

-RESEARCH ARTICLE-

## ASSESSMENT OF THE DIGITALIZATION LEVEL OF EDUCATION IN THE REPUBLIC OF KAZAKHSTAN

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### —Abstract—

As nations increasingly adopt digital-first economic models, the extent of digitalisation within educational systems has emerged as a key factor influencing national competitiveness and the development of human capital. This research evaluates the digitalisation of Kazakhstan’s education system over the period 2018–2024. A factor-point method was employed across 16 indicators, organised into three categories: financial, quantitative, and monetary. Annual indexes were calculated using normalization procedures combined with the geometric mean. The dataset, obtained from the Bureau of National Statistics of Kazakhstan, encompasses all education levels, from preschool through tertiary education. Findings indicate that the overall education sector achieved an "acceptable" digitalisation score of 0.591, with higher education serving as the principal driver of digital transformation. Econometric analysis further suggests that a 1% rise in ICT expenditure is associated with a 2.15% increase in GDP.

**Keywords:** Digitalization of Education; Education Digital Transformation; Kazakhstan Education System; Econometric Analysis; ICT Investment in Education; Human Capital Development; Economic Growth and Education; Educational Technologies (EdTech); Artificial Intelligence in Education; Blockchain in Education.

## INTRODUCTION

The extent of digitalisation in education constitutes a crucial determinant of systemic quality and national development in Kazakhstan. Within this framework, it is important to differentiate between informatization—the preliminary phase involving the provision of hardware and foundational digital tools—and digitalisation, which entails a profound transformation of educational practices through integrated technological applications. Progress in information and communication technologies (ICT) is essential for enhancing management, learning, and productivity across public sectors. This study is grounded in Human Capital Theory, which asserts that investments in education and technology directly improve labour force productivity (Becker, 1993). The notion of human capital has been elaborated over decades by numerous international and domestic economists (Schulz, 1961). Through their contributions, the concept has evolved in recent years towards the "knowledge economy," offering a more comprehensive understanding of education’s increasing role as a source of intellectual capital in contemporary society (Marginson, 2009).

Digitalization functions as a developmental catalyst, enhancing university

competitiveness and fostering novel educational models, including hybrid learning and digital campuses. By reducing operational costs and expanding accessibility, digital transformation establishes a higher-quality equilibrium across the socio-economic system (Katrin, 2022). The central aim of this research is to quantitatively measure the level of digitalisation across all tiers of Kazakhstan's education system, encompassing preschool, secondary, technical, and tertiary institutions. Employing a factor-point methodology alongside an elasticity-based macroeconomic model, the study seeks to deliver empirical insights into the effectiveness of ICT investments and their impact on national Gross Domestic Product (GDP). The findings, coupled with the proposed software framework, provide actionable insights for multiple stakeholders. Government bodies, particularly the Ministry of Science and Higher Education and the Ministry of Education of the Republic of Kazakhstan, may leverage these results to inform targeted ICT investment and policy initiatives. Likewise, educational administrators can apply the reproducible algorithm to monitor digitalisation progress within their institutions and identify infrastructural deficiencies.

However, the rapid integration of digital teaching practices has also produced unintended effects. A large-scale survey of over 6,600 university students in Peru revealed that, although digitalisation increased flexibility and accessibility, it also heightened stress from cognitive overload, diminished interpersonal interaction, and introduced ongoing technological challenges. These outcomes highlight the necessity of designing virtual education strategies that balance operational efficiency with student well-being (Norabuena-Figueroa et al., 2025). Additionally, research on gamification in introductory programming courses indicated gender-specific responses: male students benefited more from gamified approaches, while female students performed better under traditional methods. This underscores the importance of tailoring gamification strategies, advocating for blended or customisable models to promote equity in ICT-based education (Mellado et al., 2024).

## LITERATURE REVIEW

International research indicates that the EdTech and digital education market surpassed \$300 billion in 2023 and continues to expand. The most significant advancements are observed in North American and East Asian countries, where infrastructure is well-established and national strategies for educational digitalisation are actively implemented. Nevertheless, developing nations are also increasing their engagement, perceiving digital technologies as a means to reduce educational inequality. Consequently, the digital transformation of education represents a long-term strategic initiative rather than a temporary trend, influencing both national competitiveness and the future quality of human capital. The "Digital Russia" index provides a structured framework for evaluating regional digitalisation, enabling comparisons across various economic sectors, including education, and offering a useful benchmark for Kazakhstan's ongoing digital reforms (Moscow School of Management SKOLKOVO, 2018). Similarly, a comprehensive assessment of Russian universities highlighted by

(Plotnikova et al., 2019) demonstrates that uneven institutional development necessitates integrated strategies for ICT adoption to maintain sustainable competitiveness in higher education.

Artificial intelligence (AI) is increasingly recognised as a transformative educational technology, with applications in higher education spanning profiling and prediction, assessment and evaluation, adaptive learning systems, and intelligent tutoring systems, although the field still shows limited critical reflection on pedagogical and ethical implications (Zawacki-Richter et al., 2019). Alongside AI, research on virtual reality (VR) technologies highlights strong potential for immersive learning across multiple disciplines; however, existing studies note gaps in the integration of learning theories, limited focus on learning outcomes, and the predominance of experimental rather than routine educational use (Radianti et al., 2020). The concept of digital pedagogy, as discussed by Buzaubakova et al. (2022), underscores the systematic integration of digital tools into education to improve student engagement, learning efficiency, and inclusivity. The expansion of Big Data creates significant opportunities for discovering hidden patterns and heterogeneity in large-scale datasets, but the high dimensionality and massive sample sizes also introduce substantial computational and statistical challenges that require new analytical paradigms (Fan et al., 2014; Sivarajah et al., 2017). Within the Kazakhstani context, universities are actively integrating digital technologies and online platforms to enhance the management and delivery of educational processes, expanding access to learning resources while simultaneously facing challenges related to infrastructure, technical support, and data security (Nurtayeva et al., 2024; Nazyrova et al., 2025). This trend also raises important information security concerns in remote education environments, where unauthorized access to learning systems may compromise valuable educational data, highlighting the critical role of robust user authentication mechanisms (Gurina & Modestov, 2013).

Early analyses of ICT integration in higher education across CIS and Baltic countries have documented both progress and persistent gaps in infrastructure and digital skills, highlighting structural barriers that continue to influence the region's capacity for educational modernisation (GUAP, 2009). Pecherskaya et al. (2020) developed the "University + Employer" information module to enhance interaction between universities, students, and employers, showing a fourfold increase in graduate employment efficiency compared with older database systems. Research by (Samusevych et al. 2020) examined the convergence of the "economy-education-digitalization-national security" chain, revealing that in a limited number of countries, substantial alignment exists between economic, educational, and digital development. However, existing studies present several limitations:

- Education is not conceptualised as an integrated system with feedback mechanisms among its components.
- Analyses often focus on isolated aspects of educational development rather than system-wide dynamics.

- The digitalisation of the economy and industry is prioritised over the education sector, underestimating the importance of allocating resources for comprehensive ICT integration in teaching and learning.
- Research largely remains theoretical, with insufficient quantitative assessment of education's role in human capital formation and economic outcomes.

Recent studies affirm that evaluating both the benefits and risks of digitalisation in education is complex. Informatization is considered a prerequisite to full digitalisation, rendering analyses of state-level initiatives academically and policy-relevant. ICTs are especially critical in areas characterised by weak institutional structures, as digitalisation in such contexts can improve system stability and enhance governance efficiency ([Government of the Republic of Kazakhstan, 2024](#)). In Kazakhstan, the level of educational digitalisation directly influences improvements in learning quality. Greater digitalisation increases the likelihood of achieving global competitiveness, provided that policies are effectively designed. Furthermore, advances in ICTs can enhance productivity and effectiveness across industrial, managerial, and educational sectors, establishing a higher qualitative equilibrium. Analyses confirm that educational digital transformation is a global trend determining national competitiveness. Nonetheless, successful digitalisation requires not only technological deployment but also:

- Legal safeguards and cybersecurity.
- Reduction of digital inequality.
- Investments in infrastructure and personnel.
- Political commitment and governmental support.

[Gapsalamov et al. \(2020\)](#) investigated the influence of the digital era on education and the economy in leading countries, aiming to identify challenges in introducing digital technologies and propose improvements. Their findings show that government agencies are the primary drivers of educational digitalisation worldwide, exemplified by Germany's Digital Package (€5 billion, 2018–2022), Australia's ICT modernisation programs (USD 2.2 billion plus additional STEM investments), South Korea's billion-dollar initiatives including Smart Education and nationwide school Wi-Fi, Switzerland's investments in educational innovation and start-ups, and Finland's integration of national digital competence strategies into school curricula. ([Ashtikar and Manoharan, 2020](#)) examined digital transformation in India's higher education system, highlighting pedagogical challenges and opportunities. The Indian education system, affected by historical governance issues and inefficiencies, experienced accelerated digitalisation due to the COVID-19 pandemic. They argue that successful transformation requires comprehensive integration of technologies. Digital transformation is advancing across all educational levels, with higher education being particularly critical. Digitalisation enhances the quality of educational services, boosts university competitiveness, and facilitates new learning models such as online courses, hybrid learning, and digital campuses. Economic benefits include reduced costs,

expanded access, and creation of new revenue sources (Modernizing the Higher Education System through Digital Technologies: An Analysis of Economic Efficiency). (Maltseva et al., 2022) assessed how e-learning platforms shape youth competencies, emphasising that social and cultural dimensions must accompany technological change. Azarov and Chekmarev (2022) highlighted the COVID-19 pandemic as a catalyst for rapid adoption of digital tools and higher education models.

Globally, digital transformation has become a pressing priority, accelerated by the pandemic, which disrupted learning for over 1.5 billion students across 190 countries and underscored the necessity of digital tools for educational continuity (Kermanidis et al., 2025). International organisations such as UNESCO, the World Bank, and OECD support this transition through initiatives including Digital School and Education for All, emphasising that the digital economy requires not only technical proficiency but also critical thinking, communication, and adaptability to new societal realities (Cravero et al., 2024). Despite the expanding literature on digital pedagogy, research in Kazakhstan reveals persistent gaps. Education is rarely approached as an integrated system with internal feedback mechanisms. Studies tend to prioritise the digitalisation of the economy, overlooking the specific structural and financial requirements of the education sector. Quantitative analyses linking educational digitalisation to macroeconomic outcomes, such as human development and GDP, are scarce. This study addresses these gaps by providing the first empirical econometric evidence on the efficiency of digitalising education in Kazakhstan.

## MATERIALS AND METHODS

To measure the extent of educational digitalisation in the Republic of Kazakhstan, sixteen indicators were identified and organised into three separate categories: financial-economic activity, quantitative system characteristics, and monetary expenditures on ICT development. The dataset for these indicators was obtained from the Bureau of National Statistics of the Republic of Kazakhstan covering the years 2018–2024. The first category includes the indicators presented in Table 1.

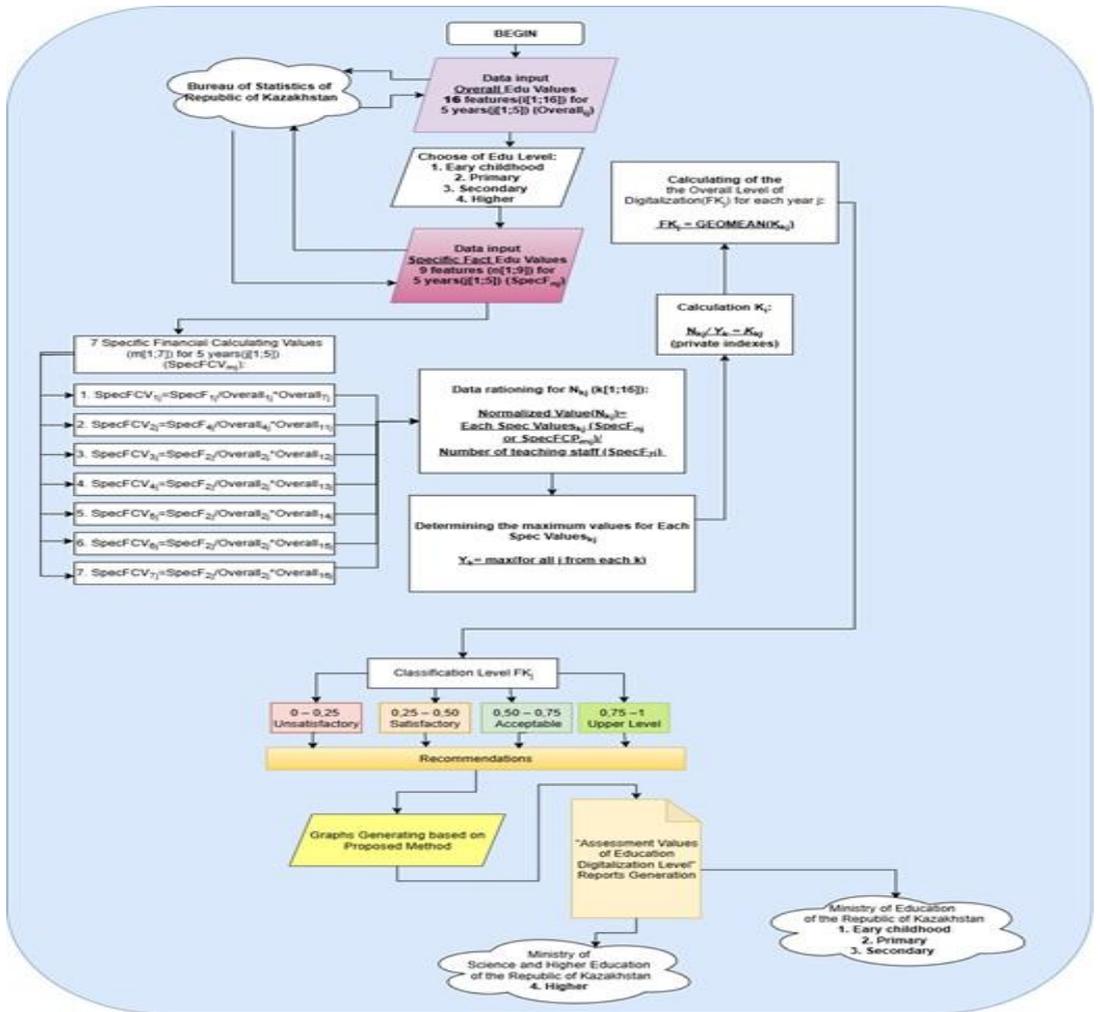
**Table 1: Classification of Indicators for Assessing Education Digitalization**

No.	Group	Indicator	Unit of Measurement
1	Group 1: Financial & Economic Activity	Volume of Services Provided	Thousand Tenge
2		Total Expenses	Thousand Tenge
3		Depreciation Expenses	Thousand Tenge
4		Fixed Assets Availability	Million Tenge
5		Intangible Assets Availability	Million Tenge
6		Investments in Education	Thousand Tenge
7	Group 2: Quantitative Characteristics	Number of Educational Institutions	Units
8		Number of Students	Persons
9		Number of Graduates	Persons
10		Number of Teaching Staff	Persons

**Table 1: Classification of Indicators for Assessing Education Digitalization (cont...)**

11		Student Enrolment	Persons
12	Group 3: Monetary ICT Development	Total ICT Costs	Thousand Tenge
13		Software Licensing Costs	Thousand Tenge
14		Internal Software Development Costs	Thousand Tenge
15		ICT-Related Employee Training Costs	Thousand Tenge
16		Third-Party IT Service Costs	Thousand Tenge

The analysis of the data was conducted through a multi-step econometric procedure, which involved normalising the raw data, converting values into dimensionless form using row maxima, and computing a geometric mean index (Kt) to maintain equal weighting across all factors. Figure 1 presents a block diagram illustrating the algorithm for assessing educational digitalisation by constructing a factor-point scale.



**Figure 1: Block-Diagram of Algorithm Calculating Education Digitalization Level**

To evaluate the level of digitalisation within the education system, a factor-point methodology was employed. The analysis utilises sixteen indicators, organised into three categories:

1. Financial and economic operations of educational institutions.
2. Quantitative features of the education system.
3. Investments in ICT and digitalisation initiatives.

Let  $X_{r,t}$  denote the raw value of indicator  $r \in \{1, \dots, 16\}$  for year  $t \in \{2018, \dots, 2024\}$ . Each indicator was normalized relative to a denominator  $D_{r,t}$ , usually the number of teaching staff ( $r=9$ ), yielding dimensionless values:

$$N_{r,t} = \frac{X_{r,t}}{D_{r,t}} \quad (1)$$

Following the implementation of the software, specific exceptions were applied:  $d(12) = 14$ ,  $d(13) = 15$ ,  $d(15) = 11$ , and  $d(16) = 11$ .

To ensure comparability across indicators, all values were rescaled relative to their respective row maxima.

$$U_{r,t} = \frac{N_{r,t}}{\max_t N_{r,t}}, U_{r,t} \in [0,1] \quad (2)$$

The yearly digitalisation index was calculated as the geometric mean of the sixteen rescaled indicators.

$$K_t = \left( \prod_{r=1}^{16} U_{r,t} \right)^{\frac{1}{16}} \quad (3)$$

This approach minimises the influence of extreme values and guarantees that all factors are equally weighted. Temporal changes were monitored using absolute differences, percentage growth rates, and the geometric mean across years.

$$\Delta K = K_{2024} - K_{2018} \quad (4)$$

$$\% \Delta K = \frac{K_{2024}}{K_{2018}} - 1 \quad (5)$$

$$\bar{K} = \left( \prod_{t=2018}^{2024} K_t \right)^{\frac{1}{5}} \quad (6)$$

For the purpose of interpreting the results, four distinct classification bands were established:

- $0 < K_t < 0.250$  = Unsatisfactory digitalization, urgent interventions required.
- $0.251 \leq K_t \leq 0.500$  = Satisfactory, expansion of competencies required.
- $0.501 \leq K_t \leq 0.750$  = Acceptable, programmatic improvements required.
- $0.750 < K_t \leq 1.000$  = High, consolidation of achieved level.

Finally, an elasticity-based macroeconomic model was employed to examine the relationship between ICT expenditures and outcomes in human development and GDP.

$$\Delta IND_i = KE_i \cdot \Delta Z_i \quad (7)$$

$$\Delta IND_{glob} = \sum_i \alpha_i \cdot \Delta IND_i \quad (8)$$

$$\Delta IND_{hg} = \beta \cdot \Delta IND_{glob} \quad (9)$$

$$\Delta GDP = \gamma \cdot \Delta IND_{hg} \quad (10)$$

Once the final index is determined, the recommendation system provides tailored solutions aimed at enhancing the level of digitalisation or increasing the Kij index. The results are visualised through HTML-based graphs, allowing users to intuitively review current digitalisation indicators. Additionally, the analysis can be exported as a PDF report for further reference. The developed software also offers features that facilitate efficient and user-friendly data management. Notably, it supports the integration of Excel files (xlsx), which are automatically processed by the system. This functionality eliminates manual data entry, reducing time consumption and minimising the likelihood of errors during the evaluation process. Imported data undergoes the same computational procedures with minimal user intervention, ensuring a more intuitive and automated workflow.

To perform an economic assessment of digital transformation within Kazakhstan's education sector, a system of interrelated economic and mathematical models is constructed, incorporating the digitalisation factor to the greatest extent possible. The following fundamental formulas (11)–(15) are applied:

A macroeconomic model is formulated to examine the relationship between gross domestic product (GDP) and factors including investment in fixed capital (IFC), total employment in the economy (EMPE), and the human development index (HDI).

$$GDP = IFC \cdot EMPE \cdot HDI \quad (11)$$

Where,

GDP= Gross domestic product.

IFC= Investment in fixed capital.

EMPE= Number of employees in the economy.

HDI= Human development index.

### Model of the Global Index of the Quality of Specialist Personnel

This index represents a comprehensive indicator reflecting the overall quality generated through the interconnected links of the education system. Accordingly, the model is constructed as a multifactor function of quality indices corresponding to each component of the education system. Calculations are performed based on the outcomes

derived from formula (7).

$$ND_{glob} = IND_1 \cdot IND_2 \cdot IND_3 \cdot IND_4 \quad (12)$$

Where,

IND1= Indicator of the quality of preschool preparation in the preschool link of the education system.

IND2 = Indicator of the quality of education in secondary education.

IND3 = Indicator of the quality of training of professional personnel in Technical and vocational education.

IND4= Indicator of the quality of training of specialist personnel in higher and postgraduate education.

A Model of the Human Development Index is Constructed Based on a Factor Representing the Overall Quality of Specialist Personnel

$$HDI = IND_{glob} \quad (13)$$

Where,

INDglob = Global index of the quality of specialist personnel (or global index of the quality of the education system).

Models of Quality Indicators By the Links of the Education System

Calculations of the model parameters are carried out on the basis of the same program of statistical data processing using time series of indicators of the development of the education system links, according to the formula for each indicator:

$$IND_n = DO(3 - 6) \cdot Z_{do} \quad (14)$$

Where,

DO (3-6)= Share of children aged 3-6 covered by preschool preparation.

Zdo = Expenditures on ICT technologies in preschool education.

A 1= Percent increase of each quality indicator  $\Delta IND_n$  (1%) is determined.

Next, an assessment of the contribution of all quality indicators is carried out:

$$\Delta IND_{glob} = \Delta IND_1 + \Delta IND_2 + \dots \Delta IND_n \quad (15)$$

Subsequently, the parameters of the econometric model were estimated using the data provided in [Table 2](#). A standard statistical analysis software operating in the Windows environment was employed, enabling implementation of the classical least squares method. These computations allowed for the identification of the optimal model, which

is expressed in the following form.

**Table 2: Dynamics of Macro-Indicators of Development of the Republic of Kazakhstan**

Years	GDP, Billion Tenge	IFC, Billion Tenge	EMPE, Thousand Tenge	HDI
1	2	3	4	5
2010	21 815,5	4 653,5	8 114,2	0,714
2011	28 243,0	5 010,2	8 301,6	0,745
2012	31 015,2	5 473,2	8 507,1	0,754
2013	35 999,0	6 072,7	8 570,6	0,754
2014	39 675,8	6 591,5	8 510,1	0,757
2015	40 884,1	7 024,7	8 433,3	0,788
2016	46 971,1	7 762,3	8 553,4	0,794
2017	5 4378,9	8 770,6	8 585,2	0,800
2018	61 819,5	11 179,0	8 695,0	0,817
2019	69 532,6	12 576,8	8 780,8	0,825
2020	69 547,1	12 332,7	8 732,0	0,827

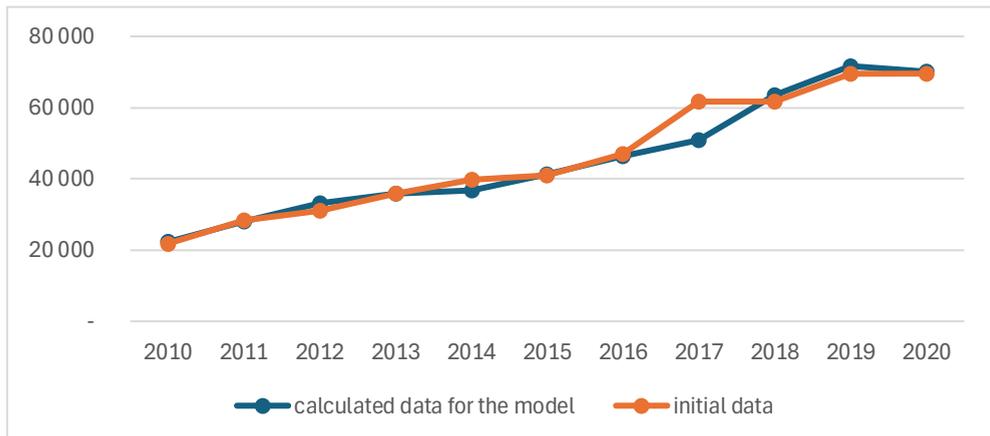
**Note:** Compiled based on national statistical collections *Statistics of the Education System of the Republic of Kazakhstan* for 2012–2020 (Bureau of National Statistics of the Republic of Kazakhstan).

### A MACROMODEL OF THE DEPENDENCE OF THE GROSS DOMESTIC PRODUCT (GDP) ON THE FACTORS OF INVESTMENT IN FIXED CAPITAL (IFC), EMPLOYMENT IN THE ECONOMY (EMPE), AND THE HDI (FORMULA 11)

Calculations using the indicators from [Table 3](#) will take the following form:

$$\text{GDP} = 24,42 \times \text{IFC}^{0,491} \times \text{TR}^{3,469} \times \text{IND}_{\text{hg}}^{2,806} \quad (16)$$

[Figure 2](#) presents a graphical illustration of the approximation capabilities of the model.



**Figure 2: Graphical Illustration of the Approximation Capabilities of the Model**

The coefficient of determination was calculated as  $R^2 = 0.953$ , indicating a near-functional relationship between the primary indicator and the associated development factors. Moreover, the graphical representation in [Figure 2](#) demonstrates that the model closely approximates the original data with a high level of accuracy. These results support the model's suitability for use in forecasting and analytical applications.

## MODEL OF THE GLOBAL INDEX OF THE QUALITY OF SPECIALIST PERSONNEL

This index serves as a comprehensive, resultant measure of the quality formation across the interconnected components of the education system. Consequently, its model is formulated as a multifactor function based on the quality indices of each educational subsystem. [Table 3](#) displays the indicators used to construct the model for the global index of specialist personnel quality.

**Table 3: Dynamics of the Values of Quality Indicators By the Links of the Education System, %**

Years	IND1	IND2	IND3	IND4	INDglob
1	2	3	4	5	6
2010	0,99920	0,792	0,616	0,754	0,36756
2011	0,99930	0,831	0,613	0,756	0,38484
2012	0,99938	0,851	0,667	0,760	0,43112
2013	0,99940	0,852	0,681	0,766	0,44418
2014	0,99951	0,851	0,705	0,768	0,46054
2015	0,99971	0,850	0,696	0,759	0,46489
2016	0,99976	0,849	0,695	0,770	0,47493
2017	0,99980	0,847	0,696	0,779	0,49914
2018	0,99983	0,852	0,694	0,781	0,53272
2019	0,99985	0,857	0,697	0,795	0,56481
2020	0,99990	0,858	0,411	0,827*	0,57612

**Note:** Compiled based on national statistical collections *Statistics of the Education System of the Republic of Kazakhstan for 2012–2020* (Bureau of National Statistics of the Republic of Kazakhstan).

The calculations carried out using the data from [Table 4](#) made it possible to identify the following model (formula 12 transformed):

$$IND_{glob} = 0,468 \times IND1^{491,63} \times IND2^{0,062} \times IND3^{0,337} \times IND4^{-0,227} \quad (17)$$

Where,

IND1= Indicator of the quality of preschool preparation in the preschool link of the education system.

IND2= Indicator of the quality of education in secondary education.

IND3= Indicator of the quality of training of professional personnel in Technical and

vocational education.

IND4= Indicator of the quality of training of specialist personnel in higher and postgraduate education.

## MODEL OF THE HUMAN DEVELOPMENT INDEX BASED ON THE FACTOR: THE GLOBAL INDICATOR OF THE QUALITY OF SPECIALIST PERSONNEL

The computations were performed using the relevant data from [Tables 3](#) and [4](#). The resulting model is expressed in the following form (transformed formula 13):

$$\text{HDI} = 0,518 + 0,5545 \times \text{IND}_{\text{glob}} \quad (18)$$

Where,

INDglob = Global index of the quality of specialist personnel (or global index of the quality of the education system).

## MODELS OF QUALITY INDICATORS BY THE LINKS OF THE EDUCATION SYSTEM

Using the time series data for the development indicators of the education system's components, the model parameters were estimated through statistical analysis, as summarised in [Table 4](#).

**Table 4: Dynamics of Indicators of the Development of the Education System Links, %**

Years	DO (3-6)	Zdo	Zso	Dped	Zptu	Zvuz
1	2	3	4	5	6	7
2010	30,0	150,8	104,8	1,14	116,7	120,5
2011	35,1	204,1	106,0	1,73	117,8	112,9
2012	39,4	132,6	109,0	5,99	118,7	118,9
2013	40,2	117,1	109,7	5,41	119,5	112,0
2014	78,6	113,8	109,6	7,80	120,1	102,3
2015	81,6	116,4	109,8	5,80	121,0	96,9
2016	85,8	88,4	110,2	11,10	121,1	104,3
2017	90,5	91,0	111,5	13,30	121,7	100,8
2018	95,2	138,7	110,6	17,80	126,4	111,1
2019	98,5	113,6	114,2	20,10	125,5	121,4
2020	98,7	120,5	114,6	23,80	110,7	100,8

**Note:** Compiled based on the following sources: *National Report on the State and Development of the Education System of the Republic of Kazakhstan* (Information and Analytical Center, 2017); *Analytical Report on the Implementation of the Bologna Process Principles in the Republic of Kazakhstan* (Center for the Bologna Process and Academic Mobility of the Ministry of Education and Science of the Republic of Kazakhstan, 2018); Bureau of National Statistics of the Republic of Kazakhstan.

**Model of the IND1 Indicator (Formula 4 will be Transformed for Each Indicator)**

$$IND1 = 4,603 \times DO_{(3-6)}^{0,00029} \times Zdo^{0,000043} \tag{19}$$

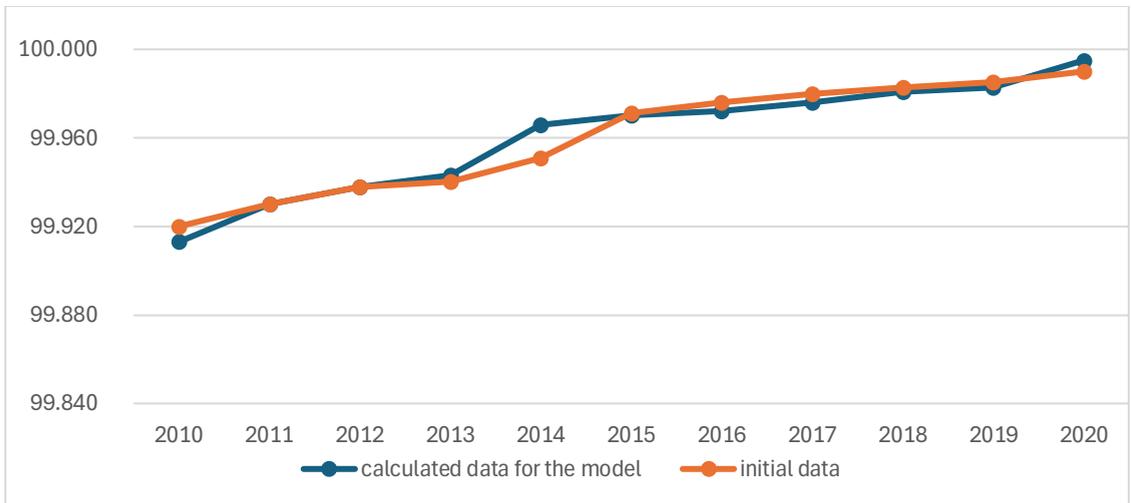
Where,

DO(3-6) = Share of children aged 3-6 covered by preschool preparation.

Zdo = Expenditures on ICT technologies in preschool education.

The coefficient of determination,  $R^2 = 0.953$ , indicates that the developed model is suitable for application in forecasting and analytical research. Furthermore, it should be noted that comparable assessments of acceptability apply to the econometric models developed for the remaining indices.

Figure 3 illustrates the degree to which the calculated model (19) approximates the observed data.



**Figure 3:** Graphical Illustration of the Calculated Dynamics According to the Model

**Model of the IND2 Indicator**

$$IND2 = 0,482 \times Zso^{0,0585} \times t^{0,024} \tag{20}$$

Where,

Zso= Expenditures on ICT technologies in secondary education.

t = Time factor.

**Model of the IND3 Indicator**

$$IND3 = 20,125 \times Dped^{-0,058} \times Zptu^{4,156} \tag{21}$$

Where,

Dped = Share of teachers who have improved ICT competencies.

Zso = Expenditures on ICT technologies in the Technical and vocational education link.

### Model of the IND4 Indicator

$$IND4 = 1,157 \times Zvuz^{0,185} \times t^{0,012} \quad (22)$$

Where,

Zvuz = Expenditures on ICT technologies in higher and postgraduate education.

t = Time factor.

## RESULTS AND DISCUSSION

### In Education as Overall

The digitalisation index ranged from 0.427 to 0.836 over the analysed period. The seven-year average value was 0.591, reflecting a moderate level of digitalisation in the education sector relative to its maximum potential. Compared with the initial year of analysis (2018), this represents a 51% growth in the indicator. For nominal values relating to financial and economic activity and structural ICT expenditures, a positive trend is observed. However, total ICT expenditures show a regression, which may be linked to inconsistencies in the methodology used to account for ICT costs. During 2019–2020, the digitalisation level remained below average (0.427–0.447), indicating stagnation in the development of Kazakhstan’s digital education. This suggests that distance learning was implemented under challenging conditions, influenced by factors such as inadequate infrastructure, insufficient equipment, limited internet speed, resistance to change among certain teachers and administrators due to low digital skills, and restricted funding prior to the launch of large-scale national initiatives. In 2021–2022, the digitalisation level began to rise, reaching an acceptable range of 0.531–0.581. Key factors contributing to this improvement include:

- Implementation of state programs and national initiatives, such as “Digital Kazakhstan” and “Digital School,” with targeted investments in the education sector.
- Significant infrastructure upgrades, including procurement of computers, interactive whiteboards, servers, and high-speed internet connectivity.
- Professional development of teachers in digital competencies through advanced training courses and grant programmes.
- Strengthening the practical skills of educators in using online teaching tools.

## Higher and Postgraduate Education

The higher education sector exhibited an acceptable level of digital transformation, with values ranging from 0.450 to 0.788 and an average index of 0.597 for the period 2018–2024. The most pronounced growth occurred in 2023–2024, when the indicator reached a high level of 0.788. By 2024, the digitalisation level in higher education had risen by 32% compared with 2018. This increase can be attributed to the implementation of modern learning management systems, the enhancement of digital competencies among both educators and students, and integration with global educational platforms. The COVID-19 pandemic (2020–2021) also acted as a catalyst for the accelerated adoption of digital tools. However, a significant reduction in the number of educational institutions led to a sharp decrease in ICT expenditures. As an aggregating factor, this decline created a domino effect that influenced the overall assessment of digitalisation. Nevertheless, the initially high level of digital transformation confirms that higher education serves as the leading sector driving the broader digitalisation of the national education system.

## Technical and Vocational Education

An unusual trend is observed in the technical education sector. In 2018, this level of education achieved an “acceptable” digitalisation score of 0.600. However, during 2019–2021, the index declined to a “satisfactory” range of 0.455–0.489. This reduction may be attributed to the COVID-19 pandemic, as technical education faced greater challenges in adapting to remote formats. Many technical programmes require access to specialised equipment, such as CNC machines, laboratories, and test benches, which cannot be fully replicated online. The period 2022–2023 marked the beginning of recovery, with the digitalisation index rising to 0.568–0.667, and by 2024 it reached a high level of 0.833, representing a 39% increase relative to 2018. This improvement resulted from substantial public and private investments following the easing of restrictions, including the deployment of digital laboratories, simulators, VR/AR technologies, and digital twins for practical training.

## General Secondary Education

This level of education is the most extensive among all educational stages, encompassing primary education (grades 1–4), basic secondary education (grades 5–9), and general secondary education (grades 10–11 or 10–12). The digitalisation index for 2018–2024 ranged from 0.408 to 0.823, with a seven-year average of 0.583. During 2019–2020, the digitalisation level was within the “satisfactory” range (0.408–0.448), likely due to limited ICT funding in schools, insufficient computers, outdated equipment, slow internet connectivity in rural areas, and low digital literacy among some teachers. The period 2021–2022, corresponding to the pandemic, saw an accelerated transition to distance learning, which stimulated rapid implementation of

digital platforms, content, and tools. In 2023–2024, the digitalisation index rose to 0.766–0.823, reflecting a 57% increase compared to 2018. This growth is supported by enhanced digital competencies among teachers, achieved through active professional development and retraining in ICT. Under the “Digital Kazakhstan” state programme, multiple initiatives have been undertaken to modernise the education sector digitally, including the expansion of the EdTech sector, growth of digital educational resources, online courses, and applications, targeted infrastructure investments, and the introduction of electronic journals and platforms for testing and parent engagement. An interesting observation emerges in the structural dynamics of the factors affecting digitalisation: unevenness is evident. Specifically, the factor-point assessment of quantitative education parameters showed regression, which is linked to the fact that student numbers are increasing at a faster rate than the growth of teaching staff, indirectly highlighting the persistent shortage of teachers in secondary education.

### **Preschool Education and Training**

The digitalisation index for this level ranged from 0.433 to 0.860, with a seven-year average of 0.584. Due to the particular characteristics of preschool education, the digitalisation level remained in the moderate range for much of the period. Growth prior to 2023 was constrained by limited infrastructure in kindergartens and lower digital competencies among educators compared with school and university teachers, reflecting the greater emphasis on live interaction in early childhood education. Additionally, funding priorities were primarily focused on schools and higher education institutions rather than preschool facilities. Recent years, however, have witnessed substantial digital transformation in this sector. By 2024, the digitalisation index had increased to 0.860, representing a 56% rise compared with 2018. Key factors contributing to this progress include:

1. Implementation of a state programme for preschool digitalisation, introducing electronic journals, parent interaction platforms, and digital educational resources.
2. Expansion of technical infrastructure in kindergartens, including tablets, interactive panels, and online learning platforms for children.
3. Post-pandemic effects, as the COVID-19 pandemic highlighted the need for digital tools even for preschool-aged children, such as video lessons and remote consultations with parents.
4. Enhancement of educators’ digital literacy through professional development courses and government-led initiatives.

In summary, the education sector across all stages demonstrates a high level of digitalisation. However, two caveats should be noted: first, the assessment does not account for quality indicators or the actual usage and material-technical base of ICT resources; second, the methodology relies on normalised data and geometric mean calculations, which can distort the overall picture by reflecting relative rather than

absolute changes and failing to weight indicators according to their significance. Nevertheless, the evaluation provides a useful overview of digitalisation trends over time and allows comparisons of the status quo across reporting periods. The analysis also highlights areas for improvement, including insufficient digitalisation funding and adverse structural changes in the sector that may limit further progress.

From the perspective of supporting digital development in industrial and social sectors with skilled personnel, the State Programme “Digital Kazakhstan” identifies the goal of “Improving digital literacy in secondary, technical, vocational, and higher education” under the “Human Capital Development” direction (Woessmann, L, 2003), which is expected to substantially increase the training and graduation of qualified specialists. To perform an economic assessment of digital transformation in Kazakhstan’s education sector, a system of interconnected economic and mathematical models of educational units has been developed, maximally incorporating the digitalisation factor. Calculations were performed using data from national statistical agencies and standard foundational formulas.

To evaluate the impact of ICT expenditure on the development of educational components within the resulting quality indicators:

$$\Delta IND = KE_i \times \Delta Z_i \quad (23)$$

Where,

$KE_i$  = The coefficient of elasticity for the  $i$ -th link of the education system, which shows how much the resulting indicator will increase from a change in the cost factor by 1%.

$\Delta Z_i$  = The increase in the cost of ICT technologies in the  $i$ -th link of the education system.

$$\Delta IND1 = 0.000043, \Delta IND2 = 0.0585, \Delta IND3 = 4.156, \Delta IND4 = 0.185$$

To evaluate the contribution of these indicators from various levels of education to the global quality education indicator using model parameters:

$$\begin{aligned} \Delta IND_{glob} &= 491.63 \cdot \Delta IND1 + 0.062 \cdot \Delta IND2 + 0.337 \cdot \Delta IND3 - 0.227 \cdot \Delta IND4 \quad (24) \\ \Delta IND_{glob} &= 491.63 \cdot 0.000043 + 0.062 \cdot 0.0585 + 0.337 \cdot 4.156 - 0.227 \cdot 0.185 = 1.3833 \\ &\approx 1.38\% \end{aligned}$$

To estimate the contribution of the results of digital transformation of education to the human development index using the parameters of the model:

$$\Delta IND_{hg} = 0.5545 \cdot \Delta IND_{glob} = 0.5545 \cdot 1.3833 = 0.767 \quad (25)$$

Finally, to assess the contribution of investments in the digitalization of education to

economic development using a model:

$$\begin{aligned}\Delta VVP &= 2.806 \cdot \Delta \text{INDhg} \\ \Delta VVP &= 2.806 \cdot 0.767 = 2.152\end{aligned}\tag{26}$$

The econometric analysis conducted in this study demonstrates a direct relationship between ICT investment in education and national economic outcomes. A 1% increase in ICT expenditures across educational links corresponds to an approximate 2.15% growth in Kazakhstan's GDP. Based on the 2020 GDP of 69.55 trillion tenge, this additional 1% investment translates to roughly 1.5 trillion tenge in economic growth. Furthermore, digitalisation efforts contribute meaningfully to the HDI, producing an estimated 1.38% increase in the global quality indicator. The economic and mathematical evaluation of the model parameters, particularly the elasticity coefficients, allows preliminary conclusions regarding the relative significance of different educational stages. In particular, the preschool and primary education factor, represented by the IND1 indicator—which reflects the quality of preparation for primary schooling—has a substantial impact on the global quality of education. This observation supports expert recommendations that digital tools and the development of digital competencies should be introduced from the primary education level. In this context, the state programme “Digital Kazakhstan” is relevant, as it cites an Ernst & Young study demonstrating a direct correlation between education and national economic growth. It is evident that, under consistent digital transformation and with flexible scaling of implementation across different educational levels, these estimated impacts could increase significantly.

Empirical studies consistently confirm the macroeconomic returns to educational development. Prior research indicates that an additional year of upper secondary education may increase GDP by approximately 0.44% (Barro, 1991). Long-term education development programmes exceeding ten years have been linked to GDP growth of nearly 5% (Hanushek & Woessmann, 2007), and improvements in PISA performance are positively associated with both labour productivity and economic growth.

## CONCLUSION

This study demonstrates that the education sector in the Republic of Kazakhstan has reached a high level of digital transformation, particularly within higher and preschool education. The factor-point assessment highlights a stagnation period during the initial COVID-19 transition, followed by a strong recovery driven by national initiatives such as “Digital Kazakhstan.” Nevertheless, the analysis also identifies significant challenges, including the uneven allocation of ICT expenditures and the absence of quality indicators within existing state normative acts. Effective digitalisation requires moving beyond the mere provision of hardware towards a comprehensive information management system that integrates legislative frameworks with contemporary

pedagogical practices. Strategically, the Republic must prioritise equalising digital access between urban and rural areas while establishing policies for ongoing professional development. Econometric results indicate that a 1% increase in ICT investment produces a 2.15% growth in GDP, underscoring that education digitalisation represents not only a social service but also a critical macroeconomic driver. Future research should expand this framework to incorporate qualitative measures, such as actual ICT utilisation rates and the digital literacy levels of graduates entering the workforce. Based on the findings, the following strategic directions can be outlined conceptually to guide an effective digital transformation of the education system.

#### Strategic Direction 1: The Formation of a Digital Educational Environment Within the Links of the Education System

This involves addressing the development of ICT infrastructure that provides access to educational resources from both national and international domains.

#### Strategic Direction 2: Formation of a Unified Information and Educational Management System

This entails creating and continuously enhancing mechanisms and tools for managing the education sector as an integrated system for the Ministry of Science and Higher Education of the Republic of Kazakhstan and local education authorities. It is also essential to establish the corresponding regulatory and legislative support for these processes. Domestic experts have highlighted for several years that large-scale informatization efforts in Kazakhstan, using digital educational resources, were not accompanied by revisions to state normative legal acts governing higher education content, particularly state standards, curricula, and educational programmes. The improvement of these acts was not aligned with advancements in ICT. Under the Law of the Republic of Kazakhstan “On Education,” the creation and implementation of an education management information system (EMIS) remain confined to individual automated systems within educational institutions, without full integration across the education system.

#### Strategic Direction 3: Implementation of Flexible Regulatory Policies for Prioritising Funding of Digital Transformation Processes

This involves addressing the equalisation of financial and other conditions for educational development across regions, as well as reducing disparities in access to quality education between urban and rural areas.

#### Strategic Direction 4: Implementation of the Principle of Continuing Education

This focuses on integrating additional vocational training into the education system to ensure the preparation of high-quality specialists for the labour market.

## Strategic Direction 5: Strengthening the Impact of the Education System on Economic and Social Development

This requires assessing the influence of education on human development and its contribution to economic growth to inform timely measures for rational regulation of the sector's development. It is important to note that success in addressing these priorities depends heavily on the comprehensiveness and consistency of the educational information base, which will enhance the effectiveness of economic and mathematical tools used to evaluate the economic impact of education. Overall, the author posits that the proposed conceptual approach to digital transformation in the education system holds scientific and methodological significance and may attract practical interest from relevant government agencies and expert communities.

## REFERENCES

- Ashtikar, S. P., & Manoharan, G. (2024). Digital transformation in higher education: A pedagogical perspective. In Proceedings of the 3rd International Conference on Computational Modelling, Simulation and Optimization (IC-CMSO). IEEE. <https://doi.org/10.1109/ICCMSO61761.2024.00051>
- Azarov, V. N., & Chekmarev, A. V. (2022). Optimization Model of Digital Higher Education-SMART University 4.0. 2022 International conference on quality management, transport and information security, information technologies (IT&QM&IS), <https://doi.org/10.1109/ITQMIS56172.2022.9976700>
- Barro, R. J. (1991). Education as a determinant of economic growth. [https://www.hoover.org/sites/default/files/uploads/documents/0817928928\\_9.pdf](https://www.hoover.org/sites/default/files/uploads/documents/0817928928_9.pdf)
- Becker, G. S. (1993). *Human capital. A Theoretical and Empirical Analysis with Special Reference to Education* (3rd ed.). the University of Chicago press. <https://doi.org/10.7208/chicago/9780226041223.001.0001>
- Bureau of National Statistics of the Republic of Kazakhstan. (n.d.). Education and innovation statistics database. <https://stat.gov.kz/ru/industries/social-statistics/stat-edu-science-inno/dynamic-tables/>
- Buzaubakova, K. D., Amirova, A. S., & Makovetskaya, A. A. (2022). Digital pedagogy. IE Beisenbekova A. Zh. [http://lib.dulaty.kz/rus2/all.doc/Elektron\\_res/Buzaubakova.html](http://lib.dulaty.kz/rus2/all.doc/Elektron_res/Buzaubakova.html)
- Center for the Bologna Process and Academic Mobility of the Ministry of Education and Science of the Republic of Kazakhstan. (2018). Analytical report on the implementation of the Bologna Process principles in the Republic of Kazakhstan. [https://enic-kazakhstan.edu.kz/uploads/additional\\_files\\_items/28/file\\_en/analiticheskiy-otchet-final-14-12-2018-1.pdf](https://enic-kazakhstan.edu.kz/uploads/additional_files_items/28/file_en/analiticheskiy-otchet-final-14-12-2018-1.pdf)
- Cravero, A., Alvarez, D., Sepulveda, S., Valdivieso, M.-I., & Munoz, L. (2024). Meta4CBC: Metamodel for Competency-Based Curriculum Design in Higher

- Education. *Applied Sciences*, 14(22), 10110.  
<https://doi.org/10.3390/app142210110>
- Fan, J., Han, F., & Liu, H. (2014). Challenges of Big Data analysis. *National Science Review*, 1(2). <https://doi.org/10.1093/NSR/NWT032>
- Gapsalamov, A. R., Akhmetshin, E. M., Bochkareva, T. N., & Vasilev, V. L. (2020). "Digital era": Impact on the economy and the education system (country analysis). *Utopia y Praxis Latinoamericana*, 25(10), 170-186.  
<https://doi.org/10.5281/zenodo.4155437>
- Government of the Republic of Kazakhstan. (2024). On approval of the Concept for the Development of Artificial Intelligence for 2024–2029.  
<https://adilet.zan.kz/rus/docs/P2400000592>
- Gurina, E. Yu., & Modestov, A. A. (2013). User authentication mechanisms for remote education systems. *Information Technology Security*, 20(1), 49–55.  
<https://doaj.org/article/166b50b89514411ab0c75acd3ddbe97e>
- Hanushek, E. A., & Woessmann, L. (2011). How much do educational outcomes matter in OECD countries? *Economic Policy*, 26(67).  
[https://www.ifo.de/DocDL/cesifo1\\_wp3238.pdf](https://www.ifo.de/DocDL/cesifo1_wp3238.pdf)
- Information and Analytical Center. (2017). National report on the state and development of the education system of the Republic of Kazakhstan.  
<https://tal dau.edu.kz/storage/app/media/materials/test/UlTTYq%20bayandama%201991-2021%20full%20kaz.pdf>
- Katrin, E. (2022). Digitalization: on approaches to defining a definition in political science. *TRANSBAIKAL STATE UNIVERSITY JOURNAL*, 28(5), 49-52.  
<https://api.semanticscholar.org/CorpusID:249253062>
- Kermanidis, K. L., Tzimiris, S., Nikiforos, S., Nikiforos, M. N., & Mouratidis, D. (2025). ICT Adoption in Education: Unveiling Emergency Remote Teaching Challenges for Students with Functional Diversity Through Topic Identification in Modern Greek Data. *Applied Sciences*, 15(9), 4667.  
<https://doi.org/10.3390/app15094667>
- Maltseva, D., Safonova, O., Fedotov, D., & Aleynikov, A. (2022). Digital educational platforms in modern Russia: Technologies, solutions, risks and services in the context of smartization. In Proceedings of the International Conference on Computer and Applications (ICCA). IEEE.  
<https://doi.org/10.1109/ICCA56443.2022.10039674>
- Marginson, S. (2009). The knowledge economy and higher education: A system for regulating the value of knowledge. *Innovación Educativa*, 9(47), 63-71.  
<https://www.redalyc.org/pdf/1794/179414895007.pdf>
- Mellado, R., Cubillos, C., Vicari, R. M., & Gasca-Hurtado, G. (2024). Leveraging gamification in ICT education: Examining gender differences and learning outcomes in programming courses. *Applied Sciences*, 14(17), 7933.  
<https://doi.org/10.3390/app14177933>
- Moscow School of Management SKOLKOVO. (2018). Methodology for calculating

- the “Digital Russia” index of the constituent entities of the Russian Federation. Moscow School of Management SKOLKOVO. [https://sk.skolkovo.ru/storage/file\\_storage/00436d13-c75c-46cf-9e78-89375a6b4918/SKOLKOVO\\_Digital\\_Russia\\_Methodology\\_2019-04\\_ru.pdf](https://sk.skolkovo.ru/storage/file_storage/00436d13-c75c-46cf-9e78-89375a6b4918/SKOLKOVO_Digital_Russia_Methodology_2019-04_ru.pdf)
- Nazyrova, A., Miłosz, M., Bekmanova, G., Omarbekova, A., Aimicheva, G., & Kadyr, Y. (2025). The digital transformation of higher education in the context of an AI-driven future. *Sustainability*, 17(22), 9927. <https://doi.org/10.3390/su17229927>
- Norabuena-Figueroa, R. P., Deroncele-Acosta, A., Rodríguez-Orellana, H. M., Norabuena-Figueroa, E. D., Flores-Chinte, M. C., Huamán-Romero, L. L., Tarazona-Miranda, V. H., & Mollo-Flores, M. E. (2025). Digital Teaching Practices and Student Academic Stress in the Era of Digitalization in Higher Education. *Applied Sciences*, 15(3), 1487. <https://doi.org/10.3390/app15031487>
- Nurtayeva, D. K., Kredina, A., Kireyeva, A. A., Satybaldin, A. A., & Ainakul, N. (2024). The role of digital technologies in higher education institutions: The case of Kazakhstan. *Problems and Perspectives in Management*. [https://doi.org/10.21511/PPM.22\(1\).2024.45](https://doi.org/10.21511/PPM.22(1).2024.45)
- Pecherskaya, E. A., Artamonov, D. V., Safronov, M. I., Polosina, E. V., Renzyaeva, I. A., & Shepeleva, A. E. (2020). Improving the Effectiveness of the Information Module for the Interaction between Universities and Employers. 2020 V International Conference on Information Technologies in Engineering Education (Inforino), <https://doi.org/10.1109/Inforino48376.2020.9111689>
- Plotnikova, E., Efremova, M., & Zaborovskaya, O. (2019). Comprehensive assessment of the level of digitalization of leading universities of the Russian Federation. *Bulletin of the Altai Academy of Economics and Law*, 9(2), 98–108. <https://vaael.ru/ru/article/view?id=728>
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147. <https://doi.org/10.1016/j.compedu.2019.103778>
- Samusevych, Y. V., Novikov, V. V., Artyukhov, A. Ye., & Vasylieva, T. A. (2021). Convergence trends in the “economy–education–digitalization–national security” chain. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, 6, 177–185. <https://doi.org/10.33271/nvngu/2021-6/177>
- Schulz, T. (1961). Investment in Human Capital *The American Economic Review*, 51(1), 1-17. <https://la.utexas.edu/users/hcleaver/330T/350kPEESchultzInvestmentHumanCapital.pdf>
- Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research*, 70, 263–286. <https://doi.org/10.1016/j.jbusres.2016.08.001>
- State University of Aerospace Instrumentation (GUAP). (2009). The use of ICT in

higher education in the CIS and Baltic countries: Current state, problems and development prospects. GUAP. <https://iite.unesco.org/publications/3214561/>

Woessmann, L. (2003). Specifying human capital. *Journal of Economic Surveys*. <https://doi.org/10.1111/1467-6419.00195>

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1). <https://doi.org/10.1186/S41239-019-0171-0>