ISSN: 1563-2415 (Print), ISSN: 2959-0469 (Online)

Статистика, учет и аудит, 2(101)2026. стр. 239-252
DOI: https://www.doi.org/10.51579/1563-2415.2026.-2.17

Interdisciplinary research in economics
SRSTI 06.77.02
UDC 331.52

HUMAN CAPITAL ADAPTATION TO AI-DRIVEN DIGITAL ECONOMY OF KAZAKHSTAN

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Abstract. *The article analyzes the adaptation of human capital in Kazakhstan to the challenges of an AI-driven digital economy. A theoretical framework is developed to understand how digital transformation and artificial intelligence (AI) technologies demand new competencies and continuous learning from the workforce. A literature review highlights global findings that human capital – encompassing skills, knowledge, and adaptability – is a decisive factor in successful AI adoption and innovation. The paper discusses Kazakhstan's digital initiatives, including large-scale AI education programs and policy reforms, in the context of this theoretical background. Key findings indicate that Kazakhstan has made significant strides (e.g., integrating AI into university curricula and launching nationwide digital skills training) to align its human capital with the needs of the digital economy. Practical recommendations are offered to promote continuous skills development, strengthen public-private cooperation in education, and create a favorable environment for innovation to develop human capital, ensuring that Kazakhstan's workforce can successfully adapt and contribute to economic growth and development in the digital age of AI.*

Keywords: *human capital, digital economy, artificial intelligence, adaptation, skills, digital transformation.*

Main provisions. Human capital adaptation to the digital economy, with an emphasis on AI, should be viewed as a multidimensional process that includes education, digital policy, labor market demand, and institutional conditions. For example, this process is shaped by state digitalization initiatives, the expansion of AI-related educational programs, unequal access to advanced digital opportunities across regions, and a major obstacle represented by the mismatch between the growing demand for AI-related competencies and the ability of the education and retraining system to provide relevant skills.

Hypothesis 1. Human capital adaptation in the AI-driven digital economy depends on a combination of digital literacy, cognitive flexibility, creativity, ethical awareness, and the capacity for lifelong learning.

Hypothesis 2. The effectiveness of human capital adaptation in Kazakhstan is determined by the interaction of state policy, educational modernization, labor market demand, and regional access to digital opportunities.

Cite this article as: Yerimpasheva A.T., Myrzakhmetova A.M. Human capital adaptation to ai-driven digital economy of Kazakhstan. *Statistics, accounting and audit.* 2026, *2*(101), 239-252. DOI: https://www.doi.org/10.51579/1563-2415.2026.-2.17

Hypothesis 3. The mismatch between the growing demand for AI-related competencies and the ability of education and retraining systems to provide relevant skills is a key barrier to inclusive human capital development in Kazakhstan.

Introduction. In a rapidly changing global economy driven by advances in digital technology and AI, human capital will determine a country's long-term economic growth and its ability to innovate [1]. Since 2018, Kazakhstan has implemented a number of large-scale initiatives under the program "Digital Kazakhstan," designed to advance the digitalization of its economy, increase its competitiveness, and establish a dedicated Ministry of Artificial Intelligence and Digital Development and National Digital Code for the implementation of a strategy of AI-technology driven development [2], among others. In today's digital environment, human capital is enhanced by the interaction of cognitive abilities, digital literacy, social skills, and ethical awareness [3, 4].

The theoretical framework provides evidence to suggest that human capital adaptation in response to AI-driven economies will require: (1) broadening the scope of the types of skills that are considered relevant, (2) creating institutions that support ongoing learning, (3) aligning human capital development with the firms' innovation strategy, and (4) proactive educational and policy interventions.

The main challenge is the gap between the existing workforce's skill set and the skills needed to develop Kazakhstan's AI-enabled digital economy. Despite the high level of education in Kazakhstan, the country still lacks specific digital competencies. According to global data, the pre-AI difference in human capital accounted for approximately 33% to 50% of the variation in AI adoption levels across countries [1]. These results indicate that AI adoption in Kazakhstan will be limited by the country's ability to develop human capital to support such growth.

The purpose of this study is to develop recommendations for adapting human capital to the new realities associated with digitalization and the expanded use of AI across all sectors of the Kazakh economy. To achieve this goal, the following set of *objectives* was addressed:

– Conceptualize and integrate theoretical models of human capital adaptation in the context of AI and digitalization.

– Assess the current state of Kazakhstan's digital economy and the adequacy of its human capital for this economy.

– Identify the main barriers to human capital adaptation in Kazakhstan.

– Develop recommendations for policymakers, educational institutions, and business leaders in Kazakhstan to help improve the adaptability of their human capital to changing labor market demands.

The scientific novelty of this article lies in developing an integrated analytical framework for examining human capital adaptation to the AI-driven digital economy in Kazakhstan. The article does not limit human capital adaptation to formal education or professional skills, but considers it as a multidimensional process that includes AI literacy, digital competencies, lifelong learning capacity, cognitive flexibility, labor market responsiveness, firm-level innovation, and inclusive access to digital opportunities.

The authors' contribution. Unlike studies that separately analyze digital transformation, education policy, or labor market change, this article brings these dimensions together within a single country-specific framework. The article also contributes by showing that Kazakhstan's strong performance in digital governance indicators, including e-government and e-participation, creates an important institutional foundation for AI-driven transformation, but does not automatically ensure full human capital readiness.

Literature review. A growing body of literature has explored the relationship between human capital and the digital/AI-driven economy. Classical human capital theory, formalized by economists such as Becker [5], treated education and training as investments that improve worker productivity. However, contemporary researchers argue for a broader view of human capital. Islam & Amin, in a systematic review, note that human capital is "not only about individual competence but includes acquisition, utilization, and development of competence in a broader sense" [6], and they link it to employee well-being.

Several studies have directly examined human capital in the context of technological adoption. Brey & van der Marel provide empirical evidence that differences in human capital are a key driver of differences in AI adoption across European countries [7]. Their estimates suggest that between one-third and one-half of the variance in AI adoption can be explained by the availability of skilled human capital in a given country-industry segment.

Lenihan et al. observe that traditional human capital research focused mainly on education and technical skills, while overlooking "motivationally-relevant elements" such as job satisfaction, organizational commitment, and openness to change [4]. Their research in Ireland showed that firms with human resource practices that foster employee engagement (e.g., proactive work practices and consultative cultures) were more likely to have employees who were willing to innovate and adapt. This suggests that adaptability and mindset are integral parts of human capital in a digital context. Similarly, Aman-Ullah et al. found that human capital capacity, knowledge, and skills all have a significant positive relationship with organizational performance, and that innovative leadership can further enhance this effect [8].

When it comes to digital transformation and resilience, human capital is often cited as the linchpin. Shakir & Vrînceanu, studying post-crisis digital transformation in emerging economies, highlight that digital agility and human capital are crucial for post-crisis business sustainability [9]. They report a strong positive correlation between a workforce's digital agility (ability to rapidly adopt digital tools) and the resilience of businesses in Eastern Europe and the Middle East after economic shocks [9].

Researchers focusing on education and skills development provide further insights. Horilyi & Ivanova argue that education systems must urgently adapt, as "the growing tension between relatively rigid education and training systems and rapidly changing skill requirements" [3] can hinder economic resilience. Their analysis shows that human capital formation is being reshaped by digital transformation – it now requires a combination of cognitive abilities, digital competencies, social skills, and ethical awareness. This holistic approach is echoed by Zapukhlyak et al., who present education reform scenarios as determinants of global development [10]. They highlight the growing importance of digital literacy, hybrid education models, and the integration of soft skills into curricula, linking these to macroeconomic outcomes such as innovation and the adaptability of national economies [10].

Another important theme in literature is the impact of AI on the labor market and the corresponding need for reskilling and social policies. Mykytas explores AI's transformative role and finds that AI adoption accelerates the automation of both manual and cognitive tasks, reducing demand for lower-skilled labor while increasing demand for highly specialized professionals [11]. This transition raises concerns about job displacement and inequality if workers are not retrained or upskilled. Mykytas concludes that lifelong learning, digital upskilling, and educational reform are core components of economic resilience in the AI era. Similarly, Cass, Clark, Griswold, and Sigelman discuss the paradox that technological change does not automatically yield broad productivity gains for all workers [12]. The panel of experts in that discussion argues that whether AI leads to widespread benefits or greater inequality

depends largely on “economic incentives and worker power in the system” [12]. Digital transformation also reshapes organizational structures and customer interaction models. As shown by Ristevska-Jovanovska, digitalization significantly alters internal processes, service delivery mechanisms, and customer experience, requiring firms to upgrade both technological capabilities and workforce competencies [13].

In summary, the literature suggests that human capital adaptation to an AI-driven digital economy is a complex, multi-layered process. It involves individual continuous learning, organizational strategies to nurture and use skills, and systemic reforms in education and policy. The next sections will examine how these insights apply to Kazakhstan’s scenario, evaluating the steps taken and the gaps that remain.

Materials and methods. The study is based on the assumption that digital infrastructure and e-government development are necessary but not sufficient conditions for human capital adaptation. While they create an enabling environment for digital transformation, the actual adaptive capacity of human capital depends on the availability of AI-related skills, lifelong learning mechanisms, labor market responsiveness and inclusive access to digital opportunities. The article also assumes that the main challenge for Kazakhstan is not only technological modernization, but also the alignment of education, labor market needs and institutional policy mechanisms.

This qualitative study uses a literature-based methodology comprising two parts: a literature review and a policy analysis. The literature review methodology includes three components: First, the methodology consists of an extensive review of the academic literature published between 2018 and 2026 on human capital, digital transformation, and AI adoption. The primary sources for this part of the study included peer-reviewed journals, conference proceedings, and reports from international organizations. The literature review developed the study’s theoretical framework and identified global best practices and challenges in adapting the workforce to the digital age. A review of national strategic documents, government programs, and statements related to the development of Kazakhstan’s digital economy was conducted (official statements by President Kassym-Jomart Tokayev on digital transformation [2] and the national Digital Kazakhstan program). The review also includes data on Kazakhstan’s performance in international rankings and indices (e.g., the World Digital Competitiveness Index [14] and the UN e-Government Development Index [15]). The case studies examined publicly available information about specific initiatives, including the ALEM AI Center and the AI-Sana training platform. Where possible, priority was given to official institutional materials, government sources and project-related reports; media sources were used only as supplementary contextual evidence. Policy recommendations were developed based on the results of the literature review and case studies.

To be transparent about methodology, this study outlines the primary analytical elements, the types of data sources, and the expected results for each phase of the research. The table below (Table 1) displays a summary of the structure of the overall research design and illustrates the integration of three stages of inquiry: Literature Review, Policy Analysis, and Case Study Examination to explore the ability of human capital to adapt to the AI-driven Digital Economy in Kazakhstan.

Table 1 – Analytical structure of the study

Research component	Source base	Analytical focus	Expected output
Literature review	Academic articles and international reports	Human capital, digital transformation, AI adoption	Theoretical framework and key global trends
Policy analysis	National strategies, programs and official statements	Digital transformation and AI governance priorities	Identification of institutional priorities
International benchmarking	Global indices and rankings	Kazakhstan's digital readiness in comparative context	Assessment of digital readiness and governance capacity
Case studies	Public materials on ALEM AI Center and AI-Sana	AI-related institutional and educational adaptation	Examples of skills development and innovation support
Synthesis and recommendations	Findings from previous stages	Integration of theoretical and empirical results	Policy recommendations for Kazakhstan
Note: compiled by the authors			

As shown in Table 1, the methodology follows a layered research logic. The literature review provides the theoretical basis for understanding human capital adaptation in the AI-driven economy. Policy analysis situates this theoretical framework within Kazakhstan's national development agenda. International benchmarking and descriptive quantitative indicators make it possible to assess Kazakhstan's digital readiness in comparative and measurable terms.

Results and discussion. There has been significant recent progress toward developing a digital economy in Kazakhstan. Progress toward developing a digital economy will have many implications for human capital development. Through the "Digital Kazakhstan" program, Kazakhstan is positioning itself as a regional leader in digital innovation. Programs within "Digital Kazakhstan" include digital education, digital and artificial intelligence, digital infrastructure, and digital security/cybersecurity. Examples of progress include Kazakhstan's e-government performance: Kazakhstan ranked 24th of 193 countries in the 2024 UN E-Government Development Index and placed among the top 10 in the Online Services Index [15]. Kazakhstan's e-government performance represents the availability of well-developed digital public services and demonstrates that many members of the population now interact with digital platforms. Additionally, Kazakhstan's IMD World Digital Competitiveness Ranking has shown improvement over time, with particular strength in Future Readiness (an indicator of an economy's preparedness to adopt or embrace new technologies). According to the 2024 IMD World Digital Competitiveness Ranking, Kazakhstan demonstrated relative stability and moderate growth in terms of digital competitiveness compared to other surveyed countries. Over the period 2020-2024, Kazakhstan's overall digital competitiveness rank showed variability but generally remained in the top 35 out of 67 surveyed economies, with a 2024 digital competitiveness score of 34 [14]. As a result of these investments in human capital, there are increased opportunities for citizens to develop digital competencies, including digital literacy. Kazakhstan's leaders emphasize that it is the people who drive societal transformations, and therefore emphasize education and talent development as foundational elements of their digital strategy [2].

To show how far Kazakhstan has progressed in using technology for long-term public governance, Table 2 presents trends in key e-government indicators for Kazakhstan from 2010 to 2024. In addition to illustrating the extent to which Kazakhstan's institutions are being transformed through technology, these indicators also show the overall structure of the environment in which people can develop their human capital to compete in a digital economy.

Table 2 – E-government indicators for Kazakhstan from 2010 to 2024

Indicator	2010	2012	2014	2016	2018	2020	2022	2024
E-Government Development Index value	0.55782	0.68438	0.72827	0.72499	0.75970	0.83750	0.86280	0.90093
Online Service Index value	0.52698	0.78431	0.74803	0.76812	0.86810	0.92350	0.93440	0.93903
Telecommunication Infrastructure Index value	0.17969	0.35546	0.57488	0.56677	0.57230	0.70240	0.75200	0.92353
Human Capital Index value	0.96773	0.91337	0.86190	0.84010	0.83880	0.88660	0.90210	0.84029
Note: compiled by the authors based on the source [16]								

Table 2 illustrates the progress Kazakhstan has made in transforming into a digitally enabled society during 2010-2024. The E-Government Development Index (EGDI) has risen from 0.55782 in 2010 to 0.90093 in 2024.

At the next stage, the E-Government Development Index (EGDI) 2024 is analyzed in comparison with the world leader, Denmark, and the regional leader, Singapore. Since Kazakhstan is identified as the sub-regional leader, this comparison makes it possible to evaluate its digital government performance both within its immediate regional context and against the highest global benchmarks.

Table 3 – Kazakhstan's E-Government Development Index in comparison with global and regional leaders, 2024

Indicator	Value	Description
Kazakhstan EGDI, 2024	0.9009	Kazakhstan belongs to the group of countries with a very high level of e-government development.
World leader: Denmark	0.9847	Denmark demonstrates the highest global level of e-government development.
Region leader: Singapore	0.9691	Singapore is the leading country in the broader regional comparison.
Subregional leader: Kazakhstan	0.9009	Kazakhstan is the leader in its sub-region.
Note: compiled by the authors based on the source [16]		

The 2024 e-Government Development Index demonstrates Kazakhstan's relatively strong position in digital governance. Kazakhstan's EGDI value reached 0.9009, placing the country among countries with a very high level of e-government development and establishing it as a subregional leader. By comparison, global leader Denmark recorded an EGDI value of 0.9847, while Singapore, a regional leader, achieved 0.9691.

Figure 1 presents a comparative visualization of Kazakhstan's key e-government development components in 2010 and 2024. By comparing the Human Capital Index, Online Service Index, and Telecommunication Infrastructure Index, the figure highlights the main structural shifts that have taken place in the country's digital transformation trajectory.

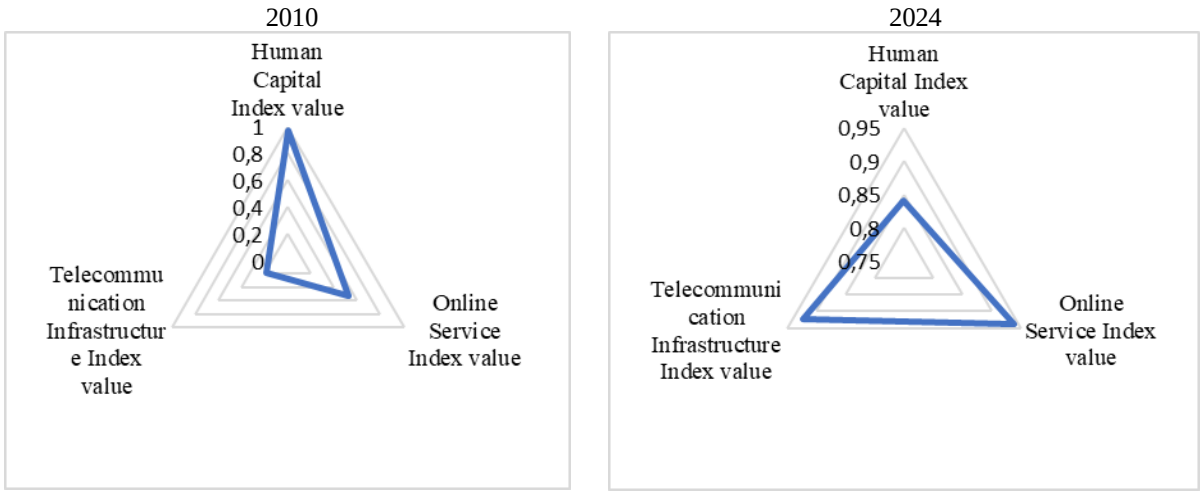

Figure 1 – Radar charts of Kazakhstan's e-government development components in 2010 and 2024

Note: compiled by the authors based on the source [16]

Figure 1 shows that Kazakhstan's e-government development profile changed significantly between 2010 and 2024. The most notable progress can be observed in the Online Service Index and the Telecommunication Infrastructure Index, both of which increased markedly over the period. In contrast, the Human Capital Index remained relatively high in both years but did not demonstrate equally strong growth.

The next indicator considered in the analysis is the E-Participation Index 2024, which reflects the extent to which digital technologies are used to engage citizens in public decision-making, consultation and interaction with government institutions. In the context of human capital adaptation, this indicator is important because digital participation demonstrates not only the availability of online services, but also the population's capacity to use digital channels for communication, access to information and civic engagement.

Table 4 – E-Participation Index, 2024

Indicator	Value / Rank	Description
Kazakhstan E-Participation Index, 2024	0.8493	Kazakhstan demonstrates a high level of digital participation.
Kazakhstan rank, 2024	27th	Kazakhstan is among the relatively strong performers globally.
World leader: Ukraine	1.0000	Ukraine achieved the maximum E-Participation Index value in 2024.
Regional leader: Japan	0.9863	Japan demonstrates one of the highest levels of digital participation in the region.
Sub-region leader: Kazakhstan	0.8493	Kazakhstan is the sub-regional leader.
Note: compiled by the authors based on the source [16]		

The data presented in Table 4 demonstrate that Kazakhstan has achieved a high level of e-participation, with an index value of 0.8493 and a global rank of 27th in 2024. Its position as the sub-regional leader confirms the country's strong role in digital public governance within Central Asia. However, comparison with Ukraine, which reached the maximum value of 1.0000, and Japan, with a value of 0.9863, indicates that Kazakhstan still has room to improve the depth and inclusiveness of digital citizen engagement.

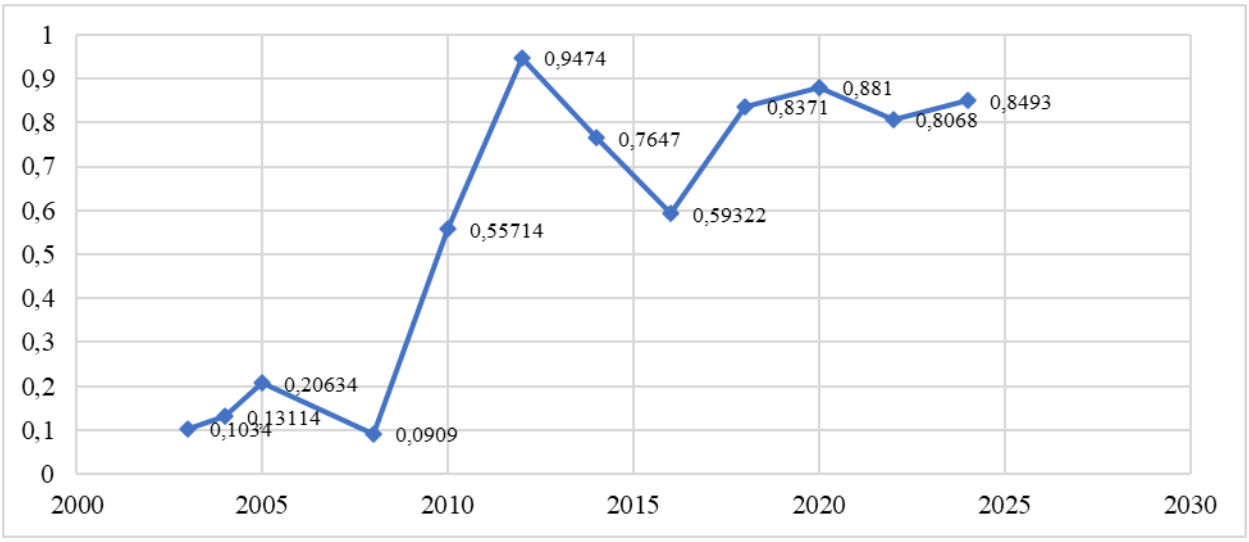

Figure 2 – The dynamics of Kazakhstan's E-Participation Index

Note: compiled by the authors based on the source [16]

The dynamics of the E-Participation Index demonstrate an uneven but generally positive trajectory. The country moved from a very low value of 0.1034 in 2003 to 0.8493 in 2024, indicating substantial progress in digital citizen engagement over the past two decades. However, the trajectory has not been linear: Kazakhstan reached a particularly high position in 2012, ranking 3rd globally with a value of 0.9474, but later experienced fluctuations in both rank and index value.

Although Kazakhstan demonstrates strong results in e-government and e-participation, these indicators do not fully capture internal differences in access to digital opportunities. For this reason, it is important to examine the urban–rural and gender dimensions of Internet access and use. In the context of an AI-driven digital economy, Internet access is a basic precondition for participation in online education, digital public services, reskilling programs, remote work and AI-related learning. Table 5 presents selected indicators of Internet access and use in Kazakhstan in 2024.

Table 5 – Urban–rural Internet access and use in Kazakhstan, 2024

Indicator	Urban	Rural	Female	Male
Households with Internet access at home, %	97.8	95.4	-	-
Individuals using the Internet, %	94.4	91.7	92.6	94.2
Note: compiled by the authors based on the source [17]				

Table 5 demonstrates that Kazakhstan has reached a high level of basic Internet access and use. The urban–rural gap is relatively small: 2.4 percentage points for household Internet access and 2.7 percentage points for individual Internet use. The gender gap is also limited, with Internet use reaching 92.6% among women and 94.2% among men. However, for human capital adaptation to the AI-driven economy, the key issue is no longer only basic access, but meaningful digital inclusion. Rural residents and some social groups may still face disadvantages in terms of connection quality, access to AI-related learning, digital skills training and participation in high-value digital employment. Therefore, digital inequality in Kazakhstan

should be understood as a qualitative gap in access to advanced digital opportunities rather than merely as a lack of Internet connectivity.

One of the most significant findings is that Kazakhstan has successfully integrated AI and digital competencies into its education system. Prior to 2025, all 93 accredited universities in Kazakhstan were required to offer AI as part of their curricula. The adoption of AI as a compulsory course topic at all accredited universities in Kazakhstan occurred rapidly, with the number of universities offering AI courses increasing from 15 in 2024 to 93 in 2025. The implementation of mandatory AI coursework across all 93 accredited universities in Kazakhstan was supported by partnerships with global technology companies (such as Google) and was mandated by a top-down directive to ensure that higher education institutions provided students with basic AI literacy and skills. In addition to implementing mandatory AI coursework across all accredited universities in Kazakhstan, 20 universities developed 25 specialized academic tracks for students interested in AI and related digital disciplines [2]. Implementing these specializations addresses the need to equip future talent with a sufficient foundation in AI knowledge and skills upon graduation. School-based programs such as “AI-Sana” (also referred to as “AI-Sana” in some sources) aim to engage up to 100,000 students in high-tech and innovation activities at a young age. In addition to “AI-Sana”, initiatives such as “Qazaq Digital Mektebi” are providing digital schooling for students at the primary and secondary levels. The creation of creative technology centers, such as the TUMO Center for Creative Technologies in Astana (for students aged 12-18), also provides students with the opportunity to gain practical experience with digital tools and creative technologies outside the classroom. These efforts are examples of a proactive approach to adapting human capital formation to meet technological trends [2].

In addition to investing in education and talent development, Kazakhstan is creating a favorable environment for the development of its digital infrastructure and regional technological integration. Analytical research reports indicate that Kazakhstan is implementing several national initiatives, including the AI SilkNET concept. The AI SilkNET concept aims to enable Kazakhstan to become a digital hub in Central Asia by leveraging AI-based platforms for data exchange and the development of innovation ecosystems. The AI SilkNET concept demonstrates that sustainable digital transformation requires not only the development of the technological infrastructure necessary to support the digital economy but also a workforce capable of operating and scaling the systems developed as part of this process [17].

One key challenge is the existing shortage of skilled personnel in a number of in-demand industries. Research into the developing digital labor market in Kazakhstan has shown a high demand for programmers (e.g., Python and Java), data analysts, cybersecurity specialists, and DevOps engineers. As the digital labor market evolves, job postings are increasingly focused on individuals with both the technical expertise to perform tasks in these areas and the soft skills to work successfully in a team [2].

Comparative analysis of international experience. To better understand how Kazakhstan’s digital transformation approach compares with the global trend of countries successfully navigating technological disruptions – for example, South Korea, Estonia, and Singapore – all three countries have placed strong emphasis on early-stage STEM education, widespread digital literacy, and flexible lifelong learning opportunities.

To strengthen the international comparative component of the study, Kazakhstan’s approach to human capital adaptation is compared with selected international cases: Estonia, South Korea and Singapore. These countries were selected because they represent different but relevant models of digital transformation. Estonia is a small digital state with advanced e-government and early integration of digital skills into education; South Korea represents a

technology-intensive economy with strong links between AI policy, industry and education; Singapore demonstrates a highly coordinated national AI strategy focused on talent development, innovation and public-sector transformation. The comparison is based on several parameters relevant to human capital adaptation: digital readiness, AI education, lifelong learning, labor market orientation, institutional coordination and digital inclusion.

Table 6 – Comparative dimensions of human capital adaptation to the AI-driven digital economy

Parameter	Kazakhstan	Estonia	South Korea	Singapore
Digital readiness	Strong e-government and e-participation; sub-regional leader in 2024.	Advanced digital state; 2nd globally in EGDI 2024.	Strong digital infrastructure and technological capacity.	Smart Nation ecosystem and advanced digital services.
AI education	AI integration in universities; AI-Sana expands AI literacy.	AI Leap 2025 introduces AI tools in education.	AI literacy is part of national education policy.	National AI Strategy 2.0 focuses on AI talent and adoption.
Lifelong learning	AI-Sana and Tech Orda support digital reskilling.	Digital competence is developed through lifelong learning and teacher training.	Lifelong learning supports AI literacy and occupational reskilling.	SkillsFuture supports continuous workforce transformation.
Labor market orientation	Demand for programmers, data analysts and cybersecurity specialists; skills mismatch remains.	Digital skills support the public sector and innovation economy.	AI policy is aligned with industry and higher education.	Talent policy is linked to business, research and innovation needs.
Institutional coordination	State programs, universities and Astana Hub support digital transformation.	Education, digital state institutions and PPPs are coordinated.	AI policy links government, industry and education reform.	Centralized AI governance through Smart Nation and national AI strategy.
Digital inclusion	Basic Internet access is high, but regional quality gaps remain.	Inclusion is supported through school technology access.	Access to AI education covers different occupational groups.	Inclusion is promoted through skills programs and digital public services.
Note: compiled by the authors based on the source [15]				

The international comparison demonstrates that Kazakhstan shares several priorities with advanced digital economies: development of digital public infrastructure, integration of AI into education, expansion of reskilling programs and stronger institutional coordination. However, Estonia, South Korea and Singapore show that successful human capital adaptation requires a long-term and systemically coordinated approach. Estonia emphasizes early digital and AI education; South Korea links AI skills with industrial needs and lifelong learning; Singapore integrates AI talent development into a national innovation strategy. Kazakhstan has created a strong foundation through e-government, AI-Sana, university-level AI integration and digital skills programs, but further progress depends on the quality of implementation, regional inclusion and the alignment of education with labor market demand.

Recommendations for Kazakhstan

Based on the previous analysis, the following practical recommendations are made to enhance human capital's adaptation to a digital economy powered by AI in Kazakhstan.

Firstly, there needs to be regular updates to the curricula of educational institutions in Kazakhstan in line with technological progress. As part of this recommendation, the curriculum

should increase the amount of material on AI; also, interdisciplinary programs (such as combining computer science with other subjects) may be developed.

Secondly, measures to promote ongoing worker training should be implemented. This can be achieved by expanding publicly funded reskilling programs such as AI-Sana and Tech Orda. These programs need to offer flexible training opportunities (e.g., online courses) and should include both hard and soft skills (e.g., digital communication and project management) to enhance flexibility.

Thirdly, public-private partnerships can be used to develop additional digital skills for the workforce. The private sector has many opportunities to contribute to digital skills development by partnering with students and faculty on collaborative projects. In addition, Kazakhstani tech companies and startup organizations in the Astana Hub can establish relationships with universities to mentor students and help develop talent.

Fourthly, another challenge that needs to be addressed is to minimize or reduce the digital divide (based on gender, urban/rural, and language). For example, the content needs to be in Kazakh and Russian (not just English).

Conclusion. The digital economy requires an abundance of successful, innovative, and adaptable human capital. Therefore, this study aimed at analyzing how Kazakhstan, a developing country undergoing rapid digitalization, is transforming its human capital to address both the challenges and opportunities presented by the digital economy. Using theoretical analysis and reviewing relevant literature, we found that, to adapt human capital to the demands of the digital economy, employees require continued skill acquisition, the integration of new technical and soft skills, and supportive education and policy systems that encourage skill acquisition. As the example of Kazakhstan shows, the country responded proactively to the demands of the digital economy: Kazakhstan integrated digital and AI skills into its national education system; developed numerous large-scale employee training programs; and transformed the institutional framework of education and employment to support innovation and the use of technology. Already, Kazakhstan's efforts have led to some positive developments: the country has achieved higher global rankings in digital readiness than before, and the emergence of a burgeoning tech industry suggests that Kazakhstan's workers are slowly being trained to operate in the digital economy.

However, the analysis shows that adapting human capital to the requirements of the digital economy is a long-term, ongoing process. A number of challenges remain to be addressed, among them the gap in specialized knowledge and skills required by many digital industries; the unequal availability of training and educational opportunities; and the need for a significant cultural shift in how employees view themselves and their roles in the workplace. Some examples of the positive actions Kazakhstan is taking include the launch of AI-Sana (a project designed to provide AI-related skills training to one million citizens) and the integration of AI training in the curricula of all universities in the country.

Conflict of Interest. The authors declare no conflict of interest. No competing financial or academic interests influenced the conduct or findings of this study.

Acknowledgments. This research was conducted within the framework of the scientific project AP32716225 "Transformation of human capital in the context of digitalization of the economy and the growing influence of artificial intelligence"

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ЖАСАНДЫ ИНТЕЛЛЕКТТІҢ ДАМУЫ ЖАҒДАЙЫНДА ҚАЗАҚСТАННЫҢ ЦИФРЛЫҚ ЭКОНОМИКАСЫНА АДАМИ КАПИТАЛДЫҢ БЕЙІМДЕЛУІ

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Түйін. *Бұл мақалада жасанды интеллекттің көмегімен Қазақстанның адами капиталының цифрлық экономикаға бейімделуі қарастырылады. Цифрлық трансформация еңбек нарығын өзгертіп, тек кәсіби білімге ғана емес, сонымен қатар жұмысшылардың үздіксіз оқу және бейімделу қабілетіне де қойылатын талаптарды арттырады. Оқыту жүйесін дамыту, үкімет, білім беру және бизнес*

арасындағы ынтымақтастықты нығайту және инновациялық ортаны қолдау бойынша ұсыныстар ұсынылады.

Түйінді сөздер: *адами капитал, цифрлық экономика, жасанды интеллект, бейімделу, цифрландыру, дағдылар.*

АДАПТАЦИЯ ЧЕЛОВЕЧЕСКОГО КАПИТАЛА К ЦИФРОВОЙ ЭКОНОМИКЕ КАЗАХСТАНА В УСЛОВИЯХ РАЗВИТИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА

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Резюме. *В статье рассматривается адаптация человеческого капитала Казахстана к условиям цифровой экономики, развивающейся под влиянием искусственного интеллекта. Цифровая трансформация меняет рынок труда и повышает требования не только к профессиональным знаниям, но и к способности работников к непрерывному обучению и адаптации. Предложены рекомендации по развитию системы обучения, укреплению сотрудничества между государством, образованием и бизнесом, а также поддержке инновационной среды.*

Ключевые слова: *человеческий капитал, цифровая экономика, искусственный интеллект, адаптация, цифровизация, навыки.*

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Received: 12.02.2026
Accepted: 17.05.2026
Available online: 30.06.2026