

Problems and Prospects for the Implementation of Artificial Intelligence in the Educational Process of Kazakhstani Universities

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ABSTRACT

Integrating artificial intelligence into education offers great prospects that improve the learning process. Individualization of learning approaches and rationalization of resource use are very productive for learning. This study analyzes the key challenges and opportunities for implementing artificial intelligence into the educational system of Kazakhstani universities. The work focuses on analyzing the current situation and ways to improve this process. This article analyzes the problems and prospects for implementing artificial intelligence into education. The aim of the article was to analyze the potential for integrating artificial intelligence into the educational process of Kazakhstani universities, as well as to identify the main challenges and opportunities for this process. The article uses an analytical method. It is aimed at studying the current state of the infrastructure, the readiness of teachers, and the necessary conditions for the effective use of artificial intelligence technologies. The results of the work demonstrate the significant potential of artificial intelligence to improve the educational process. Personalization of learning and simplification of complex scientific concepts are the main advantages. The work highlights key obstacles to implementing artificial intelligence in education in Kazakhstan. Among them is the lack of technical resources and specialized training of teachers. For the full integration of artificial intelligence into the education system of Kazakhstan, there is a need to modernize the infrastructure, improve teacher training, and develop national initiatives.

Keywords: AI integration, New technologies, Learning strategies, Educational institutions, Digital competencies.

1. Introduction

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and discussion section. For educators, the integration of artificial intelligence into education opens up great prospects. Innovative technology tools significantly diversify teaching methods and meet the needs of students. AI significantly personalizes learning paths and offers teachers special strategies, and this, in turn, enriches teaching practice. The capabilities of artificial intelligence are a valuable resource. Therefore, practical advice on implementing AI in education can significantly simplify practice. Digitalization brings unprecedented technological changes. They strongly affect various aspects of life. A top innovation is the development of artificial intelligence (AI), which is actively implemented in education, healthcare, business, etc. According to Sisel and Baron, education is not preparation for life; education is part of life [1]. This statement is especially important in the context of integrating artificial intelligence into the educational process since technologies can radically change the way we learn and teach. The relevance of this study lies in the need to identify and overcome existing obstacles to the implementation of AI in Kazakhstan's educational system.

Currently, scientists in Kazakhstan, Europe, and the USA are studying the impact of AI on learning [2], [3], [4]. However, in Kazakhstan, the issue of integrating AI into education is still insufficiently studied. Certain gaps

in the scientific literature require attention. Kazakhstani universities still lack modern hardware and software. This limits the possibilities of implementing innovations [5]. The next issue is teachers' and students' low level of digital literacy. It must be said that this is a significant barrier to implementing AI in education [6]. Financial constraints are also among the shortcomings. At the state and educational institution levels, the lack of finances significantly complicates the implementation of projects to integrate AI into the educational process [7]. These gaps in research and practice indicate the need for a comprehensive approach to solving these problems.

The purpose of the article was to analyze the potential for integrating artificial intelligence into the educational process of Kazakh universities. In addition, to identify the main barriers that prevent this. To achieve this goal, the following research questions were proposed in the paper:

1. To identify the main obstacles to integrating AI into the educational process of Kazakh universities.
2. What are the opportunities for using AI to improve the learning process?
3. What strategies can be proposed to overcome the identified barriers and optimize the implementation of AI in education?

So, if artificial intelligence has the potential to revolutionize the way we look at education, there are still many challenges and concerns to be addressed.

Despite the active research on this topic, the work identified several clear research gaps that require further investigation in the context of integrating artificial intelligence (AI) into education in Kazakhstan. The main drawback is the impact of AI on teachers' digital literacy. There is still a lack of research that would study how the integration of AI affects teachers' digital skills in Kazakhstan. This is critically important since teachers' digital competencies directly affect the effective use of technology in the teaching and learning process. Another gap that should be noted is the economic aspects of integrating artificial intelligence. They are still insufficiently analyzed. The costs of implementing the technology, potential benefits, and financing of projects based on artificial intelligence remain open questions. There is a significant lack of systematic approaches to modernizing the infrastructure of educational institutions. This is especially true for remote regions of Kazakhstan. The indicated gaps require research into the impact of infrastructural barriers that affect the implementation of AI in education. The assessment of the effectiveness of AI implementation has not been deeply studied. Research that would assess the effectiveness of artificial intelligence in the educational process, including the level of success and its impact on learning outcomes, is still under development.

It is necessary for researchers and developers to actively explore the potential of artificial intelligence in education. This will help to overcome challenges and solve problems that may arise.

This article aimed to fill the existing research gaps by identifying technical, pedagogical, and organizational barriers to implementing AI in higher education in Kazakhstan. Providing practical recommendations for educational institutions, government agencies, and other stakeholders in Kazakhstan will open up new educational prospects and transform the education system. However, all the identified barriers must be overcome for the integration of AI.

Artificial intelligence (AI) opens up vast opportunities for transforming educational processes, providing individualized learning, task automation, and access to innovative technologies. This is also relevant to Kazakhstan's digital strategy.

Artificial intelligence (AI) integration into education has evolved significantly since the 1950s [8]. The first attempts to imitate human speech with programs such as ELIZA [9, 31], created by Joseph Weizenbaum in 1964, paved the way for more advanced developments. In 1967, the first intelligent tutoring system, SAINT [10], was created to teach subjects such as mathematics. These early experiments laid the groundwork for developing this area into a powerful research field.

The 1980s were a turning point due to Judah Perl's introduction of Bayesian networks, a statistical tool for modeling uncertainty and influencing educational content creation [11]. This discovery expanded the prospects for personalizing learning.

Over the years, AI progress has created increasingly sophisticated learning tools. 1998 ALEKS, an intelligent assessment and learning tool, was introduced, marking a new stage in personalizing educational trajectories [12]. At the same time, with the advent of MOOCs (massive open online courses) in Kazakhstan, mass online learning became possible in 2008, which facilitated the integration of AI into adaptive learning platforms [13].

Significant achievements in the field of deep learning marked the 2010s. In 2011, IBM Watson demonstrated the capabilities of AI, which opened up new ways to apply it in education, particularly in creating virtual assistants [14, p. 3]. In 2014, the introduction of generative adversarial networks (GANs) enabled high-quality synthetic content, such as images, video, and audio, which opened up new opportunities for creating educational materials [15, p. 73].

In the following years, intelligent tutoring systems have emerged that can adapt to the individual needs of each student. Tools such as Mika, developed by Carnegie Learning, have shown that AI can provide personalized support equivalent to that of a human tutor. In parallel, platforms such as Duolingo have integrated AI into their language learning tools, offering personalized exercises and instant feedback [16, p. 178].

Recently, the growing popularity of generative language models, such as GPT-3, has opened up new perspectives for education. Tools such as ChatGPT, which can generate creative and relevant texts, have the potential to revolutionize the way we learn and teach [17].

In the context of education in Kazakhstan, in a related study, the authors describe how AI allows the creation of individual learning trajectories, adapting the content to the level of knowledge and pace of each student. The researchers describe learning platforms as robotic tools with AI elements that can automatically recommend materials for learning based on the user's progress [18]. Studies demonstrate the potential of AI-based interactive simulations, gamification, and virtual reality to make complex concepts in physics, chemistry, and other disciplines more understandable. According to scientists, this helps to increase students' interest in the learning process [19, p. 4]. According to Arymbekov and colleagues, the use of AI in the context of education in Kazakhstan has significantly reduced the burden on administrative staff by automating routine tasks such as registration, progress monitoring, and data processing [20].

The Covid-19 pandemic has had a significant impact on education in Kazakhstan. With the help of AI, teachers managed to simplify access to distance learning through interactive platforms and virtual assistants at a critical moment. This has become especially important for regions of Kazakhstan where access to quality education is somewhat limited.

Despite the significant development of the country in general and the latest technologies in particular, many universities in Kazakhstan face a lack of modern equipment and software for AI integration [21, p. 140]. This, in turn, limits the possibility of using innovative solutions in education.

The problem of technological skills is described by Berikkhanova, Azimbayeva, and Mukhamedkhanova. The researchers emphasize that most teachers do not currently have sufficient skills to effectively use AI in the educational process, suggesting the implementation of specialized training programs to improve teachers' digital literacy [22]. Indeed, the implementation of AI initiatives requires significant investments in technology, infrastructure and staff training. In many cases, budgetary constraints in Kazakhstan pose a significant obstacle.

Japashov, Abdikadyr, Balta, Maxutov, Postiglione, and Tzafilkou go on to note that the use of AI requires a basic level of digital skills that not all students have, especially in regional universities. In this case, the authors suggest that increased public funding and private investment could help to upgrade the technological base of universities.

Scientists emphasize the importance of creating national initiatives to train teachers in the use of AI, such as seminars, training, and online courses on the basics of AI [23]. Partnerships with international organizations and universities can help implement best practices in the use of AI in education, and the creation of AI competence centers in the regions will provide access to innovative technologies in remote areas of Kazakhstan [24]. It is evident that Artificial Intelligence (AI) opens up new prospects for personalising educational trajectories, which is particularly relevant for complex disciplines such as physics and chemistry.

AI's ability to adapt learning content to individual student needs allows customized learning experiences. This means that each student can receive targeted training depending on their knowledge level, learning pace, and difficulties. This personalization optimizes the learning process, helping them to learn at their own pace and revisit or delve deeper into specific topics as needed. In addition, innovative approaches facilitate the accessibility of complex concepts and improve the learning process [25, p. 217].

AI opens up new opportunities for creating interactive and engaging learning content for the humanities, such as virtual simulations, educational games, and personalized lessons. Such tools contribute to more fun and practical learning. According to research by Bengesi and colleagues, virtual reality, which provides a sense of

reality and engagement, is being actively implemented in education. It facilitates the visualization of abstract concepts and complex experimental tasks and increases motivation and knowledge acquisition [26].

In 2022, educational games in the VR format for biology, chemistry, and physics were developed for applied universities in Kazakhstan and successfully tested in the classroom. Devices such as Apple Vision Pro and Meta Quest, with interactive 3D environments, are now helping to teach complex concepts, perform virtual simulations, and collaborate in virtual spaces. The devices help to visualize abstract concepts such as molecular reactions or invisible forces, allowing students to understand physical and chemical laws better. AI also reduces the time required to manipulate physical systems, and changes in simulation parameters allow students to observe the effects of these changes, enhancing understanding and increasing student motivation [27].

As reference [28, p. 107] notes, the study of physical phenomena at micro- and nanoscale scales inaccessible to sensory perception can be enhanced by VR with haptic feedback systems. These VR stations provide an opportunity for an intuitive and embodied understanding of phenomena, strengthening theoretical knowledge. AI helps to increase student motivation through engagement in unique learning environments and the formation of interactive spatial representations of complex processes.

Interactive simulations and virtual reality are transforming education, especially in the sciences, by creating immersive and highly personalized learning environments. These technologies help to increase motivation, efficiency, and accessibility of learning by allowing students to explore complex concepts through an interactive and hands-on approach.

Thus, the literature review demonstrates that the introduction of artificial intelligence into the educational process of Kazakhstani universities has excellent potential for transforming the education system. Implementing all the possibilities of AI requires overcoming infrastructure and personnel barriers. Only a symbiosis of the efforts of the state and educational institutions can ensure the effective integration of AI into education in Kazakhstan. This, in turn, will contribute to improving the quality of education in Kazakhstan.

2. Research method

The work conducted a systematic review that meets the PRISMA standards. The final selection of materials for analysis was influenced by the assessment of the quality of scientific sources, which helped to identify the most reliable and relevant studies on integrating artificial intelligence (AI) into the higher education system in Kazakhstan.

The quality criteria were established by focusing on methodological accuracy. The representativeness of the sample, clarity of presentation of results, and validity of conclusions were prioritized. The choice of such a methodology allowed the exclusion of inappropriate studies that demonstrated significant methodological shortcomings.

Based on the quality assessment, the most relevant sources were selected that met the criteria and significantly contributed to the understanding of the process of implementing AI in education. These included articles that touch on various aspects of the topic, such as the technological, pedagogical, and social benefits and problems of artificial intelligence in educational institutions.

Gaps in existing research on quality assessment results highlighted the need for further study of certain aspects, such as the impact of artificial intelligence on learning outcomes and the adaptation of curricula to new technologies. This distribution will contribute to developing recommendations for future research and practice in Kazakhstan's education field. The chosen methodology for assessing sources' quality increased the review results' reliability. It provided an understanding of the presented topic and its importance for the education system of Kazakhstan.

The main research question is: What challenges and opportunities would the introduction of artificial intelligence offer higher educational institutions in Kazakhstan?

The aim was to identify technical, pedagogical, and organisational barriers to introducing AI in higher education in Kazakhstan. Several databases were used to achieve a comprehensive search, including Scopus, Web of Science, Google Scholar, and Specialised Educational Journals of Central Asia. A total of 50 scientific sources were selected for analysis. The search was limited to publications published from 2019 to 2025. Keywords used: "artificial intelligence," "higher education," "Kazakhstan," "educational technologies," and "implementation of AI." Boolean operators (AND, OR) helped to clarify the results (Fig. 1):

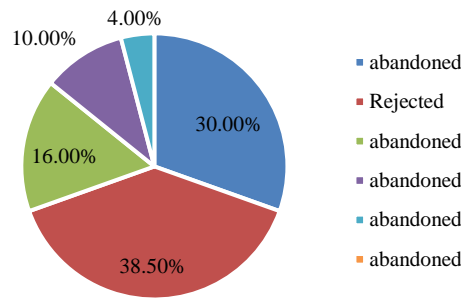


Figure 1. Visualisation of publication selection according to PRISMA recommendations

Source: authors' own development.

Inclusion and exclusion criteria (Table 1 and Table 2).

Table 1. Criteria for including related publications

Inclusion criteria	Rationale	Publications that meet the criterion
The impact of AI on education in Kazakhstan	Research should focus on the quality of education in Kazakhstan with the integration of AI	85% of publications in the list.
English, French language of publication	To ensure accessibility and standardization of results.	English (Kazakh authors) 97% of publications in the list, Kazakh - 3%
Publications 2019-2025	Ensuring the relevance of the research results	All publications in the list
Empirical research	Publications should contain practical results, not just theoretical generalizations	All publications in the list
Clear research design	Research should have a clearly defined methodology, including sampling and data collection procedures	Evaluation criteria for most publications
Statistical validity	Studies should use statistical methods to process data to confirm the reliability of the results	Includes 75% of the publications in the list

Source: authors' own development.

Table 2. The process of selecting scientific sources

Inclusion criteria	Exclusion criteria
Peer-reviewed articles and conference proceedings on AI in higher education	Articles that do not focus on AI in education.
Studies relating to or comparing Kazakhstan to other countries	Research without empirical data for Kazakhstan
Publications in English or Russian	Opinion pieces and editorials without significant analysis

Source: authors' own development.

Data were extracted using a standardized form that included:

- Information about the authors and the year of publication.
- Study design.
- Key findings.

- Relevance to the research question.

The extracted data was subject to thematic analysis to identify common themes and patterns. The thematic analysis was conducted in three stages:

- Pre-coding of texts to identify key phrases and categories.
- Coordinate results between researchers to ensure reliability.
- The following tools were used to analyze the textual data: NVivo for qualitative analysis and Python libraries (in particular NLTK and Pandas) for text processing and identifying statistical correlations.

The quality of the studies was assessed using the Critical Appraisal of Skills Programme (CASP) checklists. The main CASP criteria that had the greatest impact on the exclusion of low-quality studies were:

- A clear statement of the hypothesis.
- Validity of the sample.
- Adequacy of analysis methods.
- As a result of the analysis, 10 of the initially selected publications were excluded due to low methodological quality, which allowed us to focus on the most relevant and reliable data.

The findings were presented in a narrative form, focusing on the main themes identified during the analysis. This provided a comprehensive overview of AI's implementation in Kazakhstan's higher education, highlighting challenges (technological infrastructure, teacher readiness) and opportunities (personalized learning, increased administrative efficiency).

The proposed literature review is subject to limitations, such as language barriers that may exclude important studies published in Kazakh or other languages and the rapid development of AI technologies that may render some conclusions irrelevant.

3. Results

The research focused on the study of three main aspects of the introduction of artificial intelligence (AI) in the educational process of universities in Kazakhstan:

- What are the main challenges to integrating AI into the educational process?
- What are the prospects for using AI to improve educational practices?
- What strategies can be proposed to overcome the identified obstacles and optimize AI implementation?

Each of these aspects was investigated through a thorough analysis of related sources. The results of the presented work have highlighted the main aspects of the problem under consideration. The main obstacles to the introduction of artificial intelligence in the educational process of Kazakhstani universities are (Table 3).

Table 3. Factors hindering the integration of AI into education in Kazakhstan

Obstacle	Frequency of references in selected sources
Financial constraints	32
Technical problems	45
Resistance to change	36
Low level of digital competence	42

Source: authors' own development.

According to the literature review, the authors point to the lack of access to the latest computing resources, such as cloud platforms and high-speed Internet connections. Another problem is the possible loss of control over the learning process due to automation. The authors also question the effectiveness of new technologies. The low level of digital skills of the teaching staff is related to the knowledge to work with artificial intelligence, which makes it difficult to implement it in the educational process. Despite the identified obstacles, the use of AI opens up significant opportunities to improve the learning process. After all, artificial intelligence (AI) is becoming a powerful tool in the transformation of the educational process, opening up new horizons for personalizing learning, automating routine tasks, and creating innovative content. Among the key technologies shaping this transformation today are virtual assistants and chatbots. They use voice recognition and natural language processing to enable effective interaction between students and learning resources. Virtual assistants

are advanced software solutions that can handle complex requests and perform various functions within the educational process. They provide a more natural interaction with users, allowing students to receive information and complete tasks using voice commands. According to recent studies, these technologies have a positive impact on language learning by improving communication skills and interaction between students and teachers (Table 4).

Table 4. Benefits of AI implementation for education [29]

Personalisation of training	AI can adapt learning materials to the needs of students. For example, 81% of students surveyed said that adaptive platforms significantly improve their understanding of the material.
Automation of routine tasks	Using chatbots to automate assignment checking and answer standard questions reduces the workload of teachers.
Interactivity and innovation	Technologies such as virtual assistants provide access to interactive content and encourage students to actively participate in learning.
Accessibility of education	AI provides support for students with special needs, for example, through voice assistants.

Figure 2 demonstrates the important functionality of AI for education in Kazakhstan according to the sources studied. According to most authors, the introduction of AI in education can provide information and support in real-time, which is especially useful in conditions of high teacher workload. Many developments in this area demonstrate successful examples of chatbots in education, as they are able to adapt to student requests using natural language processing methods and specialized ontologies.

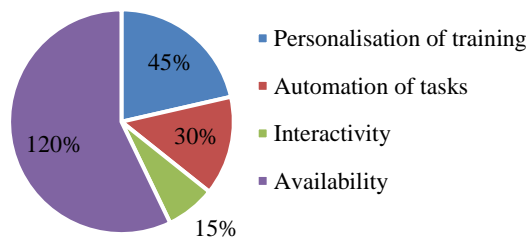


Figure 2. Distribution of AI's positive impact on learning by processed data

Source: authors' own development.

The analysis of the literature also allowed us to identify the main strategies for the effective integration of AI into the educational process of Kazakhstani universities (Table 5).

Table 5. Recommended strategies for implementing AI in education in Kazakhstan

Strategy	Description
Investments in infrastructure	Expanding technical capabilities
Staff training	Professional development of teachers
Creating a culture of innovation	Encouraging innovative practices
Ethical integration	Ensuring data confidentiality
Pilot projects	Testing solutions before scaling

Source: authors' own development.

Higher education institutions in Kazakhstan are now implementing platforms based on adaptive algorithms [30]. These platforms analyse students' needs, personalising educational content. The TensorFlow platform is actively used to help create learning models [31; 32]. TensorFlow can adapt to each student's level of knowledge. Of course, all these features make it possible to master the material more effectively and improve student performance.

4. Discussion

In Kazakh higher education institutions with a humanitarian aspect, AI tools for natural language processing have become particularly popular. The most popular is GPT-4 chat, implemented in language courses to create interactive chatbots and virtual assistants [33]. They help students access learning materials, answer frequently asked questions, or practice writing and pronunciation skills. Similar chatbots implemented at the Kazakh National University, named after Al-Farabi, provide advice on admission, class schedules, and academic support. The university is also investing in cloud services. Amazon Web Services (AWS) and Google Cloud optimize data processing and reduce storage costs. The institution purchases equipment for working with big data, including servers and graphics processors, which opens up opportunities for data analysis and improvement of educational processes [34, p. 600; 35].

Investments in infrastructure play an important role in introducing the latest technologies into the educational process. Increased access to cloud services helps to improve information processing and reduce data storage costs, improving the quality of educational services [35, 36, 37]. The purchase of big data equipment allows universities to use analytical tools to better understand learning processes and adapt courses to students' needs [38].

However, the successful implementation of these investments is impossible without training teachers, who should first be taught how to work with virtual assistants, as they help automate routine tasks of teachers, such as checking assignments. Virtual assistants are already used at the National University of Kazakhstan [39-41]. The university has developed a system of automatic assessment of written works based on deep learning algorithms. They have also implemented systems for predicting student performance based on TensorFlow. TensorFlow analyses historical data on academic performance and predicts which students need additional support. The latest technologies speed up the assessment process and reduce teachers' workload [42; 43]. In this context, it is necessary to introduce training on the use of artificial intelligence. This will enable teachers to master and integrate new technologies into their practice. Online courses on the use of AI developed based on Coursera and EdX platforms, integrated with local resources of Kazakhstani universities, provide teachers with access to relevant knowledge and techniques, which helps to improve their skills [44]. In this context, Nazarbayev University organizes regular courses on the basics of TensorFlow and Python for academic staff.

Creating an innovative culture in educational institutions is an important stage in modernising education. Encouraging teachers to introduce new technologies through grant programmes stimulates their innovation activity [45]. Promoting successful examples of the use of technology in education can inspire other teachers, leading to an overall increase in educational standards.

The ethical implementation of new technologies, including artificial intelligence, is important for gaining the trust of students and their parents [46]. Developing principles for the ethical use of AI helps to ensure the confidentiality of student data and prevent possible misuse, which is especially important in the context of growing amounts of information.

Implementing pilot projects is important to assess the effectiveness of introducing artificial intelligence into education. Launching such programs at several universities allows us to test the impact of new technologies on learning, collect data, and analyze the results [47; 48]. This will become the basis for further large-scale integration of artificial intelligence into the educational system, opening up new opportunities for the development of modern education.

Thus, introducing virtual assistants and chatbots in the educational process can significantly change the educational sector in Kazakhstan. However, as the analysis of the available literature shows, there are certain difficulties. It is important to ensure the successful integration of these technologies, considering the needs of teachers and students and overcoming resistance to innovation among some teaching staff. In the future, work in this area can become the basis for further development and implementation of AI in education. This, in turn, will contribute to creating innovative solutions to improve the country's education quality.

The integration of artificial intelligence into the educational process of Kazakhstani universities has significant potential. However, it is important to consider the specifics of the local context to successfully integrate AI. An important aspect is compliance with ethical standards. Developing strategies for scaling technologies is a prerequisite that will significantly improve the country's education quality.

Like many countries, education in Kazakhstan is facing new challenges and opportunities. These arise from introducing technologies, particularly artificial intelligence (AI) [1]. This work focused on identifying specific

problems and potential benefits of integrating AI into the educational process of higher education institutions in Kazakhstan. The goal was to identify the problems and develop recommendations for their resolution.

The results of the study showed that the use of AI in the educational process can significantly improve learning efficiency. However, ref. [49] identify a number of barriers, such as insufficient training of teachers, limited access to technology, and difficulties in adapting curricula.

A comparison of the results with the works of other researchers shows that the findings are partially consistent with international studies that also emphasize the importance of technological training of teachers and the adaptation of curricula to the impact of AI [50, p. 470]. For example, European universities note that many teachers do not have the necessary knowledge to implement new technologies, which hinders innovation [51, p. 63]. This confirms our results, which indicate the need for advanced training of teaching staff in Kazakhstan [52, p. 45].

However, our results also revealed some unique aspects specific to Kazakhstan. In particular, local universities face more serious problems with access to modern technologies than their Western counterparts. This is due to financial and administrative barriers that make it difficult to introduce the latest hardware and software [53; 54]; thus, although general trends in education point to the positive impact of AI, the realities of Kazakhstani education require a separate study.

Also, related works confirm the results that the introduction of artificial intelligence into the educational process is a key aspect of modern innovative development of higher education, but the implementation of these opportunities is accompanied by certain challenges that require detailed consideration. This technology has the potential to significantly improve the quality of learning by automating routine tasks, personalizing learning content, and increasing access to educational resources, but there are still many barriers [55, p. 8]. Scientists also describe the opportunities associated with the integration of artificial intelligence into the educational process of Kazakhstani universities, as well as the development of recommendations for optimizing this process [56]. The authors also highlight the technical infrastructure as one of the main problems that arise when integrating AI. The low level of technological infrastructure, especially in regional universities, is a serious barrier. Many educational institutions face difficulties in financing hardware and software upgrades [57]. This is supported by research that indicates a lack of qualified technical staff in educational institutions [58; 59]. The assessment also indicates that insufficient infrastructure serves as a significant barrier to AI adoption, particularly in rural areas.

Another important issue is the training of teachers to use the latest technologies. The lack of appropriate teacher training programs that would provide them with technical and methodological knowledge on the use of AI is a serious problem, which is confirmed by the results of other studies [60; 61]. The ethical aspects of AI in education also deserve attention, as they raise the issue of student data privacy and algorithm transparency [62]. Research findings indicate a lack of clear regulations in Kazakhstan, which limits trust in technology.

The results of this study largely correlate with the findings of other authors. However, the specifics of the Kazakhstani context, particularly the uneven technological development between cities and villages, underlines the need to adapt general recommendations to local conditions.

The proposed study's limitations are related to the small sample of respondents and the lack of long-term observations of the implementation of AI in the educational process. This may affect the generalisability of the results for the entire higher education system of Kazakhstan. Further research with a larger number of educational institutions and different specialties is necessary for a more detailed analysis.

As for the interpretation of the results, it is worth noting that some of them were unexpected, in particular regarding the attitude of students towards the use of AI in education. Many of them expressed concerns about the possibility of replacing teachers, which points to the need to communicate the role of AI as a supportive tool rather than as a replacement for traditional forms of education. The issue of ethics in the implementation of new technologies should be considered primarily when developing curricula.

This work contributes to the scientific field by clarifying the specifics of implementing AI in education in Kazakhstan. The results will provide new information about the barriers and opportunities that arise during the integration of technologies into education. The work emphasizes the importance of teacher training and adapting education content to new conditions. Scientific novelty is one of the first attempts at a systematic analysis of AI's impact on Kazakhstan's educational process.

5. Conclusions

The education system in Kazakhstan faces many obstacles. The integration of artificial intelligence opens up opportunities for personalized learning. AI improves understanding of complex topics and increases student engagement through interactive tools (simulation and virtual reality).

Despite the potential of these opportunities, there are obstacles. First, there is insufficient technological infrastructure and problems with teacher training. Educational institutions in remote regions do not have the necessary resources to implement such innovations effectively, and teachers often do not receive sufficient training to effectively use artificial intelligence in the educational process.

It is important to invest in infrastructure development to properly integrate AI into the education system in Kazakhstan. Teachers should also be given access to continuous learning programs and provided with the necessary technical support. This will create conditions for more equitable, interactive, and effective education in the coming years.

In the future, the development of AI-based applications can significantly change traditional teaching. New AI applications will allow students to receive interactive and personalized learning through chatbots and GPT models, receive real-time explanations, complete exercises tailored to their needs, and continuously monitor their progress. For teachers, AI technologies will provide access to an extensive research base. This will make it easier to access the latest research and teaching materials. In addition, it integrates virtual assistants to help with administrative tasks such as automatic grading, score management, and communication with students and their parents.

This technological solution will not only increase the efficiency of the educational process, but also allow teachers to focus on supporting students, which in turn will help modernise education and prepare young people for future scientific challenges.

Further research into the use of artificial intelligence in Kazakhstan's higher education system could focus on several important areas. First, in-depth empirical studies should be conducted to examine the impact of specific AI technologies on learning outcomes in various subjects. This will help identify the most effective ways to integrate new technologies into the learning process.

Secondly, it is important to study the socio-cultural aspects of AI implementation, in particular, how students and teachers perceive these technologies, as well as what difficulties they face in adapting to new forms of learning. Teachers' readiness to work with modern technologies requires special attention. The development of educational programs for advanced training is a priority.

Further, the study of economic aspects of AI implementation, including the cost of infrastructure modernization, the creation of specialized software, and its further support, is necessary. Opportunities for cooperation between the public and private sectors to finance relevant projects should be considered at the state level. State policy should be aimed at developing national standards and strategies for implementing AI in education, taking into account the specifics of the Kazakhstani education system and global trends. Scientists should focus on interdisciplinary research that combines knowledge from pedagogy, computer science, psychology, and economics. An interdisciplinary approach will make it possible to obtain a complete picture of the impact of AI on the educational process for effective solutions to existing problems.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

Zhanarka Ibrayeva, Almagul Maimakova: study conception and design; Yekaterina Gavrilova: data collection and literature review; Altynbek Akerke, Yernar Akimbayev: analysis and interpretation of results; Zhanarka Ibrayeva, Almagul Maimakova, Yekaterina Gavrilova: draft preparation; All authors: critical revision and approval of the final version of the manuscript.

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