DOI: https://doi.org/10.15407/ugz2026.01.102

Nurgazina, A.[1] 0000-0002-1020-5283,
Sergeyeva, A.[2] 0000-0002-6821-8773,
Omirzakova, M.[3] 0000-0003-3804-356X,
Ravshanov, A.[4] 0009-0002-5249-878X,
Ibragimov, L.[4] 0000-0002-1524-8469,
Usmanov, M.[4] 0000-0002-7009-8053

[1] "Zhetysu University" named after I. Zhansugurov, Taldykorgan, Kazakhstan
[2] L. N. Gumilyov Eurasian National University, Astana, Kazakhstan
[3] K. Zhubanov Aktobe Regional University, Aktobe, Kazakhstan
[4] Samarkand State University, Samarkand, Uzbekistan

Barriers and Drivers of Artificial Intelligence Integration in Geographical Education: A Comparative Study of Kazakhstan and Uzbekistan

UDC 37.091.3:91]:004.8(574+575.1)(045)

The study aims to identify the key barriers and drivers of artificial intelligence (AI) integration in geographical education through a comparative analysis of Kazakhstan and Uzbekistan, where digital transformation processes develop in parallel but differ in institutional and pedagogical orientation. A mixed-methods approach was applied, combining document analysis of national education digitalization policies with an online survey of 966 educators (471 from Kazakhstan and 495 from Uzbekistan), including schoolteachers, college instructors, and university lecturers. The analysis focused on levels of digital competence, institutional readiness, and practical integration of AI tools in teaching geography. The findings reveal notable cross-country differences. Kazakhstan demonstrates a practice-oriented approach emphasizing digital pedagogy, interactive mapping, and applied use of AI in spatial analysis. Uzbekistan, in contrast, prioritizes the development of academic infrastructure and research platforms for AI. Common barriers include weak Internet connectivity in rural areas, limited teacher training, lack of methodological frameworks, and psychological resistance to innovation. However, strong drivers are evident—state support for digital education, the spread of geospatial analytics, and the emergence of AI-based tools for spatial modeling and personalized learning. The study provides one of the first comparative assessments of AI adoption in geographical education across Central Asia. It conceptualizes AI not as a replacement for teachers but as an intelligent partner that enhances research thinking, spatial imagination, and cognitive autonomy, laying the foundation for sustainable digital transformation of geographical education.

Keywords: *artificial intelligence; geographical education; digitalization; digital literacy; Kazakhstan; Uzbekistan.*

Introduction

The rapid development of artificial intelligence (AI) technologies in recent years has had a significant impact on educational systems worldwide, transforming teaching methods, forms of teacher–student interaction, and the content of academic disciplines. In the context of educational digitalization, the integration of AI into the teaching of geography has gained particular importance. Geographical education in the era of AI goes beyond traditional cartography and regional studies, evolving into an interdisciplinary platform that integrates geoinformatics, analytical technologies, and pedagogical innovations ***[1, 2]***.

Kazakhstan and Uzbekistan, as leading Central Asian nations, are undergoing comparable stages of

For citation:
Nurgazina, A., Sergeyeva, A., Omirzakova, M., Ravshanov, A., Ibragimov, I., & Usmanov, M. (2026). Barriers and Drivers of artificial intelligence integration in Geographical education: a comparative Study of Kazakhstan and Uzbekistan. *Ukrainian Geographical Journal.* 1, 102–115. [in English]. DOI: https://doi.org/10.15407/ugz2026.01.102

digital transformation in their educational systems. For both countries, the integration of artificial intelligence (AI) into education represents a strategic priority. Educational digitalization is embedded in national policy agendas—reflected in Kazakhstan's Digital Kazakhstan and National Education Development Project and Uzbekistan's Digital Uzbekistan 2030 Strategy and Artificial Intelligence for Sustainable Development Program. However, the countries differ in their levels of infrastructural readiness, teacher qualification, and institutional support for innovation, leading to uneven adoption of AI tools— particularly in disciplines that require high levels of visualization and data analytics, such as geography.

Contemporary global challenges—such as climate change, urbanization, spatial inequality, and natural resource conflicts—underscore the growing importance of geographical education as a tool for fostering environmental awareness and spatial literacy. The integration of AI technologies, including machine learning, satellite data analysis, geoinformation services, and ChatGPT-like models, creates new opportunities for teaching research methods, spatial analysis, and digital cartography. However, these opportunities are often constrained by the lack of methodological frameworks, pedagogical competencies, and institutional support.

The purpose of this study is to identify and classify the key barriers and drivers of artificial intelligence integration in geographical education in Kazakhstan and Uzbekistan, as well as to determine strategic directions for enhancing the effectiveness of its implementation.

Analysis of previous research

In recent years, artificial intelligence (AI) has emerged as one of the key technological paradigms shaping the evolution of modern education. Scholars emphasize that the application of AI opens new possibilities for learning personalization, adaptive assessment systems, and intelligent teacher support. The integration of AI into the educational process is accompanied by the continuous improvement of pedagogical practices, contributing to a sustainable increase in the quality of education ***[3]***.

Among the most significant directions of AI integration in education are generative AI technologies, virtual and augmented reality, and intelligent data analysis systems ***[4–5]***. These innovations foster the development of learners' self-organization, critical thinking, and interdisciplinary collaboration skills. AI effectively supports project-based and research-oriented learning, shaping 21st-century competencies among future educators ***[6–8]***.

Contemporary literature places particular emphasis on the potential of AI in geographical and environmental education. Chang and Kidman ***[9]*** view the emergence of generative language models as both a challenge and an opportunity to reconsider methods of teaching geography and environmental studies. Lee ***[10]*** highlights the necessity of a comprehensive integration of advanced technologies, including geoinformation services and modeling systems, into the learning process. Similarly, Ahmed ***[11]*** underscores the role of artificial intelligence in the development of intelligent geographic information systems (AI-GIS) for spatial data analysis.

A significant contribution to understanding the role of AI in geographical education has been made by studies focusing on the use of Web-GIS and digital cartographic platforms for educational purposes ***[12–14]***, as well as on assessing the potential of ChatGPT for teaching spatial analysis ***[15]***. Lee et al. ***[16]*** examine the transformation of geography curricula and teaching methodologies under the influence of generative technologies, including automated assessment and the enhancement of fieldwork practices. Wilby and Esson ***[17]*** introduce the concept of AI literacy in geographical education, emphasizing the importance of developing a critical attitude toward the use of AI and fostering students' digital competence ***[18–20]***.

Similar trends are observed in the higher education system of Kazakhstan, where educators demonstrate a strong interest in adopting and applying artificial intelligence technologies in the teaching process ***[21–22]***. However, there remains a shortage of methodological resources, practical guidelines, and digital tools tailored to the content of educational programs. This limits the effectiveness of AI integration in teaching and constrains the development of students' digital and analytical competencies essential for contemporary geographical science.

The regional context of Kazakhstan and Uzbekistan is gradually reflected in academic literature. National methodological recommendations highlight the importance of adapting AI tools to subject-specific content, including geography, through the development of application scenarios involving digital maps, satellite data, and machine learning platforms.

Despite the growing body of literature on the digitalization of education, comparative studies across Central Asian countries remain limited. Factors influencing the successful implementation of artificial intelligence—such as technical, human, institutional, and sociocultural dimensions—have not yet been sufficiently explored. For the sustainable development of the region's educational systems, empirical evidence is required to capture the specificity of national contexts and to identify opportunities for the exchange of best practices.

Research Methods

The study on the barriers and drivers of artificial intelligence (AI) integration into geographical education in Kazakhstan and Uzbekistan was conducted using a mixed methods design that combined qualitative and quantitative approaches. This framework enabled the comparison of institutional conditions and pedagogical practices with the empirical assessments of participants in the educational process.

The methodological framework of the research included the following methods:

- *Document analysis*—examination of national policy documents and strategic programs regulating digital transformation and AI development in Kazakhstan and Uzbekistan, as well as academic publications on educational digitalization;
- *Comparative analysis*—identification of similarities and differences in institutional conditions, regulatory frameworks, and educational practices related to AI implementation in the two countries;
- *Online survey*—empirical data collection through a structured questionnaire (Google Forms) consisting of 12 items organized into thematic blocks;
- *Statistical processing of quantitative data*—descriptive statistical analysis of survey responses to identify dominant trends, barriers, and drivers of AI integration.

Within the framework of document analysis, the primary sources included national development programs of the Republic of Kazakhstan and the AI Technology Development Strategy 2030 of the Republic of Uzbekistan. This stage enabled the identification of key policy directions and institutional challenges in integrating AI into geographical education.

The empirical phase was conducted through an online survey involving geography teachers, graduate students, and representatives of the academic community. The questionnaire was structured into four thematic blocks: (1) awareness of AI; (2) frequency and forms of use; (3) barriers and limitations; and (4) perceived potential of AI for improving geography teaching. The survey was administered in three languages—Kazakh, Russian, and Uzbek—to ensure linguistic representativeness.

A total of 966 respondents participated in the survey (Kazakhstan—471; Uzbekistan—495). The majority were secondary school teachers (82.1% and 80.0%, respectively), allowing for an assessment of practices at the basic education level, while the inclusion of college and university representatives ensured vertical coverage of the entire education system. The sample comprised educators with experience in teaching geography and an interest in applying AI in educational practice. The distribution of respondents is presented in ***Tab.1.***

The majority of respondents were secondary school teachers (82.1% in Kazakhstan and 80.0% in Uzbekistan). The participation of representatives from higher education institutions and colleges expanded the scope of the analysis, encompassing all levels of the educational system. All respondents were informed about the purpose of the study and the use of data exclusively for research purposes. The study adheres to the principles of academic ethics and confidentiality. The combination of document analysis and a large-scale survey ensured the comparability and reproducibility of results, which were essential for identifying the institutional and pedagogical factors that both hinder and promote the integration of artificial intelligence into geographical education in the two countries.

The integration of artificial intelligence into educational systems in Kazakhstan and Uzbekistan is embedded within broader national digitalization strategies. In Kazakhstan, AI development is supported by the "Digital Kazakhstan" program and subsequent national initiatives aimed at fostering digital transformation in education. Regulatory discussions increasingly address issues of academic integrity, particularly in relation to plagiarism detection systems, automated content generation, and the ethical use of AI-based tools in higher education institutions. The Law on Education and institutional academic integrity codes emphasize originality, independent work, and transparency in the use of digital technologies.

In Uzbekistan, AI implementation is guided by the "Digital Uzbekistan 2030" Strategy and the

Table 1. **Distribution of respondents by teaching experience (*n* = 966)**

Characteristics	Kazakhstan (*n* = 471)	Uzbekistan (*n* = 495)
Gender		
Male	102	120
Female	369	375
Teaching experience		
Less than 1 year	15	7
1–3 years	44	37
4–7 years	85	97
8–10 years	102	106
11–15 years	115	121
16–20 years	81	91
More than 20 years	29	36
Type of educational institution		
Secondary schools	387	396
Colleges	12	19
Universities	72	80

"Artificial Intelligence for Sustainable Development" Program. Similar to Kazakhstan, regulatory documents highlight digital modernization but provide limited detailed guidance regarding the ethical use of generative AI in academic settings. Academic integrity policies in Uzbek universities primarily focus on plagiarism prevention and research ethics, while explicit regulation of AI-assisted content creation remains underdeveloped.

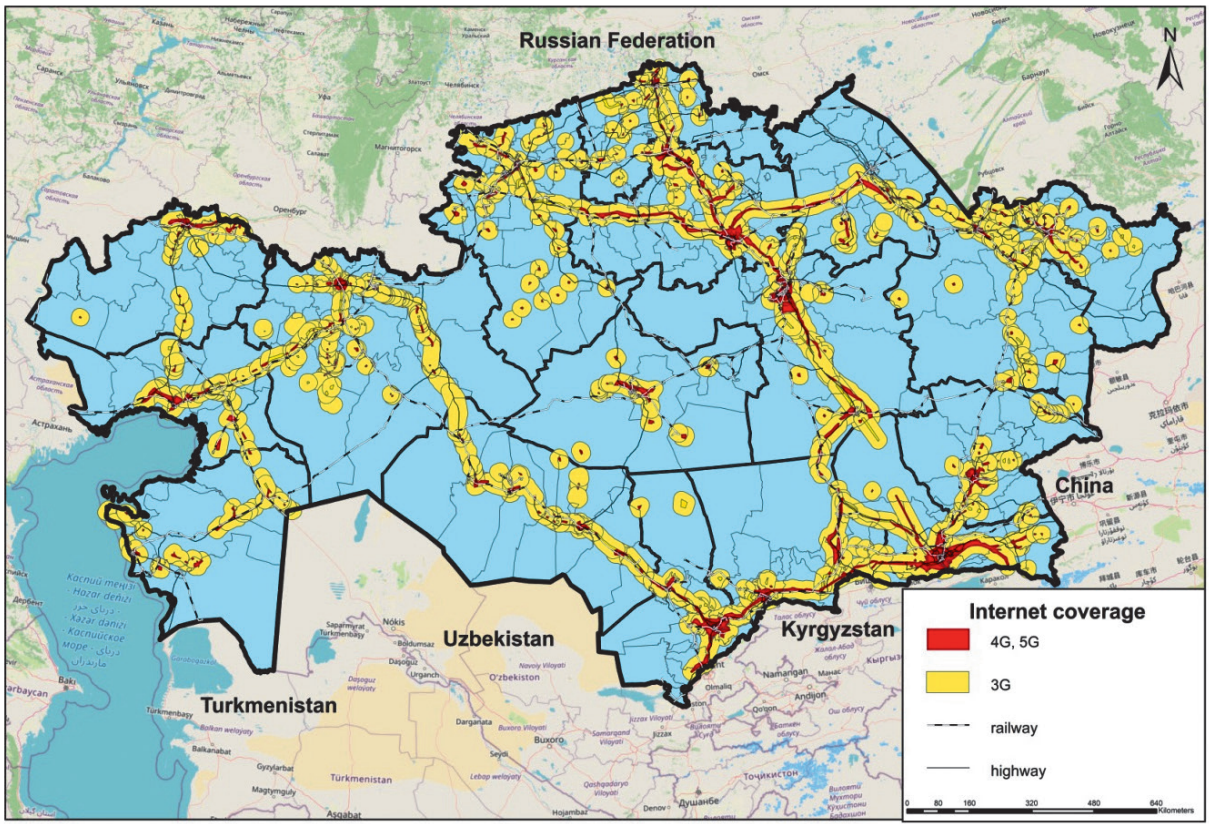
A comparative analysis demonstrates that both countries recognize AI as a strategic development priority; however, regulatory mechanisms governing its responsible use in education are still evolving. In both contexts, there exists a normative gap between rapid technological adoption and clearly articulated standards of academic integrity concerning AI-generated content. This gap creates institutional uncertainty and may contribute to inconsistent practices among educators and students.

Results and Discussion

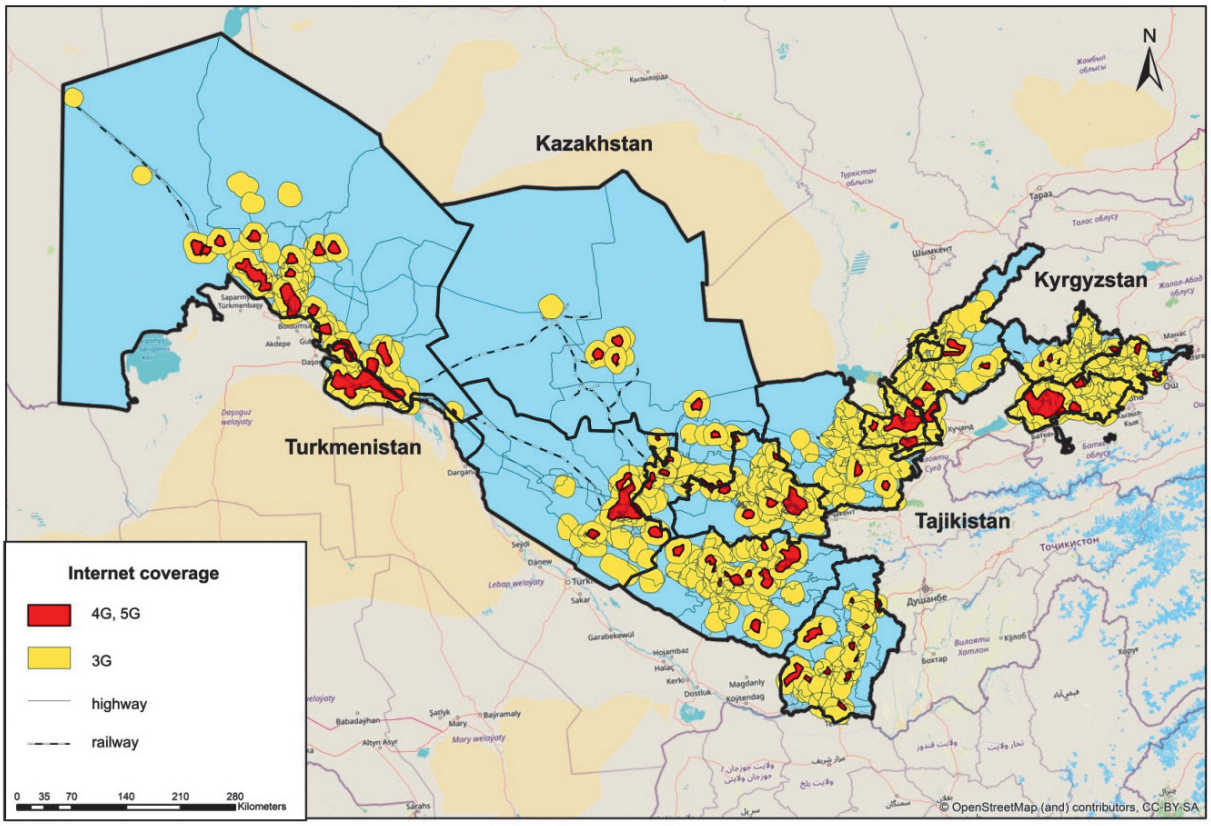
One of the key infrastructural barriers to the integration of artificial intelligence into geographical education remains the uneven development of communication networks and the limited availability of high-speed Internet. Despite the active expansion of 4G technologies and the partial introduction of 5G in Kazakhstan and Uzbekistan, a significant portion of rural and remote areas still experience weak signal coverage or lack connectivity altogether. This situation complicates the use of cloud services, online platforms, and geographic information systems, which constitute the foundation of digital educational technologies and AI-based tools ***(Fig. 1)***.

One of the conceptually significant aspects of the study concerns the degree of cognitive and practical adoption of artificial intelligence (AI) technologies by the teaching community within the educational process. The empirical data reveal a pronounced cross-country differentiation in the level of digital competence. In Kazakhstan, the dominant group of respondents (190 individuals) demonstrated not only a declarative understanding of AI functioning principles but also partial operationalization of these tools in pedagogical practice. In Uzbekistan, a comparable group (110 individuals) exhibited a lower degree of institutional AI integration, reflecting the relative inertia of digital transformation within the educational environment.

A separate analysis concerns the cohort of teachers characterized by episodic or superficial use of intelligent technologies. In Uzbekistan, this group is predominant (176 individuals), while in Kazakhstan its size is smaller (131 individuals). This distribution illustrates the difference in the pace of transition from declarative awareness to instrumental and practical application of AI. Notably, in Kazakhstan, the proportion of teachers with only basic familiarity with AI (56 individuals) or com-



(*a*) Spatial distribution of Internet coverage in Kazakhstan



(*b*) Spatial pattern of Internet connectivity across Uzbekistan

Fig. 1. Internet coverage and spatial inequality of digital infrastructure in Kazakhstan and Uzbekistan.
Source: This map was created by the author based on data from the nPerf website (Coverage Map section) ***[24]***.

pletely unaware of its capabilities (35 individuals) is significantly lower than in Uzbekistan (112 and 51, respectively). These findings empirically confirm a higher level of digital adaptability and professional-practical readiness among Kazakhstani educators.

A promising direction for the use of AI lies in the field of geographical education, where intelligent systems enable the implementation of interactive mapping services, automated geospatial analysis procedures, and intelligent assessment of learning tasks. According to the survey results, 159 respondents from Kazakhstan and 103 from Uzbekistan recognize the substantial potential of AI in enhancing the educational process. In addition, 80 and 69 respondents, respectively, noted the opportunities for personalized learning, in which algorithms adapt to learners' cognitive trajectories and levels of knowledge acquisition.

Nevertheless, a persistent skeptical discourse remains regarding the pedagogical relevance of artificial intelligence. In Uzbekistan, 142 respondents, and in Kazakhstan, 93 respondents, expressed doubts about its practical effectiveness, pointing to the limitations of simulated interaction compared to authentic pedagogical engagement. Furthermore, a considerable proportion of participants (111 in Kazakhstan and 138 in Uzbekistan) emphasized the irreplaceable role of the teacher as a mediator of knowledge and a formative agent of the educational experience. Equally noteworthy is the segment of educators (28 in Kazakhstan and 43 in Uzbekistan) who voiced concern over the potential reduction of students' critical thinking and empirical skills as a result of the excessive integration of AI.

These positions highlight the necessity of hybridizing educational strategies—a synergistic combination of traditional field-based learning and intelligent technologies—to maintain a balance between cognitive autonomy and the technological mediation of the learning environment.

Use of Digital and Intelligent Technologies in Geography Teaching

The current stage of geographical education development is characterized by intensive digitalization, accompanied by the integration of geoinformation, multimedia, and artificial intelligence technologies into the pedagogical process. The use of digital tools ensures multidimensional representation of spatial data, promotes the development of students' analytical thinking, and fosters competencies aligned with the demands of the digital transformation era.

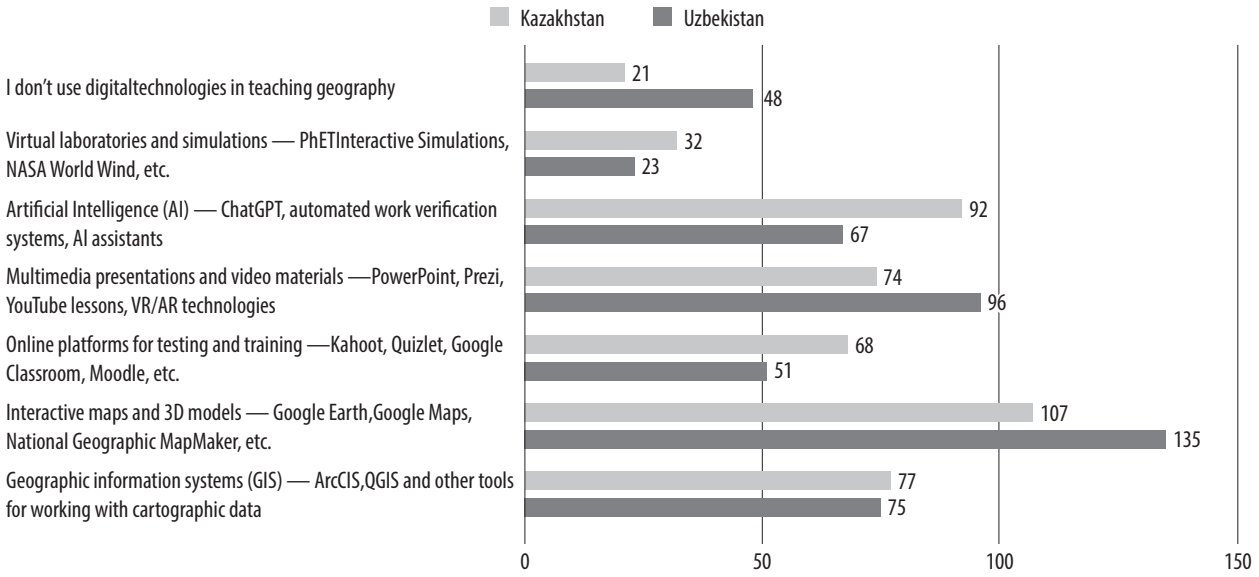
The survey results indicate the widespread use of interactive mapping services and three-dimensional models (such as Google Earth, Google Maps, and National Geographic MapMaker), which are actively employed by 107 teachers in Kazakhstan and 135 in Uzbekistan. This highlights the significant potential of geoinformation systems as a key means of visualizing and modeling spatial phenomena within the educational environment. In addition, multimedia presentations and video materials are used by 74 and 96 respondents, respectively, reflecting a growing emphasis on the visual and communicative components of the learning process.

A relatively lower level of integration is observed in the use of online platforms for testing and distance learning (such as Kahoot, Quizlet, Google Classroom, and Moodle), which are employed by 68 teachers in Kazakhstan and only 51 in Uzbekistan. This imbalance may be attributed to disparities in infrastructural capacity and differences in the level of digital readiness among educational institutions. The use of AI assistants and automated grading systems was reported by 92 teachers in Kazakhstan and 67 in Uzbekistan, indicating the gradual penetration of intelligent technologies into the practice of geographical education. Meanwhile, virtual laboratories and simulation environments (PhET, NASA World Wind) remain limited in use—32 and 23 users, respectively—suggesting restricted accessibility and insufficient methodological integration.

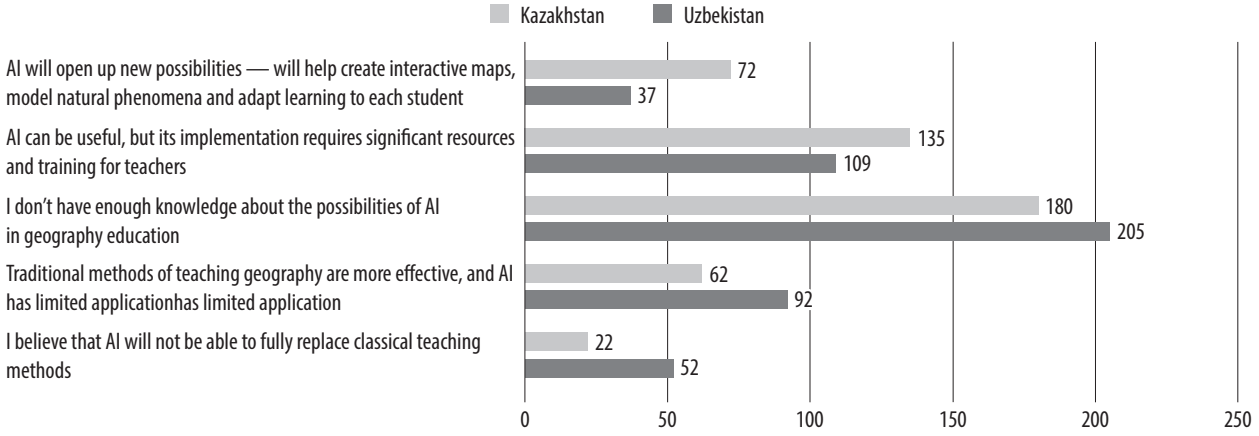
It is noteworthy that in Uzbekistan, 48 teachers reported not using any digital technologies at all, which is twice as many as in Kazakhstan (21). This highlights an institutional and technological gap and the uneven pace of digitalization processes within the educational landscape.

Teachers' Attitudes Toward the Potential of Artificial Intelligence

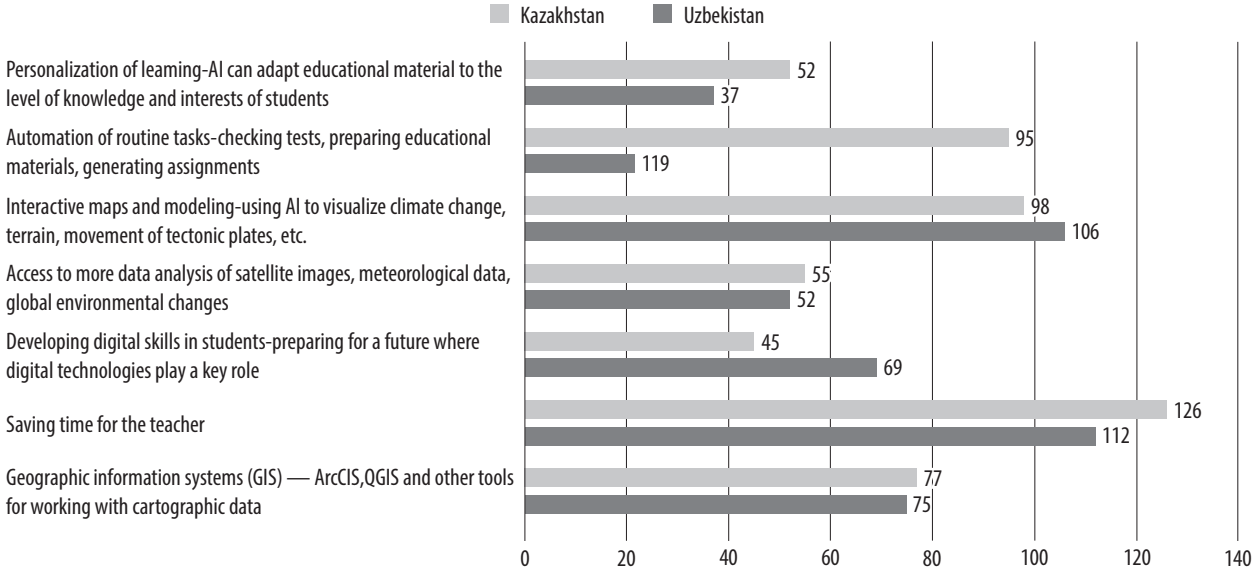
Despite the growing interest in the intellectualization of the educational process, there remains a shortage of knowledge and methodological readiness among teachers for the practical application of AI tools (180 respondents in Kazakhstan and 205 in Uzbekistan). This trend underscores the relevance of professional development programs aimed at fostering digital-pedagogical competencies. At the same time, 135 teachers in Kazakhstan



(*a*) Digital technologies are used in the educational process of teaching geography

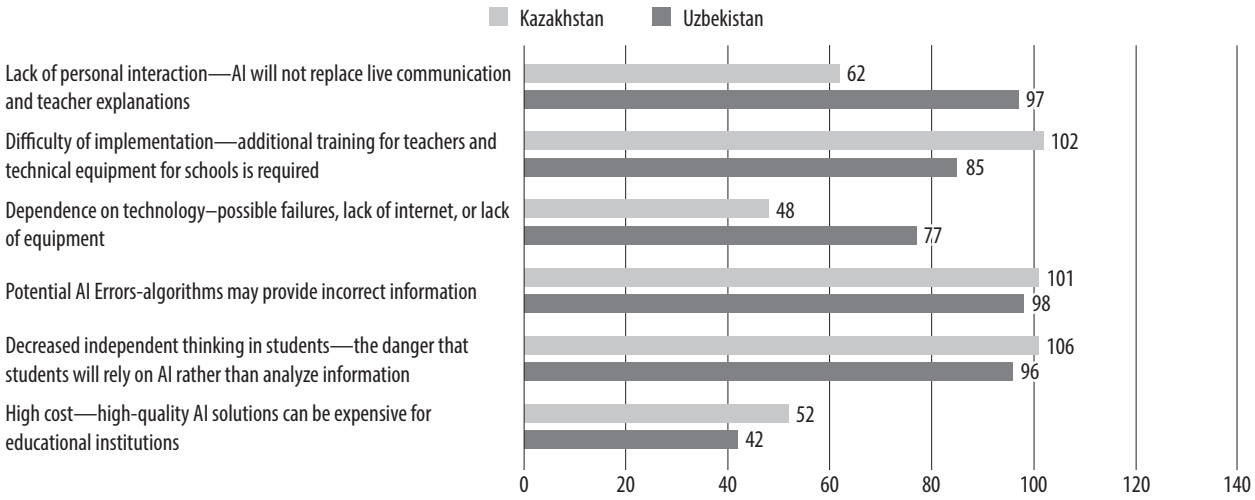


(*b*) The potential of artificial intelligence lies in the creation of interactive maps, the modeling of geographical processes, and the personalization of the educational process

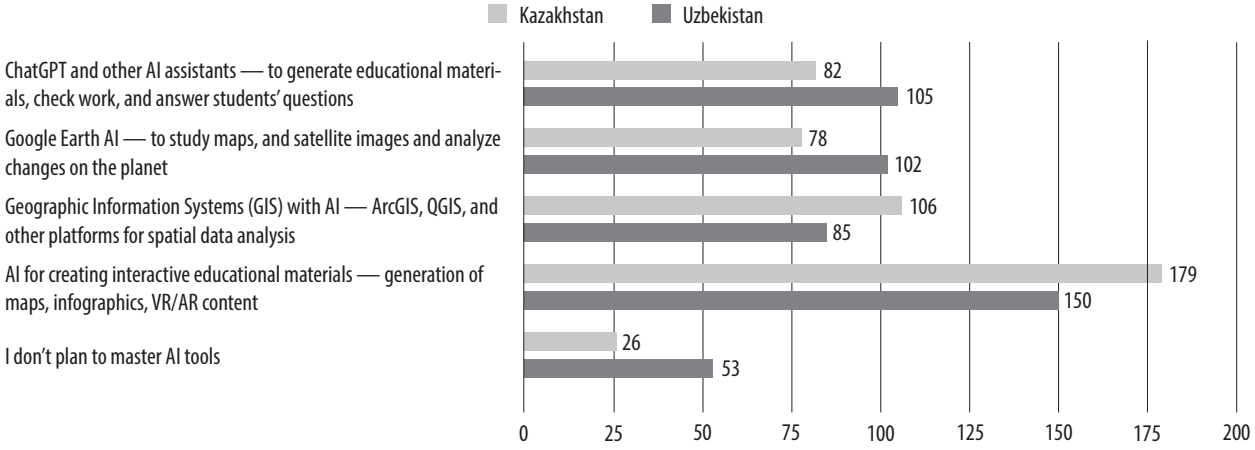


(*c*) Advantages of applying artificial intelligence in geographical education

Fig. 2. Artificial intelligence in geographical education: benefits, limitations, and developmental prospects.
(Continued on next page).



(*d*) Advantages of applying artificial intelligence in geographical education



(*e*) AI tools are being mastered to enhance professional and research competencies

Fig. 2 (continued). (*d, e*).

and 109 in Uzbekistan regard AI as a promising means of improving educational practices, while acknowledging the high resource intensity of its implementation.

An optimistic perception of AI is observed only among 72 Kazakhstani and 37 Uzbek respondents, who view it as a driver of qualitative innovation in teaching methodology, particularly in terms of personalized learning and the creation of interactive geospatial models. However, 62 and 92 teachers, respectively, continue to consider traditional teaching methods more effective, and 22 and 52 respondents believe that AI cannot fully replace classical approaches that ensure pedagogical interaction and the heuristic dimension of learning ***(Fig. 2)***.

Advantages, limitations, and institutional prospects of integrating artificial intelligence into geography teaching

The integration of artificial intelligence (AI) into geographic education is shaping a new paradigm of the learning process, grounded in automation, intellectualization, and personalization of instruction. The key advantages identified by respondents include the optimization of pedagogical activities through the automation of routine tasks (95 instructors in Kazakhstan and 119 in Uzbekistan) and the expansion of spatial modeling capabilities via interactive cartographic platforms (98 and 106, respectively). A significant factor in the effectiveness of AI integration is the reduction of instructors'

time expenditure (126 and 112 respondents), which creates prerequisites for deeper individualization of the educational interaction.

Nevertheless, alongside its functional advantages, a range of systemic limitations has been identified. The most frequently mentioned risk concerns the decline of learners' cognitive autonomy resulting from excessive dependence on algorithmic solutions (106 respondents in Kazakhstan and 116 in Uzbekistan). Additional barriers include technological vulnerability (48 and 77), infrastructural deficiencies, as well as epistemological risks associated with potential errors in data generation (101 and 98). The high cost of software and hardware solutions remains a significant constraint on the digital transformation of educational institutions.

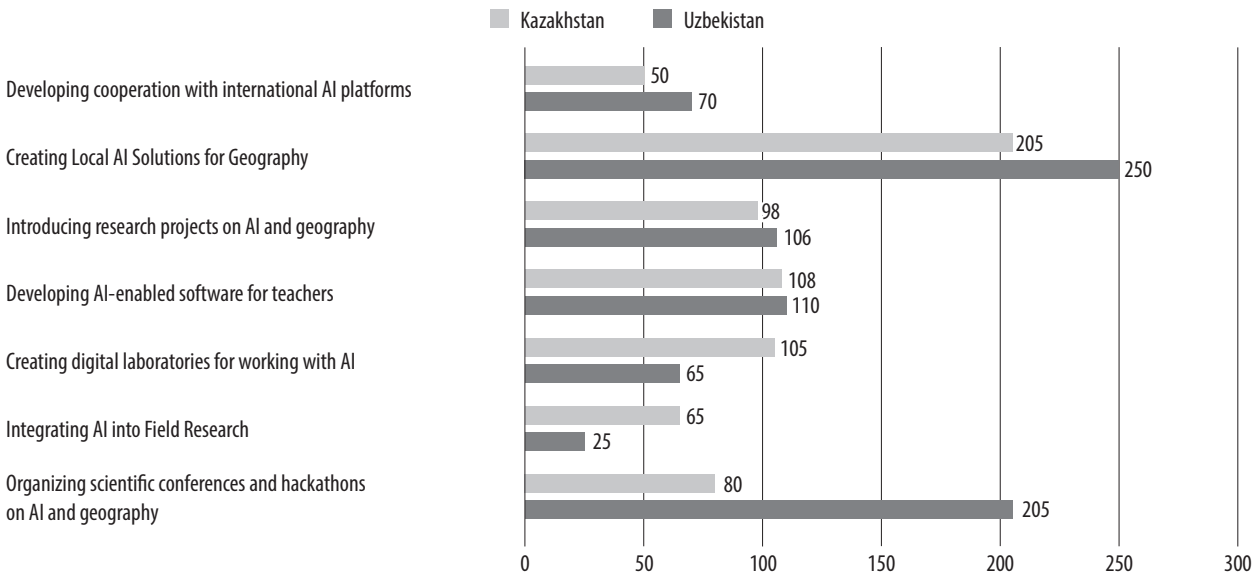
Among the most in-demand AI tools are systems for generating interactive learning materials—maps, infographics, and VR/AR content (179 and 150 respondents); geoinformation systems incorporating elements of machine analysis (106 and 85); and satellite data processing services such as Google Earth AI (78 and 102). Considerable interest is also observed in intelligent assistants (ChatGPT and its analogues), which are viewed as tools for automating the assessment and generation of educational texts (82 and 105). At the same time, a proportion of educators continue to exhibit technological skepticism (26 and 53), reflecting psychological and motivational barriers to digital adaptation.

Institutional strategies for integrating AI into educational practice vary across countries. Support for international partnerships with technological corporations (Google, ESRI, NASA) remains limited (50 and 70 respondents), while the idea of developing national AI solutions receives stronger endorsement in Kazakhstan (102) than in Uzbekistan (55), reflecting differing levels of technological sovereignty.

One of the practical directions of AI applications is the analysis of geospatial data using GIS, satellite imagery, and unmanned aerial technologies (105 and 65 respondents). However, the integration of AI into field-based research remains limited (65 and 25), primarily due to the high cost of equipment and the lack of an established methodological framework.

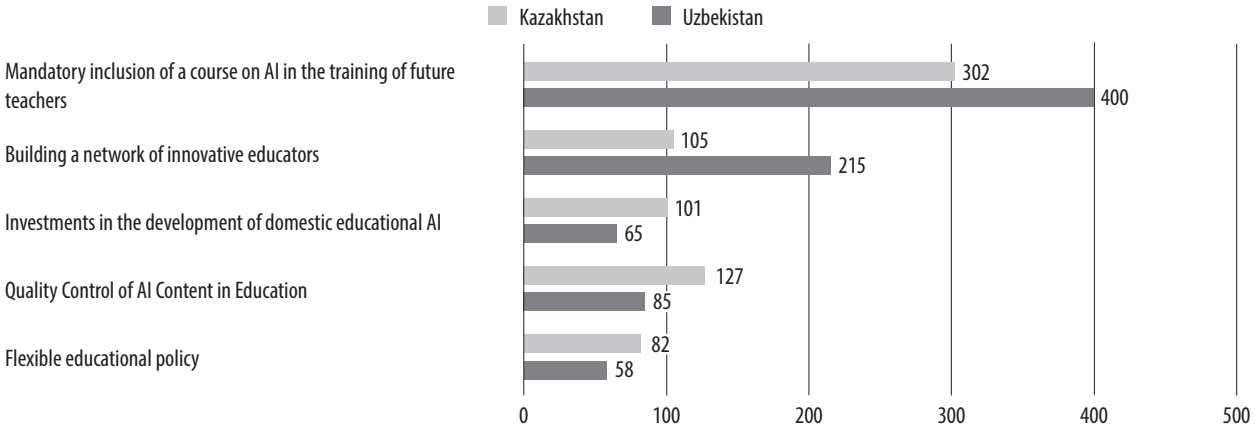
Effective implementation of AI requires systematic governmental support aimed at fostering digital pedagogy. According to respondents, the most prioritized measure is the institutionalization of AI-related courses within teacher education programs (302 in Kazakhstan and 400 in Uzbekistan). The second most significant direction involves the creation of networked professional communities of innovative educators (105 and 215), emphasizing the need for collective experience exchange and the development of a pedagogical innovation ecosystem ***(Fig. 3)***.

The issue of reliability and verification of AI-generated content is gaining particular relevance: 127



(*a*) How do you think AI can be integrated into the geographical education system in Kazakhstan and Uzbekistan?

Fig. 3. Artificial intelligence in geographical education of Kazakhstan and Uzbekistan: integration prospects and governmental support. (Continued on next page)



(*b*) What kind of support from the government or educational institutions do you think is necessary to successfully implement AI in teaching?

Fig. 3 (continued). (*b*).

respondents in Kazakhstan and 85 in Uzbekistan emphasize the need for state regulation of generative systems to prevent the dissemination of false or distorted information within the educational environment. At the same time, the idea of deregulation and simplification of procedures for integrating digital tools into curricula received limited support (82 in Kazakhstan and 58 in Uzbekistan), indicating the persistence of institutional and regulatory inertia that hinders the technological modernization of the educational process.

Artificial intelligence in geographical education of Kazakhstan and Uzbekistan: challenges and prospects of integration

Modern digital technologies are radically transforming the educational landscape, with artificial intelligence (AI) emerging as a key instrument of this transformation. In geographic education, AI enables the visualization of spatial processes, the processing of large geospatial datasets, and the personalization of learning experiences. However, the implementation of intelligent technologies in Kazakhstan and Uzbekistan faces a number of systemic barriers.

The main challenge lies not in technological accessibility but in the lack of pedagogical competencies. According to the survey, 180 teachers in Kazakhstan and 205 in Uzbekistan reported insufficient knowledge regarding the practical application of AI. The absence of specialized courses in teacher-training universities and limited opportunities for professional development impede the formation of digital pedagogy. Furthermore, older generations of educators often experience difficulties when using even basic ICT tools.

Infrastructural limitations exacerbate the divide: many schools lack stable internet connectivity, and their technical equipment does not meet the requirements of contemporary educational programs—particularly in rural regions. The solution to this problem may lie in the advancement of cloud technologies, the development of national educational platforms, and state-subsidized access to digital learning resources.

The psychological factor is also significant: some educators perceive AI as a threat to traditional forms of teaching, fearing a decline in students' independence and potential algorithmic errors. Nevertheless, when properly integrated, AI serves not as a substitute but as a partner to the teacher, enabling the automation of routine tasks and allowing greater focus on analytical work and individualized learning approaches.

The challenges of implementation also extend to specific software solutions: GIS platforms (ArcGIS, QGIS), remote sensing programs (ENVI, Google Earth Engine), analytical tools (Python, GeoDa), virtual laboratories (PhET, NASA World Wind), and AI assistants (ChatGPT, AI Tutor) all require a high level of professional qualification and methodological support.

In Kazakhstan, the emphasis is placed on the practical integration of AI into the educational process and on enhancing teachers' digital competence. In Uzbekistan, by contrast, an institutional infrastructure is being developed—AI departments

Table 2. **SWOT analysis of artificial intelligence integration into geography teaching in Kazakhstan and Uzbekistan**

Component	Kazakhstan	Uzbekistan
Strengths	• Active implementation of GIS and AI technologies in schools and universities. • Governmental support for education digitalization. • Enhancement of teachers' digital competence through training courses and pilot projects. • Development of practice-oriented approaches and use of interactive mapping tools.	• Establishment of university departments and research centers specializing in AI. • Existence of a national strategy for the digital transformation of education. • Emphasis on fundamental research and the development of national AI platforms. • Growing student interest in AI technologies.
Weaknesses	• Insufficient teacher preparation in AI and programming. • Limited infrastructure, particularly in rural schools. • Absence of a unified national strategy for AI integration in education. • High cost of licensed software and technical equipment.	• Slow implementation of AI at the school level. • Inadequate teacher qualifications and shortage of methodological resources. • Limited practical orientation of educational projects. • Dependence on foreign digital solutions.
Opportunities	• Establishment of national AI competence centers and university laboratories. • Development of partnerships with international companies (Google, ESRI, Microsoft). • Use of cloud technologies and open platforms (Google Earth AI, PhET). • Formation of networks of innovative educators and integration of AI into teacher education.	• Expansion of academic programs and research projects on AI. • Creation of national educational platforms. • Increasing investment activity in digital education. • Introduction of VR/AR and immersive technologies in geography teaching. • Expansion of academic programs and research projects on AI. • Creation of national educational platforms. • Increasing investment activity in digital education. • Introduction of VR/AR and immersive technologies in geography teaching.
Threats	• Resistance from parts of the teaching community. • Insufficient funding for long-term initiatives. • Risks of unreliable AI-generated data and ethical concerns. • Digital inequality across regions.	• Bureaucratic barriers to innovation. • Lack of large-scale digital infrastructure in schools. • Technological dependence on external providers. • Slow adaptation of AI tools to national educational standards.

and research centers—which reflects a long-term academic strategy.

Geographic education of the future is inconceivable without AI: intelligent algorithms will facilitate climate data analysis, natural process modeling, and the development of adaptive learning programs. Achieving this requires systemic support measures, including the establishment of university-based AI centers, partnerships with technology companies, the expansion of cloud computing capacities, and the implementation of specialized teacher training programs.

A conducted SWOT analysis demonstrates that the integration of artificial intelligence into geography teaching in Kazakhstan and Uzbekistan proceeds under differing institutional logics ***(Tab. 2)***.

Kazakhstan demonstrates a predominantly applied and practice-oriented trajectory of digitalization, aimed at enhancing teachers' digital competence and integrating AI into the teaching process. Uzbekistan, by contrast, places emphasis on academic infrastructure and research initiatives, providing a strategic foundation but slowing down practical implementation. For both countries, key opportunities include the development of national AI platforms, international technological collaboration, and the institutionalization of teacher training in digital pedagogy, whereas the main threats

involve digital inequality, insufficient funding, and the risks of technological dependency.

Conclusions

The conducted comparative study confirms that the integration of artificial intelligence (AI) into geographic education in Kazakhstan and Uzbekistan is asynchronous yet mutually complementary. Despite sharing the overarching goal of digital transformation, the two countries exhibit distinct models of institutional adaptation: Kazakhstan follows an applied scenario focused on enhancing teachers' digital competence and incorporating AI into instructional practice, while Uzbekistan pursues an academic-infrastructural approach, developing a research and regulatory foundation for future scaling.

The identified barriers—staffing, infrastructural, methodological, and psychological—indicate the need for comprehensive modernization of pedagogical systems. Insufficient teacher training, fragmentation of methodological support, and unequal access to digital resources remain key obstacles to full-scale AI integration. At the same time, the identified drivers demonstrate significant developmental potential, including the creation of national AI platforms, the use of cloud and GIS technologies, international technological partnerships, and the institutionalization of digital pedagogy within teacher education programs.

A promising direction involves the advancement of AI literacy in geographic education, fostering not only technical but also critical and analytical competencies among teachers and learners. AI integration should therefore be accompanied by pedagogical strategies that develop students' ability to verify AI-generated information, recognize algorithmic limitations, and preserve independent analytical thinking. In this regard, artificial intelligence should function as an intellectual partner and supportive cognitive tool rather than a substitute for reflective and research-based learning.

Finally, the study has several limitations. The empirical analysis reflects only the perspectives of educators, while the views of students and parents were not included. In addition, the online survey format may influence the representativeness of responses, particularly in regions with limited digital access. The comparative framework covers only two countries, which restricts broader regional generalization and calls for further cross-national and multi-level research.

Scientific novelty and practical significance of the research

Scientific novelty of the study lies in the comparative identification and classification of barriers and drivers of AI integration in geographical education in Kazakhstan and Uzbekistan based on a large-scale empirical survey and policy analysis. Unlike previous studies focusing on general digitalization processes, this research specifically addresses the disciplinary context of geography and examines the interaction between technological adoption and national educational frameworks.

The practical significance of the research consists in the development of strategic recommendations for improving institutional support, teacher training, and regulatory alignment in the field of AI implementation in geographical education. The findings may be used by educational policymakers, university administrators, and curriculum developers in both countries.

References [Література]

1. Hamal, O., El Faddouli N. E., Harouni, M. H. A., & J. Lu. (2022). Artificial intelligent in education. *Sustainability*, 14(5), 2862. DOI: https://doi.org/10.3390/su14052862.

2. Ramirez, E. A. B., & Esparrell, J. A. F. (2024) Artificial Intelligence (AI) in Education: Unlocking the Perfect Synergy for Learning. *Educational Process: International Journal,* 13(1), 35–51. DOI: https://doi.org/10.22521/edupij.2024.131.3.

3. Bhimdiwala, R., Neri C., & Gomez, L. M. (2022). Advancing the design and implementation of artificial intelligence in education through continuous improvement. *International Journal of Artificial Intelligence in Education,* 32, 756–782. DOI: https://doi.org/10.1007/s40593-021-00278-8.

4. Docter, M. W., de Vries T. N., Nguyen, H. D., & van Keulen H. (2024). A proof-of-Concept of an Integrated VR and AI application to develop Classroom Management competencies in teachers in Training. Education Sciences, 14(5), 540. DOI: https://doi.org/10.3390/educsci14050540.

5. Ng, D. T. K., Tan, C. W., & Leung, J. K. L. (2024). Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study. *British Journal of Educational Technology,* 55(4), 1328–1353. DOI: https://doi.org/10.1111/bjet.13454.

6. Viruel, S. R., Rivas E. S., & Palmero J. R. (2025). The Role of Artificial Intelligence in Project-Based Learning: Teacher Perceptions and Pedagogical Implications. *Education Sciences,* 15(2), 150. DOI: https://doi.org/10.3390/educsci15020150.
7. Uygun, D. (2024). Teachers' perspectives on artificial intelligence in education. *Advances in Mobile Learning Educational Research,* 4(1), 931–939. DOI: https://doi.org/10.25082/AMLER.2024.01.005.
8. Uwosomah, E. E., & Dooly, M. (2025). It Is Not the Huge Enemy: Preservice Teachers' Evolving Perspectives on AI. *Education Sciences,* 15(2), 152. DOI: https://doi.org/10.3390/educsci15020152.
9. Chang, C. H., & Kidman, G. (2023). The rise of generative artificial intelligence (AI) language models-challenges and opportunities for geographical and environmental education. *International Research in Geographical and Environmental Education,* 32(2), 85–89. DOI: https://doi.org/10.1080/10382046.2023.2194036.
10. Lee, J. (2023). Beyond geospatial inquiry-How can we integrate the latest technological advances into geography education? *Education Sciences,* 13(11), 1128. DOI: https://doi.org/10.3390/educsci13111128.
11. Ahmed, Z. Y. (2024). Artificial Intelligence Geographic Information Systems-AI GIS. *International Journal of Advanced Engineering and Business Sciences,* 5(1). 5–19. DOI: https://doi.org/10.21608/ijaebs.2024.235886.1087.
12. Li, J., Xia, H., Qin, Y., Fu, P., Guo, X., Li, R., & Zhao, X. (2022). Web GIS for Sustainable Education: Towards Natural Disaster Education for High School Students. *Sustainability*, 14(5), 2694. DOI: https://doi.org/10.3390/su14052694.
13. Popenici, S. A., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning,* 12(1), 22. DOI: https://doi.org/10.1186/s41039-017-0062-8.
14. Yufeia, L., Salehb, S., Jiahuic, H., & Syed, S. M. (2020). Review of the application of artificial intelligence in education. *Integration (Amsterdam)*, 12(8), 1–15. DOI: https://doi.org/10.53333/IJICC2013/12850.
15. Redican, K., Gonzalez, M., & Zizzamia, B. (2024). Assessing ChatGPT for GIS education and assignment creation. *Journal of Geography in Higher Education,* 2, 1–17. DOI: https://doi.org/10.1080/03098265.2024.2397332.
16. Lee, J., Cimova, T., Foster, E. J., France, D., Krajňáková, L., Moorman, L., Rewhorn, S., & Zhang, J. (2025). Transforming geography education: the role of generative AI in curriculum, pedagogy, assessment, and fieldwork. *International Research in Geographical and Environmental Education,* 1, 1–17. DOI: https://doi.org/10.1080/10382046.2025.2459780.
17. Wilby, R. L., & Esson, J. (2024). AI literacy in geographic education and research: Capabilities, caveats, and criticality. *The Geographical Journal,* 190(1), e12548. DOI: https://doi.org/10.1111/geoj.12548.
18. Janowicz, K., Sieber, R., & Crampton, J. (2022). GeoAI, counter-AI, and human geography: A conversation. *Dialogues in Human Geography,* 12, 446–458. DOI: https://doi.org/10.1177/20438206221132510.
19. Smith, T. R. (1984). Artificial intelligence and its applicability to geographical problem solving. *The Professional Geographer,* 36(2), 147–158. DOI: https://doi.org/10.1111/J.0033-0124.1984.00147.X.
20. Almelweth, H. (2022).The effectiveness of a proposed strategy for teaching geography through artificial intelligence applications in developing secondary school students' higher-order thinking skills and achievement. *Pegem Journal of Education and Instruction,* 12(3), 169–176. DOI: https://doi.org/10.47750/pegegog.12.03.18.
21. Shumakova, G., Sergeyeva, A., Abdullina, A., & Aliaskarov, D. (2024). Problems of Studying the Urbanization Process for Students of the Educational Program 'Geography' in Kazakhstan. *Indonesian Journal of Geography,* 56(2), 197–207. DOI: https://doi.org/10.22146/ijg.87685.
22. Sergeyeva, A. M., Yessembek, S. A., Abdullina, A. G., Baubekova, G. K. (2023).The Analysis of the Content of the Geography School Curriculum for the Section Country Studies in the Republic of Kazakhstan. *Ukrainian Geographical Journal,* 2023(2), 60–70. DOI: https://doi.org/10.15407/ugz2023.02.060.

The article was received by the editorial office on 02/22/2025,
accepted for publication on 03/05/2026.

Нургазіна А.[1] 0000-0002-1020-5283,
Сергєєва А.[2] 0000-0002-6821-8773,
Омірзакова М.[3] 0000-0003-3804-356X,
Равшанов А.[4] 0009-0002-5249-878X,
Ібрагімов Л.[4] 0000-0002-1524-8469,
Усманов М.[4] 0000-0002-7009-8053

[1] Жетисуський університет імені І. Жансугурова, Талдикорган, Казахстан
[2] Євразійський національний університет імені Л. М. Гумільова, Астана, Казахстан
[3] Актюбінський регіональний університет імені К. Жубанова, Актобе, Казахстан
[4] Самаркандський державний університет, Самарканд, Узбекистан

Бар'єри і драйвери інтеграції штучного інтелекту в географічну освіту: порівняльне дослідження Казахстану та Узбекистану

УДК 37.091.3:91]:004.8(574+575.1)(045)

Це дослідження присвячене вивченню бар'єрів і драйверів упровадження штучного інтелекту (ШІ) в географічну освіту на основі порівняльного аналізу Казахстану та Узбекистану — двох країн Центральної Азії,

що проходять паралельні, але відмінні процеси цифрової трансформації. Застосовано дослідницький підхід, що поєднує аналіз національних політик цифровізації з онлайн-опитуванням 966 респондентів (471 з Казахстану і 495 з Узбекистану), серед яких — учителі географії, викладачі коледжів і університетів. Результати виявили помітні міждержавні відмінності в рівнях цифрової компетентності, інституційної готовності та педагогічної інтеграції ШІ. У Казахстані спостерігається більш практикоорієнтована модель, зосереджена на цифровій педагогіці та прикладному використанні інструментів ШІ, тоді ж як в Узбекистані основний акцент роблять на розвитку академічної інфраструктури та наукових досліджень. Дослідження підкреслює необхідність розвитку ШІ-грамотності в географічній освіті як основи сталої цифрової трансформації, розглядаючи ШІ не як заміну викладача, а як інтелектуального партнера, що сприяє формуванню дослідницького мислення, просторової уяви та когнітивної автономії студентів.

Ключові слова: *штучний інтелект; географічна освіта; цифровізація; цифрова грамотність; Казахстан; Узбекистан.*

Цитування:
Нургазіна А., Сергєєва А., Омірзакова М., Равшанов А., Ібрагімов Л., Усманов М. (2026). Бар'єри і драйвери інтеграції штучного інтелекту в географічну освіту: порівняльне дослідження Казахстану та Узбекистану. *Український географічний журнал.* 1, 102–115. DOI: https://doi.org/10.15407/ugz2026.01.102