDUCTION, ENERGY SAVINGS AND LONG-TERM COMPETITIVENESS.....                           | 122 |
| <b>Kurbanova Mehriniso Nematjanovna</b>                                                                                                                        |     |
| AN INTELLECTUAL HYBRID MODEL AND FEATURE SPACE FOR NAMED ENTITY RECOGNITION IN KARAKALPAK TEXTS .....                                                          | 127 |
| <b>Kalmuratov Bekbosin Kushkinbaevich, Uzakbaev Jangeldi Sabit-uli, Rzambetova Suliwxan Baxtiyarovna</b>                                                       |     |
| COMPARATIVE ANALYSIS OF EXISTING METHODOLOGIES FOR ASSESSING THE EFFICIENCY OF LENDING PRACTICE .....                                                          | 133 |
| <b>Turdiyev Eralijon Muxtarovich</b>                                                                                                                           |     |
| STRATEGIC MANAGEMENT OF SERVICE QUALITY: ADAPTING THE GAP MODEL TO SERVICE ENTERPRISES.....                                                                    | 140 |
| <b>Tuxliyev Baxtiyor Maxmaziyayevich</b>                                                                                                                       |     |
| ORGANISATIONAL AND LEGAL FOUNDATIONS FOR THE DEVELOPMENT OF ISLAMIC FINANCE IN UZBEKISTAN .....                                                                | 145 |
| <b>Khodjaev Aziz Shovkatovich</b>                                                                                                                              |     |
| REGIONAL TRANSMISSION OF MACROECONOMIC SHOCKS AND THE DYNAMICS OF ECONOMIC CONVERGENCE .....                                                                   | 153 |
| <b>Elyor Nazarov</b>                                                                                                                                           |     |
| PRIORITY DIRECTIONS FOR INCREASING SECTORAL DIVERSIFICATION IN THE ECONOMY OF UZBEKISTAN'S REGIONS .....                                                       | 159 |
| <b>Mamarasulov Nozimjon Mamajonovich</b>                                                                                                                       |     |
| THE ROLE OF STATE STRATEGIC RESERVES IN ENSURING FOOD SECURITY: POLICY EVOLUTION AND REASSESSMENT OF THE MILITARY SUPPLY SYSTEM IN THE CASE OF UZBEKISTAN..... | 165 |
| <b>Bazarov Nazirjon Sobirovich</b>                                                                                                                             |     |
| LOCAL ADAPTATION OF MRA-FW FOR CARDIOVASCULAR RISK ASSESSMENT IN ARAL SEA REGION INPATIENTS.....                                                               | 170 |
| <b>Uteuliev Niyetbay, Saytov Aralbek, Saytov Kamiljan</b>                                                                                                      |     |
| GREEN FINANCE IN UZBEKISTAN: FROM SOVEREIGN BONDS TO FOREIGN DIRECT INVESTMENT IN RENEWABLE ENERGY (2021–2026).....                                            | 176 |
| <b>Temirova Nozima Shuhrat qizi</b>                                                                                                                            |     |
| IMPROVING THE ACCOUNTING OF REVENUE, EXPENSES AND FINANCIAL RESULTS IN PRIVATE HIGHER EDUCATION INSTITUTIONS .....                                             | 182 |
| <b>Saidova Kamolat Farhodovna</b>                                                                                                                              |     |
| THE IMPACT OF DIGITAL TRANSFORMATION ON SERVICE DELIVERY EFFICIENCY IN LOCAL HIGHER EDUCATION INSTITUTIONS.....                                                | 187 |
| <b>Masaidova Marguba Muratovna</b>                                                                                                                             |     |

# THE IMPACT OF DIGITAL TRANSFORMATION ON SERVICE DELIVERY EFFICIENCY IN LOCAL HIGHER EDUCATION INSTITUTIONS

Masaidova Marguba Muratovna

Independent Researcher, Andijan State University, Uzbekistan

**Abstract.** This article analyses the impact of digital transformation on the efficiency of service delivery in local higher education institutions, examining trends from 2020 to 2025 across selected universities in different regions of Uzbekistan. The study is grounded in the premise that digitalisation is not merely a technical upgrade but a comprehensive institutional mechanism for managing higher education services. Based on the growth of regional student populations, enrolment dynamics, and the diversification of learning formats, the study examines the potential efficiency gains associated with scaling operations, distance learning, and digital integration and develops a system of indicators to assess the effectiveness of digital transformation in higher education institutions.

**Keywords:** digital transformation, higher education services, HEMIS, economies of scale, integration, performance indicators.

**Аннотация.** В статье анализируется влияние цифровой трансформации на эффективность предоставления образовательных услуг в отечественных высших учебных заведениях на основе изучения тенденций развития отдельных университетов, расположенных в различных регионах Узбекистана, за 2020–2025 годы. Исследование основывается на положении о том, что цифровизация представляет собой не просто технологическую модернизацию, а комплексный институциональный механизм управления услугами высшего образования. На основе анализа роста численности студентов в регионах, динамики приёма и диверсификации форм обучения рассматриваются потенциальные возможности повышения эффективности за счёт масштабирования деятельности, дистанционного обучения и цифровой интеграции. Кроме того, разработана система показателей для оценки эффективности цифровой трансформации высших учебных заведений.

**Ключевые слова:** цифровая трансформация, услуги высшего образования, HEMIS, эффект масштаба, интеграция, показатели эффективности.

## INTRODUCTION

The digital transformation of higher education services is not merely a separate technological initiative within modern universities; rather, it represents a comprehensive institutional change that shifts the mechanisms for designing, delivering, accessing, monitoring, and evaluating educational services towards a qualitatively new management model. Therefore, assessing the effectiveness of digital transformation solely in terms of the number of computers, internet speed, electronic platforms, or the proportion of digitised documents is insufficient.

The rapid expansion of demand for higher education services in Uzbekistan has transformed digitalisation from an optional technological upgrade into an objective necessity for effective institutional management.

Under conditions of rapid growth in student enrolment, maintaining an unchanged traditional university administration model would lead to a proportional increase in the demand for personnel and physical infrastructure across dean's offices, registrar services, accounting departments, libraries, student support services, attendance monitoring systems, and other administrative functions. Digital technologies, by contrast, enable universities to expand their service delivery capacity without increasing staff numbers or administrative facilities at the same rate as student enrolment.

The aim of this study is to comparatively assess the impact of digital transformation on the efficiency of higher education services using the example of seven selected universities located in different regions of Uzbekistan and to substantiate the institutional mechanisms underlying this impact.

## LITERATURE REVIEW

The theoretical foundations of digital transformation have been examined in various studies focusing on institutional change, technological integration, and organisational efficiency. Vial (2019) conceptualises digital

transformation as a process involving organisational changes associated with digital technologies [10]. Verhoef et al. (2021) examine digital transformation from a multidisciplinary perspective, highlighting its implications for organisational structures and value creation [9]. In the context of education, the OECD (2023) emphasises the importance of developing an effective digital education ecosystem that integrates technological infrastructure, digital resources, and institutional processes [7]. Similarly, UNESCO (2023) examines the role of educational technologies and the conditions influencing their effective use in education [8]. These studies provide a theoretical basis for assessing digital transformation not merely through technological adoption but also through institutional integration, resource utilisation, and educational outcomes.

## RESEARCH METHODOLOGY

The study employs systemic and comparative analysis, statistical grouping, time-series analysis, and institutional and structural approaches. The research focuses on seven higher education institutions located in geographically and economically diverse regions of Uzbekistan, together with their respective regional contexts. These institutions include the National University of Uzbekistan (NUUz, Tashkent city), Andijan State University (ASU, Andijan region), Fergana State University (FSU, Fergana region), Samarkand State University named after Sharof Rashidov (SamSU, Samarkand region), Karshi State University (KSU, Kashkadarya region), Bukhara State University (BSU, Bukhara region), and Urgench State University named after Abu Rayhan Beruni (UrSU, Khorezm region).

The empirical basis of the study comprises official statistical data on Uzbekistan's higher education system for 2020–2025, real-time educational statistics collected through the Higher Education Management Information System (HEMIS), and performance indicators obtained from official university reports. To ensure an accurate assessment of the impact of digital transformation on individual universities, the overall higher education services market and student admission flows in the corresponding regions were also examined in parallel.

## ANALYSIS AND RESULTS

According to the analysis of official statistical data, the total number of students enrolled in higher education institutions in Uzbekistan increased from 571,512 in 2020 to 1,535,006 in 2025, representing an increase of 963,494 students, or 168.6%, over the five-year period (see Table 1). These figures highlight the potential economic significance of digital transformation in the higher education sector.

Given that student enrolment increased by a factor of 2.69, maintaining the traditional university administration model without corresponding organisational changes could result in a proportional increase in demand for personnel and physical infrastructure across dean's offices, registrar services, accounting departments, libraries, student support services, attendance monitoring systems, and other administrative functions. Digital technologies, however, provide opportunities to expand service delivery capacity without requiring staff numbers or administrative facilities to increase at the same rate as student enrolment.

Table 1. Dynamics of Student Enrolment in Uzbekistan's Higher Education System, 2020–2025<sup>1</sup>

| No. | Indicator                            | 2020  | 2020  | 2020    | 2020    | 2020    | 2020    | 2021                        |
|-----|--------------------------------------|-------|-------|---------|---------|---------|---------|-----------------------------|
| 1   | Total student enrolment (thousands)  |       |       |         |         |         |         | +168.6                      |
|     |                                      | 571.5 | 808.4 | 1,042.1 | 1,314.5 | 1,432.8 | 1,535.0 | 2021<br>+168.6              |
| 2   | Undergraduate admissions (thousands) | 165.0 | 220.1 | 275.5   | 350.2   | 360.1   | 372.9   | +126.0                      |
| 3   | Graduates (thousands)                | 83.9  | 103.9 | 102.4   | 184.1   | 211.2   | 225.9   | +169.3                      |
| No. | Indicator                            | 2020  | 2021  | 2022    | 2023    | 2024    | 2025    | Change,<br>2020–2025<br>(%) |

Based on the preceding analysis, a key potential benefit of digital transformation is associated with economies of scale. In this context, the marginal cost of serving an additional student through digital services, such as electronic transcripts, academic data processing within HEMIS, or the delivery of learning materials through Learning Management Systems (LMS), may be lower than under traditional offline service delivery

<sup>1</sup> Source: Compiled based on official data from the National Statistics Committee of the Republic of Uzbekistan.

models. Consequently, as student enrolment increases, the initial investment costs associated with digitalisation are distributed across a larger student population, thereby reducing the average investment cost per student.

Furthermore, undergraduate admissions increased from 165,000 students in 2020 to 373,000 in 2025, representing a growth of 126.0%. This expansion highlights the increasing importance of digital platforms for managing student identification, course enrolment, academic group formation, and individual electronic student accounts.

**Table 2. Dynamics of Student Enrolment in the Regions Hosting the Seven Selected Higher Education Institutions, 2020–2025 (thousand students)<sup>2</sup>**

| № | Region / Research Object | Years | Years | Years | Years | Years | Years | Growth, 2020–2025 (%) |
|---|--------------------------|-------|-------|-------|-------|-------|-------|-----------------------|
|   |                          | 2020  | 2021  | 2022  | 2023  | 2024  | 2025  |                       |
| 1 | Tashkent city (NUUz)     | 185,5 | 271,2 | 354,0 | 491,3 | 539,4 | 579,3 | 212,2                 |
| 2 | Andijan region (ASU)     | 30,9  | 47,7  | 58,3  | 66,2  | 63,8  | 65,7  | 112,7                 |
| 3 | Fergana region (FSU)     | 48,4  | 62,3  | 77,7  | 84,9  | 85,1  | 98,9  | 104,2                 |
| 4 | Samarkand region (SamSU) | 54,8  | 70,8  | 84,7  | 90,6  | 90,7  | 93,9  | 71,2                  |
| 5 | Kashkadarya region (KSU) | 27,8  | 44,2  | 57,4  | 78,4  | 82,5  | 111,6 | 300,8                 |
| 6 | Bukhara region (BSU)     | 35,6  | 43,9  | 57,5  | 82,9  | 98,9  | 117,7 | 230,3                 |
| 7 | Khorezm region (UrSU)    | 22,8  | 28,7  | 42,8  | 53,9  | 60,6  | 65,9  | 189,4                 |

Assessing the impact of digital transformation on university efficiency without considering the regional environment presents certain methodological limitations. This is because demand for university digital services increases alongside the expansion of the overall higher education market in the corresponding region. Taking this into account, Table 2 presents the total number of students enrolled in all higher education institutions (HEIs) within each region where the selected universities are located, rather than the enrolment figures of the individual universities themselves. These indicators were used to assess the regional higher education market and the potential demand for digital services. The analysis of regional dynamics revealed several important patterns.

First, the highest growth was recorded in Kashkadarya region, where student enrolment increased from 27,800 in 2020 to 111,600 in 2025, representing a 4.01-fold expansion. The approximate compound annual growth rate was nearly 32%. This indicates that maintaining traditional models of academic and administrative service delivery in the region where Karshi State University operates would require progressively greater resources as student enrolment continues to increase.

Second, in Bukhara region, student enrolment increased from 35,625 to 117,660, representing a growth of 230.3% between 2020 and 2025. Under these conditions, digital transformation at Bukhara State University also becomes increasingly important in the context of the external competitive environment. As the regional higher education services market expands, attracting and retaining students and providing high-quality services may increasingly depend, in part, on the quality and functionality of digital platforms.

Third, in Tashkent city, student enrolment increased from 185,500 to 579,300, resulting in an absolute increase of approximately 393,700 students over the five-year period. Although the capital's relatively advanced digital infrastructure provides technological opportunities for managing this expansion, competitive conditions encourage individual higher education institutions, including the National University of Uzbekistan, to move beyond basic digitalisation towards improved digital service quality, personalisation, and data-driven management.

Fourth, in Khorezm region, student enrolment increased from 22,800 to 65,900, representing a growth of 189.4%. For a region located relatively far from the country's administrative and economic centre, this trend highlights a second distinctive benefit of digital technologies: the mitigation of distance-related costs. Electronic academic databases, distance learning courses, videoconferencing, and online consultations do not completely eliminate geographical barriers; however, they reduce the economic costs associated with distance

<sup>2</sup> Source: Compiled based on official data from the National Statistics Committee of the Republic of Uzbekistan.

in educational activities and scientific collaboration.

Fifth, Fergana and Andijan regions recorded student enrolment growth of 104.2% and 112.7%, respectively. In the densely populated Fergana Valley, the potential benefits of digital transformation are associated with managing large volumes of service users, introducing electronic queuing and request management systems, and ensuring the large-scale provision of academic information and educational resources.

Sixth, although Samarkand region recorded a comparatively lower growth rate of 71.2%, its student population reached 93,900 by 2025. Therefore, the significance of digitalisation for Samarkand State University extends beyond accommodating increasing student enrolment. It also involves the standardisation of different modes of education and academic processes within a multidisciplinary university.

It is important to emphasise that the demand for digital technologies in regional higher education markets is determined not only by the total student population but also by the annual inflow of newly admitted students. Accordingly, the study also examined official statistical data on undergraduate admissions across the selected regions (see Table 3) to provide a more comprehensive assessment of the changing demand for digital educational services.

**Table 3. Number of Students Admitted to Undergraduate Programmes in the Selected Regions, 2020–2025 (persons)<sup>3</sup>**

| № | Region             | Years  | Years  | Years   | Years   | Years   | Years   | Growth (%) |
|---|--------------------|--------|--------|---------|---------|---------|---------|------------|
|   |                    | 2020   | 2021   | 2022    | 2023    | 2024    | 2025    |            |
| 1 | Tashkent city      | 48 436 | 91 099 | 110 426 | 145 728 | 144 464 | 156 863 | 223,9      |
| 2 | Andijan region     | 7 512  | 9 588  | 11 411  | 14 778  | 11 786  | 14 666  | 95,2       |
| 3 | Fergana region     | 13 713 | 12 990 | 16 166  | 17 102  | 19 870  | 25 625  | 86,9       |
| 4 | Samarkand region   | 17 772 | 18 356 | 20 446  | 19 084  | 20 027  | 21 278  | 19,7       |
| 5 | Kashkadarya region | 7 541  | 10 369 | 14 177  | 18 948  | 27 386  | 16 014  | 112,4      |
| 6 | Bukhara region     | 11 109 | 11 602 | 16 352  | 24 511  | 29 416  | 42 103  | 279,0      |
| 7 | Khorezm region     | 6 659  | 6 990  | 9 968   | 15 524  | 15 910  | 15 142  | 127,4      |

Publicly available official HEMIS data make it possible to examine current student enrolment at individual universities by mode of study. Since these data are reported to be retrieved from the HEMIS information system in real time, they are more appropriately used to describe the current institutional structure that has emerged during the period of digital transformation rather than as part of the 2020–2025 time series.

The analysis of educational statistics collected through HEMIS suggests that digitalisation is gradually reducing the exclusive dependence of educational service delivery on physical classrooms. In particular, 1,769 undergraduate students at the National University of Uzbekistan, 714 at Andijan State University, 608 at Samarkand State University, and 553 at Bukhara State University are enrolled in distance learning programmes (see Table 4).

The availability of distance education at these universities indicates that digital technologies are functioning not merely as administrative tools but also as channels for delivering educational services.

**Table 4. Digital Diversification of Modes of Study at Selected Higher Education Institutions<sup>4</sup>**

| № | University | Full-time (Undergraduate) | Evening | Part-time (Extramural) | Distance Learning | Master's and Other Modes | Total  |
|---|------------|---------------------------|---------|------------------------|-------------------|--------------------------|--------|
| 1 | NUUZ       | 14 804                    | 1 974   | 5 151                  | 1 769             | 1 522                    | 25 220 |
| 2 | ASU        | 6 801                     | 581     | 2 374                  | 714               | 393                      | 10 863 |
| 3 | BSU        | 7 382                     | 1 331   | 3 577                  | 553               | 503                      | 13 346 |
| 4 | SamSU      | 8 237                     | 1 801   | 1 680                  | 608               | 889                      | 13 215 |

Differences between current student enrolment figures reported through HEMIS and those published in university reports as of specific dates are to be expected. For instance, according to official information

<sup>3</sup> Source: Compiled based on official data from the National Statistics Committee of the Republic of Uzbekistan.

<sup>4</sup> Source: Educational statistics retrieved from the Higher Education Management Information System (HEMIS).

published by Bukhara State University, 20,537 students were enrolled in 85 undergraduate programmes during the 2024/2025 academic year. Meanwhile, the university's official report for the end of 2025 indicated that its student population exceeded 19,000 and that 25 new academic specialisations had been introduced in fields such as information technology and artificial intelligence. Since these differences may arise from variations in reporting dates, levels of education, and statistical coverage, it is essential to specify the reference dates and methodological approaches used when presenting these data in the study.

The digital transformation model of the National University of Uzbekistan is primarily determined by its large-scale and multidisciplinary institutional structure. HEMIS data indicate that more than 25,000 students are enrolled across different modes of study, highlighting the importance of managing academic information within an integrated digital environment. For the National University of Uzbekistan, the potential benefits of digital transformation should be assessed not merely by the number of electronic services available but by the extent to which the principle of "single data entry and multiple uses" is implemented. If students' personal information, course enrolment records, academic credits, grades, and academic status are repeatedly entered and maintained in separate databases by different administrative units, the transaction-related efficiency gains from digitalisation remain limited. Conversely, when primary data are automatically made available to academic departments, faculties, accounting units, university management, and statistical reporting systems, digital integration can generate tangible economic benefits.

Given its location in a densely populated part of the Fergana Valley, Andijan State University's digital transformation model places particular emphasis on the scalability of educational and administrative services. The total number of students enrolled in higher education institutions across Andijan region increased from 30,895 in 2020 to 65,726 in 2025. According to the university's HEMIS profile, Andijan State University has 10,863 enrolled students, including 714 undergraduate students pursuing distance education. This indicates that digital technologies can reduce the constraints imposed by physical university infrastructure on students' access to educational services.

In Fergana region, the total student population increased from 48,400 to 98,900, while undergraduate admissions reached 25,625 in 2025. This expansion suggests that a key potential economic function of digitalisation at Fergana State University is associated with managing large-scale academic and administrative processes. As student enrolment increases, the marginal costs of serving additional users through electronic applications, automated assessment systems, electronic certificates, digital learning content, and remote consultations may rise more slowly than the corresponding costs of traditional service delivery. Therefore, performance indicators such as the number of students served per employee, the proportion of academic services delivered electronically, and the average time required to process a student request are particularly relevant for evaluating the effectiveness of digital transformation at Fergana State University.

In Samarkand region, the total number of students increased from 54,827 in 2020 to 93,871 in 2025. According to official university data, 12,021 students were enrolled in full-time programmes at Samarkand State University during the 2020/2021 academic year. Current HEMIS data, however, indicate the simultaneous provision of full-time, evening, part-time (extramural), and distance education programmes. This institutional structure highlights the importance of digital transformation in managing a hybrid academic environment at Samarkand State University. Where multiple modes of study coexist, digital platforms need to ensure that students have access to consistent academic standards, educational resources, and assessment and monitoring mechanisms.

Among the selected regions, Kashkadarya recorded the highest growth in student enrolment, with the total number of higher education students increasing from 27,835 in 2020 to 111,562 in 2025. These developments highlight two key priorities for digital transformation at Karshi State University. First, the rapidly expanding regional higher education market increases the need to automate administrative services. Second, the use of digital data creates opportunities to align students' competencies with the requirements of the regional labour market in Kashkadarya.

In Bukhara region, the 230.3% increase in total student enrolment and the 279% growth in undergraduate admissions indicate a rapidly increasing demand for digital management solutions. In the case of Bukhara State University, an important feature of digitalisation is its contribution to the diversification of educational service delivery across different modes of study. HEMIS data record 7,382 full-time, 1,331 evening, 3,577 part-time (extramural), and 553 distance-learning undergraduate students. Within this structure, digital technologies enhance opportunities for the reuse of educational resources. For example, the same electronic learning materials can be delivered to full-time, evening, and distance-learning groups at different times, thereby improving resource utilisation.

In Khorezm region, the total student population increased from 22,787 in 2020 to 65,944 in 2025. According to official information published by Urgench State University for 2025, the institution had more than 25,000 students, including 24,251 undergraduate students, 825 master's students, and 201 doctoral students. The

geographical location of Urgench State University gives digitalisation an additional economic function. Online academic seminars, electronic databases, virtual laboratories, remote consultations, and online lectures delivered by international professors can reduce the travel, time, and organisational costs associated with accessing educational and research resources located in Tashkent or abroad.

The findings of the analysis provide a basis for explaining the impact of digital transformation on the efficiency of higher education services through a sequential five-stage mechanism: digital capital → data integration → process automation → resource and transaction cost savings → educational outcomes. These stages can be explained as follows.

First, digital capital is established through investments in servers, internet infrastructure, Learning Management Systems (LMS), HEMIS, electronic libraries, and other digital resources.

Second, previously fragmented data are integrated into a unified digital environment.

Third, repetitive academic and administrative processes, including course enrolment, attendance monitoring, assessment, reporting, application processing, and other routine activities, are automated.

Fourth, the automation and integration of these processes generate time savings and reduce administrative resource requirements.

Fifth, digital transformation can be considered economically effective when the resulting resource savings contribute to improvements in teaching quality, educational coverage, or graduate outcomes.

The analysis also enabled a comparative assessment of the priority areas of digital transformation across the seven higher education institutions selected for the study (see Table 5).

**Table 5. Digital Transformation Approaches in Domestic Higher Education Institutions and Their Impact on Efficiency<sup>5</sup>**

| No. | University                               | Regional Trend                                        | Leading Digital Transformation Model | Main Efficiency Channel                                                     |
|-----|------------------------------------------|-------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------|
| 1   | National University of Uzbekistan (NUUz) | Large market and intense competition                  | Scale-based integration              | Standardisation of administrative processes                                 |
| 2   | Andijan State University (ASU)           | High population density and growing student enrolment | Digital service coverage             | Large-scale electronic service delivery                                     |
| 3   | Fergana State University (FSU)           | Large higher education market                         | Economies of scale                   | Reduction of transaction costs per student                                  |
| 4   | Samarkand State University (SamSU)       | Stable and large educational market                   | Hybrid academic model                | Integration of different modes of study                                     |
| 5   | Karshi State University (KSU)            | Fastest-growing regional market                       | Dynamic digital management           | Supporting enrolment growth while limiting additional resource requirements |
| 6   | Bukhara State University (BSU)           | Rapid growth and diverse modes of study               | Multichannel digital services        | Reuse of existing resources                                                 |
| 7   | Urgench State University (UrSU)          | Geographical distance from the centre                 | Mitigation of distance-related costs | Remote access to resources                                                  |

Nevertheless, digitalisation does not automatically lead to greater efficiency. If student information must be entered separately into HEMIS, faculty databases, departmental records, and other electronic systems, existing administrative procedures may be replicated in electronic form without corresponding efficiency gains. Under

<sup>5</sup> Source: Compiled by the author based on a comparative analysis of official statistical data and HEMIS records.

such circumstances, despite the availability of digital technologies, employees' administrative and transaction-related workloads may remain unchanged or even increase.

Therefore, the level of digital transformation should be assessed not by the number of digital systems implemented but by indicators such as the degree of primary data reuse across platforms, the extent of automated data exchange, and the proportion of processes requiring manual intervention (see Table 6). This set of indicators provides a basis for evaluating digitalisation not merely as an input resource but as a productive factor that contributes to measurable institutional outcomes.

**Table 6. Proposed Indicator Framework for Assessing the Effectiveness of Digital Transformation in Higher Education Institutions<sup>6</sup>**

| No. | Efficiency Dimension | Indicator                                    | Expected Direction of Change            |
|-----|----------------------|----------------------------------------------|-----------------------------------------|
| 1   | Administrative       | Administrative expenditure per student       | ↓ – Reduction in costs                  |
| 2   | Administrative       | Processing time per electronic request       | ↓ – Reduction in processing time        |
| 3   | Digital              | Share of electronic services                 | ↑ – Expansion of service provision      |
| 4   | Digital              | Degree of inter-platform integration         | ↑ – Strengthening of integration        |
| 5   | Academic             | Student academic achievement rate            | ↑ – Improvement in academic performance |
| 6   | Academic             | Share of students with academic arrears      | ↓ – Reduction in academic arrears       |
| 7   | Academic             | Intensity of electronic content usage        | ↑ – Increased utilisation               |
| 8   | Accessibility        | Coverage of distance and hybrid education    | ↑ – Expansion of educational coverage   |
| 9   | Labour               | Number of students served per faculty member | Optimisation                            |
| 10  | Labour Market        | Graduate employment rate                     | ↑ – Increase in employment              |
| 11  | Quality              | Speed of response to student enquiries       | ↑ – Faster response times               |
| 12  | Resources            | Reuse coefficient of electronic resources    | ↑ – Increased resource utilisation      |
| 13  | Management           | Share of KPIs monitored in real time         | ↑ – Enhanced real-time monitoring       |
| 14  | Innovation           | Digital educational products and start-ups   | ↑ – Increased innovation activity       |

Overall, the higher education markets in all regions where the selected universities are located expanded significantly between 2020 and 2025. However, differences in growth rates, ranging from 71.2% to 300.8%, indicate that the regional demand for digital transformation varies considerably. In the fastest-growing regions of Kashkadarya and Bukhara, digitalisation primarily contributes to the scalability of higher education services, whereas in Tashkent city, its main functions are associated with addressing competitive pressures and integrating large student populations into unified management systems. In Khorezm, its added value is reflected in mitigating geographical distance-related constraints; in Fergana and Andijan, in facilitating large-scale service delivery; and in Samarkand, in coordinating academic processes across multiple modes of study.

From this perspective, assessing the effectiveness of digital transformation through a single technical indicator presents methodological limitations. A more appropriate approach should focus on identifying which resource constraints digital technologies help overcome, which transaction costs they reduce, and which educational outcomes they influence within each higher education institution.

## CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the statistical analysis of the seven selected higher education institutions in Uzbekistan and their respective regions provides a basis for conceptualising digital transformation not merely as the digitalisation of existing educational services but as a comprehensive organisational and economic mechanism. This mechanism integrates educational resources, student populations, academic staff activities, academic information, and regional infrastructure within a unified digital ecosystem. Such integration can contribute to improving educational outcomes per unit of resources while mitigating the constraints associated with institutional scale, geographical distance, and transaction costs.

Based on the findings of the analysis, the following scientific conclusions were formulated.

<sup>6</sup> Source: Developed by the author.

First, Bukhara region stands out in terms of undergraduate admission dynamics, with new enrolments increasing from 11,100 to 42,100 students, representing a 3.79-fold increase over five years. This development highlights the growing need for digital student onboarding at Bukhara State University, including the automation of electronic student identification, the creation of individual student accounts, enrolment in academic programmes, and the coordination of tuition payment and contractual procedures throughout the transition from admission to academic participation.

Second, in Tashkent city, the number of newly admitted students increased from 48,400 to 156,900. Such a substantial volume of admissions elevates the role of digital administrative services beyond that of a tool for operational convenience, making them an essential component of the infrastructure required to maintain institutional and operational stability.

Third, in Kashkadarya region, the number of newly admitted students declined from 27,386 in 2024 to 16,014 in 2025. This development indicates that digital management systems must be capable of accommodating not only sustained enrolment growth but also considerable fluctuations in admission volumes. Accordingly, the capacity of digital platforms should be assessed not solely in relation to the existing student population but also in terms of their ability to accommodate peak workloads.

## References

1. President of the Republic of Uzbekistan. Decree No. PF-5847 of 8 October 2019 "On Approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030". — URL: <https://lex.uz/uz/docs/-4545884>
2. President of the Republic of Uzbekistan. Decree No. PF-6079 of 5 October 2020 "On Approval of the Digital Uzbekistan – 2030 Strategy and Measures for Its Effective Implementation". — URL: <https://lex.uz/uz/docs/-5030957>
3. Higher Education Statistics Portal. Student Enrolment by Mode of Study at Higher Education Institutions. — Higher Education Management Information System (HEMIS). — URL: <https://stat.edu.uz/tables/otmlar/uni-edu-form>
4. National Statistics Committee of the Republic of Uzbekistan. Oliy ta'lim tashkilotlarining bakalavriatiga qabul qilingan talabalar [Undergraduate Admissions to Higher Education Institutions]. — SIAT Statistical Database, 2020–2025. — URL: <https://siat.stat.uz/data/1358/>
5. National Statistics Committee of the Republic of Uzbekistan. Oliy ta'lim tashkilotlarini bitiruvchi talabalar soni (jami) [Total Number of Higher Education Graduates]. — SIAT Statistical Database, 2020–2025. — URL: <https://siat.stat.uz/data/694/>
6. National Statistics Committee of the Republic of Uzbekistan. Oliy ta'lim tashkilotlarida talabalar soni (jami) [Total Student Enrolment in Higher Education Institutions]. — SIAT Statistical Database, 2020–2025. — URL: <https://siat.stat.uz/data/1357/>
7. OECD. OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem. — Paris: OECD Publishing, 2023. — 414 p. — URL: <https://doi.org/10.1787/c74f03de-en>
8. UNESCO. Global Education Monitoring Report 2023: Technology in Education — A Tool on Whose Terms? — Paris: UNESCO, 2023. — URL: <https://unesdoc.unesco.org/ark:/48223/pf0000385723>
9. Verhoef P. C., Broekhuizen T., Bart Y., Bhattacharya A., Dong J. Q., Fabian N., Haenlein M. Digital Transformation: A Multidisciplinary Reflection and Research Agenda // Journal of Business Research. — 2021. — Vol. 122. — P. 889–901. — URL: <https://doi.org/10.1016/j.jbusres.2019.09.022>
10. Vial G. Understanding Digital Transformation: A Review and a Research Agenda // The Journal of Strategic Information Systems. — 2019. — Vol. 28, No. 2. — P. 118–144. — URL: <https://doi.org/10.1016/j.jsis.2019.01.003>

**Proofreader:** Zokir ALIBEKOV

**Layout and Designer:** Oloviddin Sobir ugli

---

## **2026. № 10**

---

© When materials are reproduced, the INNOVATION SCIENCE AND TECHNOLOGY journal must be cited as the source. Authors are responsible for the accuracy of the information in materials and advertisements published in the journal. Editorial opinions may not always align with those of the authors. Submitted materials will not be returned to the editorial office.

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot\_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

**Our address:** Tashkent city, Yunusobod district, 19th block,  
House 17.



### Acceptance of articles

Published every  
monthly



### Directions

Social, economic, political,  
technological, scientific



Scopus || Scientific electronic journal specializing in Scopus

**CERTIFICATE NUMBER: №390637**

**ORDER NUMBER ACCORDING TO  
THE LICENSE REGISTER: C-5669633**

### CONTACT:



Contact us  
**+998 50 737 87 88**



Telegram channel  
**t.me/scopus\_IST2100**



Journal official website  
**<https://ist-journal.uz/index.php/IST>**