AI in Kazakhstan education system

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Abstract

This article presents a comprehensive analysis of AI integration into Kazakhstan's education system, considering international experience, national policy, and ethical considerations. It examines government strategies, capacity building, digital infrastructure, and professional standards, and proposes a multi-layered ecosystem model for AI education that integrates governance, human capital, and technology. It highlights benefits such as personalized learning, data-driven decision-making, and access to educational resources, addressing digital inequalities, limited AI literacy, privacy and data protection concerns, and risks to academic integrity. A phased framework for implementing AI in education is proposed, using a blended approach combining policy review, stakeholder engagement, and case studies. This approach prioritizes equitable access, specialized training, robust data management, and mechanisms for assessing and monitoring learning outcomes and ethical compliance.

Keywords

artificial intelligence, Kazakhstan, higher education, implementation, assessment, academic integrity, blended learning[1]

1. Introduction

AI technologies are shaping a new paradigm for education: from content digitization to intelligent systems that adapt learning to individual needs, automate routine processes, and expand access to resources. The full-scale implementation of AI in the educational process promises to improve the quality of learning, accelerate processes, optimize institutional management, and support stakeholders. Society is also faced with challenges such as equality, accessibility, privacy, and accountability – all of which require well-thought-out government and institutional policies. America's AI Action Plan recognizes AI as a critical tool and is being considered for implementation at the US government level [1]. China has initiated the establishment of the Global AI Cooperation Organization (GAC) to promote multilateralism, bridge the digital divide, and develop ethics and sustainable use of AI [2].

For Kazakhstan, AI integration is timely: large-scale reforms, infrastructure modernization, and growing edtech uptake create strong preconditions. Yet transition-economy constraints persist, uneven broadband, limited AI skills/specialization, and immature legal-ethical frameworks. Beyond assessing potential, policy must mitigate risks and safeguard educational quality while leveraging AI [3]. This study proposes a comprehensive analytical framework for responsible, sustainable AI in education, detailing governance mechanisms, competency-development models, and infrastructural prerequisites. It bridges the best international practice and national policy so that AI adoption improves quality, equity, and institutional resilience.

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2. Global trend in the application of AI in education

The AI Index 2025 [4] provides data on the implementation of responsible AI practices and expanded coverage of the growing role of AI in science and medicine. Education in science and artificial intelligence is expanding, while regional differences persist. Two national agreements call for the integration of AI into computer science in elementary grades. In the United States, 81% of computer science teachers propose the integration of AI into basic computer science instruction. The overwhelming majority of the public views that AI products and services are harmful, compared to China (83%), Indonesia (80%), and Thailand (77%). In contrast, optimism remains significantly lower in countries such as Canada (40%), the United States (39%), and the Netherlands (36%). Overall, optimism has increased significantly since 2022 in several previously skeptical countries: Germany (+10%), France (+10%), Canada (+8%), the UK (+8%), and the US (+4%).

In the United States, AI implementation is most often focused on programming, medical education, STEM, and combating cheating. Other areas of attention include the changing role of student engagement in AI-enabled learning, the shift in assessment paradigms toward adaptive models, AI-enabled instruction, and ethical controversies related to algorithmic transparency, equity, and automation in instructional design. Chinese researchers are interested in academic integrity and inclusive education, and the development of AI literacy; in the United Kingdom, the use of AI in interdisciplinary research and creative writing is studied; in Australia, the focus is on innovations in learning, digital literacy, and support for students and teachers; in Spain, the use of AI to support creative thinking and language learning; in India, interest is in the development of inclusive design; in Malaysia, support for independent learning; and in Germany, interactive learning [5]. The prevalence of AI use also varies across countries and depends on the characteristics of education systems, the level of digital skills of students and universities, and the students' English proficiency [6].

The analysis reveals growing connections between AI ethics, adaptive learning, and teacher-enabled technologies, providing a conceptual basis for national strategies like Kazakhstan's.

Determining the effectiveness of AI in other areas in Kazakhstan is relevant. AI-Sana – built on a progressive competency development model aimed at developing AI literacy and skills for integrating AI into education. Besides this, there is the AI Summer School and the National AI Platform [7]. A forecast for AI implementation in business is presented in [8]. It examines the application of AI in public administration and public service delivery, as well as its contribution to improving the quality of public services worldwide and in Kazakhstan.

3. Competency development and teacher training

The use of AI in education is no longer a novelty, and we have a considerable body of literature on the subject. However, most studies in this area are hypothetical or based on local practical experience [9]. Significantly fewer studies rely on large samples and advanced data analysis methods [10]. Most studies focus on students' use of AI to effectively and quickly complete coursework, improving their AI skills. It has been found that instructors strive to identify instances of AI use where there are direct prohibitions and hold students accountable. Few publications systematically discuss the real potential and limitations of AI. The need to develop and maintain effective and relevant tasks and assessment systems is also driving the growing research in computer science education on the use of large-scale language models (LLMs) to create and interact with coding exercises. The use of LLMs to create multiple-choice programming questions has not yet been widely explored. Table 1 summarizes the findings in [11] on learning Python programming.

Table 1
Dataset of manually generated multi-purpose questions

Course	Modules	MSQs	RMB	UND	APP	ANL	EVL	CRT	N/A	Overall
Practical programming Python	8	194	14	31	20	17	2	29	10	123
Get started Python	5	-	8	24	9	4	1	5	4	55
Python basic	4	129	-	7	-	-	-	-	14	21
Python Intermediate	4	126	1	1	4	2	-	7	5	20
DS in Python	4	-	3	2	8	-	-	1	-	14
Python and Pandas	4	-	1	1	2	-	-	9	-	13
	Total	**449**	27	66	43	23	3	51	33	**246**

The first three columns list the course titles, the number of modules per course, and the number of multi-purpose questions. The remaining columns contain the number of learning objectives (LOs) from different levels of Bloom's Taxonomy (RMB – remember, UND – understand, APP – apply, ANL – analyze, EVL – evaluate, CRT – create, N/A – not assigned).

Global recommendations link AI use with transparent attribution, contextual limitations, and verified pedagogical value [12]. Effective national frameworks rely on coordinated governance, data protection, and ethical oversight, including DPIAs and academic integrity standards [13]. International experience confirms that sustainability depends on integrating policy, infrastructure, and ethical management systems [14].

At the institutional level, AI governance should be formalized through policies that define roles, security standards, and performance indicators, fostering sustainable management and academic integrity in the use of LLMs [15]. In Kazakhstan, this governance model is embedded in state policy and aligned with UNESCO and Organisation for Economic Co-operation and Development (OECD) recommendations, emphasizing a human-centered strategy that integrates ethical norms, data protection, and interdepartmental coordination [16].

Existing studies examine AI-assisted learning but rarely link pedagogical innovations to measurable competency outcomes. This study addresses this gap by proposing an AI Competency Integration Model.

The digital transformation of the educational process encompasses from preschool to higher education. In Kazakhstan, artificial intelligence courses have already been introduced at more than 79 universities, and starting in the 2025–2026 academic year, similar topics will be included in the "Digital Literacy" and "Computer Science" school courses, followed by a mandatory AI course for students in all majors. University programs are actively being updated: in 2025, AI courses were introduced at 95 universities, and new programs are being developed, such as "Applied AI," "AI in Mining and Metallurgy," and "Smart Technologies in Transport," where students will master Python, TensorFlow, PyTorch, big data analytics, and neural network integration. Universities such as KazNU, KazNITU, East Kazakhstan Technical University, and Astana IT University are developing AI research centers in partnership with SeoulTech and EPFL, reflecting a coordinated approach to developing competencies.

Particular attention is being paid to adaptive learning: AI systems customize learning paths based on a student's level. This transformation is changing the very nature of education, making it more flexible, inclusive, and focused on the potential of each student.

Empirical research confirms that AI-driven personalization significantly enhances student engagement and adaptive feedback [17], while also improving learning support and fostering effective partnerships between humans and technology [18].

Recognizing that the success of AI implementation depends on human competencies is enshrined in Kazakhstan's strategy, which places a focus on training teachers and administrative staff through a multi-tiered professional development system based on the sequential mastery of the Acquire, Deepen, and Create levels. This model considers the initial level and professional needs of participants, and the certification mechanism in projects like AI-Sana creates a tool for validating and disseminating competencies.

Research shows [19] that improving teachers' AI literacy is an important factor in the successful transformation of education.

The creation of specialized training tracks for administrative personnel should be considered a key measure to support digital transformation. For example, Kazakhstan is already implementing an AI Summer School with two levels of training (General and Technical), focusing on the application of AI in HR, marketing, and education (Astana IT University) [20].

A unified competency development model integrating mass training, specialized tracks, and international exchange is being empirically validated. Yet, teacher preparation for AI remains underrepresented: only about 35% of studies address professional development in this area [21], highlighting the need to scale national training and institutionalize certification frameworks to build a sustainable capacity pipeline for AI-enabled education. The developed Multi-Layered Competency Development Framework integrates national training (AI-Sana), targeted programs (AI Summer School), and international exchange into a unified, empirically validated model.

5. Administrative, legal, and ethical infrastructure

Effective implementation of AI in the education system requires not only qualified personnel but also a reliable infrastructure: digital platforms, regulatory mechanisms, and clear operating rules. In Kazakhstan, for example, the National Artificial Intelligence Platform was launched, providing centralized access to computing resources, tools, and data for developers, educators, and researchers [22]. In parallel, projects are being implemented to develop supercomputer infrastructure and data centers to support the computing loads of large-scale AI applications. At the legal level, the Law on Artificial Intelligence has been adopted, establishing basic legal definitions and user rights. Educational organizations are recommended to adopt an AI Ethical Standard with specific requirements: disclosure of AI use (tool, version, nature of changes), prohibition of uncontrolled generation, data protection, counteraction to content falsification, and limitation of AI use in final assessments (except in cases of assisting students with special needs).

An additional support component is a national system of digital student profiles, designed to integrate data on academic performance and competencies and link them to AI university platforms. It is emphasized that the final control over the quality and content of education rests with humans, not algorithms.

International literature emphasizes that AI systems in education should be built in accordance with the principles of transparency, accountability, and human oversight [23], as well as with the concepts of social generative AI, where human-model interaction is viewed as a social process, and not simply an algorithmic sequence of commands [24, 25]. Table 2 summarizes the main challenges and risks discussed in this section, including digital literacy, ethical integrity, and data protection.

Table 2
The key challenges and risks

Challenge	Challenge	Examples and Sources
Insufficient level of digital literacy	The pace of training lags behind technological development; in current professional standards for teachers, artificial intelligence competencies are often defined only in general terms as digital skills [26]	Advanced training programs based on the Acquire-Deepen-Create model; updating standards in Kazakhstan's national AI strategies for 2025–2029. [27]
Ethical risks and academic integrity	Over-reliance on AI may reduce critical thinking skills; difficulties in monitoring the use of AI in assessment.	Presidential Warning; Ethical Standard with Prohibitions on AI "Authorized" Mode.
Mismatch between professions and standards	The Atlas of New Professions suggests new AI-related positions, but they are not reflected in official professional standards for teachers. [28]	Atlas of new professions; analysis of teacher profession cards.
Data protection issues	Risks of personal data leakage persist, particularly for minors, due to inadequate privacy protection and oversight practices.	The ethical standard prohibits covert data collection and biometric tracking.

6. Educational ecosystem and professional standards

Kazakhstan's education system is shaped by two complementary processes: integrating AI into future professional trajectories and developing strategic forecasting tools such as the Atlas of New Professions and Competencies. These areas form the conceptual foundation for training personnel capable of not only adapting to the digital economy but also creating it. Developed under the Ministry of Science and Higher Education, the Atlas of New Professions [28] is an analytical tool for long-term human capital planning. It forecasts labor market structures 5-10 years ahead and covers more than 470 professions across nine strategic sectors, including green energy, agrotechnology, fintech, and smart manufacturing. The Atlas underpins updates of educational programs and professional standards, while universities use it to introduce practice-oriented courses reflecting future technological trends.

New AI-related professions extend beyond development to human-machine interaction, including specialists in ethical AI, neural interface engineering, educational technology, and digital pedagogy. Flexible learning pathways combine fundamental knowledge with practical internships. The success of this transformation depends on aligning the state's digitalization strategy with predictive labor market analytics to prepare leaders of technological change.

A key condition for the successful implementation of artificial intelligence in education is the transition from isolated courses and initiatives to the creation of a holistic, multi-layered ecosystem encompassing the entire educational journey, from basic digital literacy to the training of world-class researchers. Such an ecosystem is based on three interconnected components: fundamental mathematical knowledge, engineering practices, and professional competencies, which ensures the connection between academic outcomes and industry needs.

The mathematical foundation includes disciplines that develop analytical thinking and the ability to understand the nature of algorithms, such as discrete mathematics, probability theory, and statistics. Engineering practice encompasses machine learning, neural networks, computer vision, and natural language processing, as well as modern areas such as generative AI (GenAI), explainable AI (XAI), and large-scale language models (LLM). Professional competencies are complemented by studies in ethics, digital security, big data, and quantum computing. This framework is dynamic and regularly updated to reflect new technologies, including neuromorphic computing and reinforcement learning.

The structure of this educational ecosystem is presented in Figure 1, which demonstrates the connection between industrial trends, mathematical foundations, engineering practice, and professional competencies leading to defined learning outcomes.

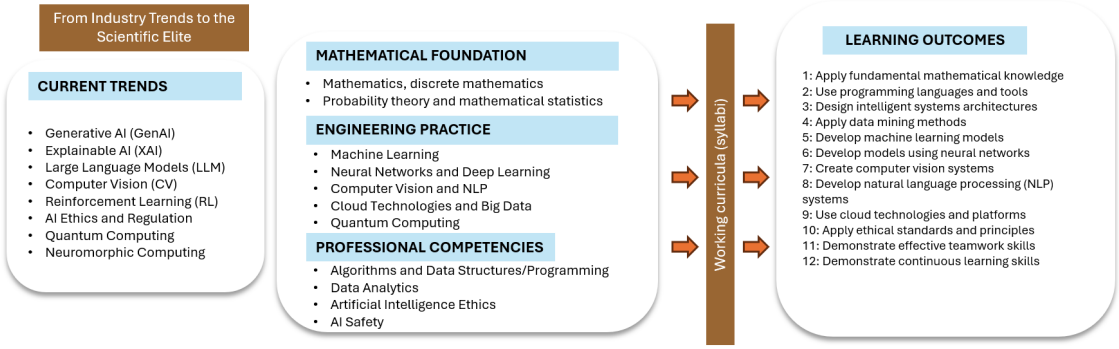

Figure 1: The structure of the Artificial Intelligence Educational Ecosystem: from industrial trends to learning outcomes.

A three-tier training model, undergraduate, master's, and doctoral, ensures continuous learning. Undergraduate programs develop applied skills, master's programs train developers and researchers, and doctoral programs focus on the creation of new models and methods. These levels are supported

by a network of research centers and laboratories providing access to cutting-edge computing resources.

The structure of the three-level AI training model and its connection with professional standards and career trajectories is presented in Figure 2.

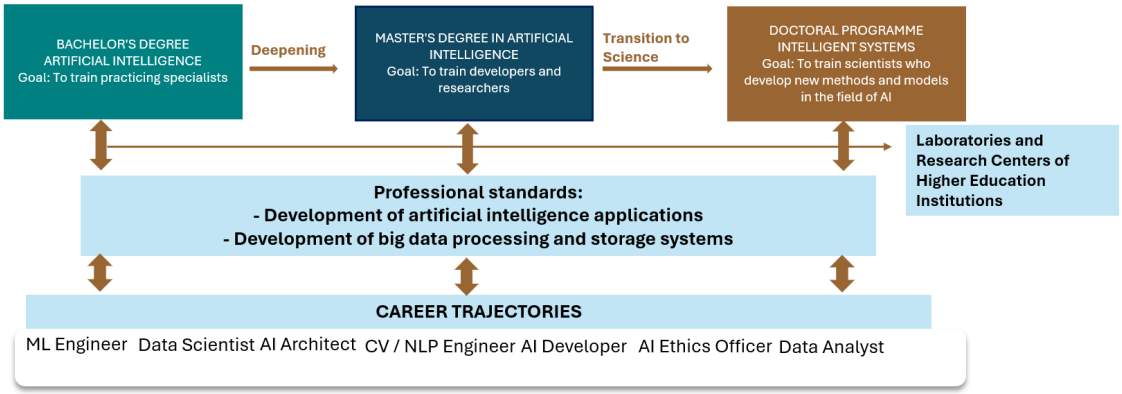

Figure 2: Three-level AI education framework linking degree programs, professional standards, and career trajectories.

Professional standards serve as a link between education and employment. Standards like "Development of Artificial Intelligence Applications" and "Big Data Processing Systems" form the foundation for career paths ranging from Data Scientist and Machine Learning Engineer to AI Ethics Officer and AI Architect. This integrated model creates a strong connection between education, research, and the labor market, ensuring the development of specialists capable of not only applying technology but also shaping the intellectual foundation of the digital society of the future.

Global practice, including reskilling programs at Amazon and Microsoft, demonstrates that sustainable results are achieved not through the acquisition of isolated technical skills, but through their meaningful application in specific professional domains. This approach fosters a shift from isolated knowledge to comprehensive solutions tailored to specific industry contexts.

For Kazakhstan, this model entails the development of interdisciplinary educational pathways that integrate technical, legal, and management aspects. For example, training specialists for the financial sector should include courses on financial regulation and cybersecurity, for medicine – on data ethics and diagnostic AI models, and for public administration – on digital policy and decision analytics. This approach bridges the gap between academic knowledge and real-world challenges, developing specialists capable of not only using technology but also developing sustainable solutions tailored to the industry context.

7. Conclusion

The integration of artificial intelligence into Kazakhstan's education system represents a strategic transformation that combines technological modernization with a human-centered approach. Our analysis shows that the successful implementation of AI depends on three interrelated areas: the development of coordinated policies and governance mechanisms, the systematic development of teacher and administrator competencies, and the creation of a robust digital and ethical infrastructure. National initiatives—such as the AI competency framework, ethical standards for educational organizations, and the National Artificial Intelligence Platform—demonstrate a comprehensive approach to building trust and professional readiness. However, challenges remain, including uneven levels of digital literacy, data privacy risks, and the need to align professional standards with labor market dynamics. Further development requires interdepartmental coordination, the integration of AI ethics into all levels of education, and the adaptation of curricula to the Atlas of Emerging Professions. The responsible and inclusive use of AI will enhance the resilience of the education system and its global competitiveness.

Declaration on Generative AI

During the preparation of this work, the authors used GPT-5 in order to: grammar and spelling check. After using these tool, the authors reviewed and edited the content as needed and takes full responsibility for the publication's content.

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