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[1]Kaldybayeva M.K., [2]Gaisin I.T.,[3]Kumarbekuly S.[*]

[1.3]Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
[2]Kazan Federal University, Kazan, Tatarstan
***Corresponding-author:** sanat_kv@mail.ru

E-mail: kaldibaeva.magzat@mail.ru, gaisinilgizar@yandex.ru, sanat_kv@mail.ru

ARTIFICIAL INTELLIGENCE IN GEOGRAPHY TEACHING METHODOLOGY: CONTEMPORARY APPROACHES, DIGITAL TOOLS, AND INFLUENCE ON THE DEVELOPMENT OF STUDENTS' CRITICAL THINKING

Annotation. This article analyses the application of artificial intelligence (AI) technologies in geography teaching at secondary and higher education levels. Drawing on empirical and analytical sources published between 2022 and 2025, it examines the principal AI tools documented in geography education — geographic information systems (GIS), generative language models, and adaptive learning systems — along with their influence on the development of students' critical thinking. The study is anchored in a meta-analysis covering 29 empirical works with a combined sample of 2,657 participants and the results of a regional comparative survey of 966 geography teachers from Kazakhstan and Uzbekistan. The central research problem is the contradiction between the documented positive educational effects of AI and teachers' limited pedagogical readiness to integrate it effectively. Contradictions between studies are explicitly identified: some research records gains in academic achievement and higher-order thinking when AI is applied in structured instructional scenarios, while others document the risk that unstructured AI use suppresses independent analytical reasoning.

Keywords: artificial intelligence in education, geography teaching methodology, critical thinking, GIS, generative AI, digital tools, SAMR model, Kazakhstan, Uzbekistan.

Introduction

Systematic integration of artificial intelligence into educational practice moved beyond the sphere of purely technological debate after 2022: AI tools have since been documented in the curricula of at least 12 school and university disciplines, including geography [1]. Within geography education, however, the research base remains sparse relative to STEM fields. According to the systematic review by Şanlı [2], published in the International Journal of Current Educational Studies, the majority of peer-reviewed empirical studies linking AI to geography instruction appeared only after 2021.

The research problem addressed here is the following: AI use in geography teaching generates measurable positive effects on academic achievement and spatial reasoning, yet its impact on critical thinking — a core competency of geographical education — remains contested. Controlled experiments report gains in higher-order thinking when AI is integrated via structured pedagogical scenarios [3]. Conversely, survey-based research finds that 83% of student-teachers were concerned that heavy AI reliance would limit their capacity for

independent judgement [4]. Wu [5], whose analysis of ChatGPT integration challenges in formal education is cited in the Dong et al. [1] meta-analysis, reinforces this concern: AI may hinder the development of deep understanding when not paired with deliberate cognitive challenge. Note: a further source — Yan et al. [6] — appears in the same meta-analysis reference list with the partial citation "Analysis and prospect of applied research," but its full bibliographic record could not be independently verified and is therefore excluded from this review.

The goal of the present study is to systematise current evidence on AI tools used in geography teaching methodology and to characterise their effect on critical thinking, based on empirical results published in 2022–2025. The working hypothesis is that the effect of AI on critical thinking is determined not by the specific tool deployed, but by the pedagogical format of integration — the nature of the task, the level of cognitive demand placed on the student, and the degree of autonomy retained in working with data.

The regional context reinforces the study's significance. An online survey of 966 geography teachers across Kazakhstan and Uzbekistan (Nurgazina et al., 2025) — the first large-scale study of its kind in Central Asia — established that both countries are at an early stage of AI integration in school-level geography [7]. Kazakhstan, ranked 72nd out of 193 countries in the Oxford Insights Government AI Readiness Index 2023, has embedded AI more actively in school curricula; Uzbekistan focuses primarily on AI research and national platform development [8]. Both states share identical primary barriers: low teacher digital literacy, shortage of qualified personnel, and limited access to modern technologies.

An international review by Lee, Cimová, Foster, France et al. [9], comprising authors from seven institutions across South Korea, the Czech Republic, the USA, the UK, Canada, and China, establishes that systematic application of generative AI within geography programmes remains rare as of 2025. Most documented classroom applications operate at the Substitution level of the SAMR model — replacing existing tools without functional transformation — rather than at the Redefinition level that the technology's potential would permit.

Materials and methods of research

This study is designed as an analytical review with a comparative component. Source selection was conducted across three databases — Scopus, Web of Science, and ERIC — applying the following inclusion criteria: (1) publication in a peer-reviewed journal or edited academic volume between 2022 and 2025; (2) subject matter involving AI tool application in education with at least one measurable outcome (academic achievement, critical thinking, spatial thinking, or teacher digital competence); (3) presence of empirical data — quasi-experiment, survey, or meta-analysis — or a verifiable analytical conclusion accompanied by a stated sample and methodology description.

The primary quantitative source for evaluating AI's effect on learning outcomes is the meta-analysis by Dong, Tang & Wang [1], from Purdue University and the University of Notre Dame, published in Computers and Education: Artificial Intelligence. The authors synthesised 29 empirical studies (January 2019 – December 2024), total n = 2,657, retrieved from Scopus, Web of Science, and EBSCO (APA PsycINFO; Education Full Text; Education Source; ERIC; Social Sciences Full Text). Coding covered moderator variables: educational level, AI role in the instructional process, intervention duration, sample size, and academic discipline. A random-effects model was applied due to expected heterogeneity.

For the subject-specific geography experiment, the primary source is Almelweth (2022), University of Jazan, Saudi Arabia, Pegem Journal of Education and Instruction, 12(3),

169–176. The quasi-experimental design involved 60 female second-year secondary school students divided into a control group (conventional instruction) and an experimental group (AI-strategy instruction). Instruments: a higher-order thinking skills (HOTS) observation card and a geography achievement test. For critical thinking, the main source is Szmyd & Mitera (2024), Ignatian Academy and Pedagogical University of Kraków, Poland, European Research Studies Journal, XXVII(2), 1022–1039, using a self-assessment questionnaire.

The regional comparative analysis relies on Nurgazina et al. [7], affiliated with Zhetysu University (Taldykorgan), Samarkand State University, and K. Zhubanov Aktobe Regional University, published in the International Journal of Innovative Research and Scientific Studies, 8(2), 1797–1811. The survey (n = 966) covered geography teachers from comprehensive schools, colleges, and higher education institutions in both countries; correlation analysis was applied to identify cross-country trends. Instruments addressed AI knowledge level, readiness for implementation, and perception of digital technologies. Ethics approval was granted by Zhetysu University Ethics Committee (Ref. No. 13-1) and Samarkand State University (Ref. No. 1).

GIS-specific evidence is drawn from the systematic review by Hickman [10] (International Research in Geographical and Environmental Education, 32(2), 140–158) covering 2010–2022 literature, and the quasi-experiment by Yang, Wang & Qian [6] on GIS-based air pollution teaching (Transactions in GIS, 28(4), 433–454). The SAMR framework analysis is based on Lee et al. [9] and tool classification on Şanlı [2]. Studies without a stated sample, with non-reproducible methodology, or published before 2022 were excluded. Table 1 summarises the key sources.

Table 1 - Key empirical sources included in the review (2022–2025)

Author / Year	n	Method	Country / Level	AI Tool	Key Outcome
Almelweth (2022) [3]	60	Quasi-experiment	Saudi Arabia / Secondary	AI teaching strategy	Sig. improvement in HOTS & achievement ($p = 0.05$) — experimental > control
Dong, Tang & Wang (2025) [1]	2,657 (29 studies)	Meta-analysis	International / K–Higher	Mixed AI systems	Overall $d = 0.924$ (large effect); $I^2 = 93\%$
Szmyd & Mitera (2024) [4]	Pre-service teachers	Survey	Poland / Higher ed.	ChatGPT / LLMs	83% concerned AI limits independent thinking; AI rated helpful but not decisive for CT

Nurgazina et al. (2025) [7]	966 teachers	Online survey + correlation	Kazakhstan & Uzbekistan / K–Higher	GIS, AI platforms	KZ: 190/471 school teachers use AI tools; UZ: 110/475. KZ leads in curricular integration
Lee et al. (2025) [9]	Int'l literature review	SAMR framework analysis	7 countries / All levels	GenAI / LLMs	Most GenAI use in geography at Substitution level; Redefinition is rare
Yang, Wang & Qian (2024) [6]	Not disclosed (quasi-exp.)	Quasi-experiment	China / Secondary	GIS	GIS group outperformed controls on spatial dependency analysis tasks
Hickman (2023) [10]	Systematic review 2010–2022	Systematic review	International / K–Higher	GIS	GIS supports spatial thinking when paired with adequate digital literacy scaffolding

Results and Discussion

Overall Effect of AI on Academic Achievement

The meta-analysis by Dong et al. [1] recorded an overall positive effect of AI on student academic achievement: effect size d = 0.924 (Cohen's large effect, threshold d > 0.8). Heterogeneity was high (I^2 = 93%), indicating that results vary substantially across contexts, AI systems, and intervention designs. An earlier meta-analysis covering 24 studies published 2001–2020 reported a comparable figure of d = 0.812 (Zheng et al., 2023, cited in Dong et al., 2025). The higher value obtained from post-2019 data aligns with the hypothesis that greater tool accessibility after 2019 improved the quality and scale of pedagogical AI interventions.

Regarding moderator variables, Dong et al. [1] found that interventions shorter than two weeks yielded significantly larger effects than longer programmes. This contradicts Zheng et al. (2023), who reported the largest effect for programmes lasting two to four weeks. The authors of the 2025 meta-analysis attribute this discrepancy to inconsistent operationalisation of intervention duration across the included studies — an acknowledged limitation. A separate meta-analysis of 52 GenAI-specific studies (ResearchSquare preprint, 2025) reported an even higher Hedges' g = 1.193, exceeding Dong et al.'s estimate, which the

authors attribute to the recency of GenAI tools and more intensive instructional designs in post-2023 studies.

Subject-Specific Effect in Geography Education

The study by Almelweth [3] is, at the time of writing, the only peer-reviewed quasi-experiment that directly links AI application to geography learning outcomes at the secondary school level. The experimental group, exposed to an AI-strategy instructional approach, produced statistically significant higher scores on both the geography achievement test and the HOTS observation card compared to the control group ($p = 0.05$ in both cases). The study's limitations constrain generalisation: the sample is gender-homogeneous (60 girls only), geographically restricted to one Saudi school context, and does not include delayed post-testing to measure retention.

The review by Şanlı [2] identifies four functional categories of AI tools applicable to geography instruction. In physical geography, classification algorithms — CNN, SVM, and Random Forest — are documented for land-use mapping, soil structure analysis, climate data modelling, and disaster risk assessment. In human geography, GeoAI and location-based systems process large datasets on migration, urbanisation, cultural geography, and tourism. Intelligent tutoring systems adapt tasks in real time based on student performance. Natural language processing systems handle geographic query-response during GIS exercises. The review covers 2018–2024 literature but does not aggregate effect sizes across the cited primary studies — a methodological boundary explicitly noted by the author.

GIS and Spatial Thinking Development

The systematic review by Hickman [10], spanning 2010–2022 literature, establishes that GIS, when paired with appropriate pedagogical scaffolding, supports the development of spatial thinking, inquiry skills, and problem-solving capacity in geography learners. The critical qualifier is students' initial digital literacy: learners with low baseline technological competence show substantially smaller gains in spatial reasoning than those with established geospatial data skills. This dependency means that GIS benefits are not uniformly distributed across school populations.

The quasi-experiment by Yang, Wang & Qian [6] on GIS-based air pollution teaching in China found that the GIS group outperformed controls on tasks requiring analysis of spatial dependencies. Specific effect sizes and sample sizes are not disclosed in the open-access abstract. The broader synthesis in the review Teaching Geography with GIS (2025), citing Bondarenko (2025), Meechandee & Meekaew (2025), and Yang et al. (2024), confirms consistent improvements in conceptual understanding and spatial thinking across multiple GIS-in-geography studies — primarily in high-infrastructure educational contexts.

AI and Critical Thinking: Contradictions in the Literature

The data on AI's influence on critical thinking present a fundamental divergence that is not attributable to methodological noise alone but reflects qualitatively different instructional contexts.

Structured instructional contexts produce positive outcomes: Almelweth (2022) recorded significant gains in higher-order thinking skills under an AI-mediated geography strategy where the tool functioned as a cognitive scaffold — presenting problems, not solutions. In contrast, survey-based research by Szmyd & Mitera (2024) found that 83% of pre-service teachers perceived a genuine risk that over-reliance on AI-generated responses would erode their capacity for independent judgement. The same study notes that AI assists students in analysing large datasets and exploring alternative solutions — positioning it as

conditionally useful, not categorically harmful. The condition is the presence of tasks that keep the student in the interpretive role.

Bloom's Taxonomy analysis conducted by Lee et al. (2025) shows that GenAI reliably supports the lower cognitive levels — Remember and Understand — while its contribution to Analyse, Evaluate, and Create depends on whether the teacher designs tasks that preclude AI from substituting the student's reasoning. Gonsalves (2024), cited in Szmyd & Mitera, reaches the same conclusion: AI underperforms precisely at the three levels of Bloom's taxonomy that constitute critical thinking. The explanation proposed by Şanlı (2025): Almelweth's result was obtained under a tightly structured scenario, where the AI-strategy demanded student interpretation at each step, whereas the concerns documented by Szmyd & Mitera arise in less-structured or self-directed learning contexts where students default to accepting AI output without independent evaluation.

Teacher Readiness: Kazakhstan vs. Uzbekistan

Among the 966 geography teachers surveyed by Nurgazina et al. (2025), Kazakhstan's school-level respondents who reported understanding AI principles and using tools in teaching (n = 190 of 471 school teachers, approximately 40%) substantially outnumbered their Uzbekistani counterparts (n ≈ 110 of 475, approximately 23%). Table 2 provides a detailed cross-national comparison. In both countries, the dominant obstacles were identical: low digital literacy among educators, a shortage of qualified staff, and limited access to advanced technologies.

Table 2 - Comparison of AI integration in geography education: Kazakhstan vs. Uzbekistan (based on Nurgazina et al., 2025)

Indicator	Kazakhstan	Uzbekistan
Total teachers surveyed	471 (school) + 72 (HEI) + 12 (college) = 555	396 (school) + 80 (HEI) + 19 (college) = 495 (+ 16 N/A = 511)
Teachers who understand AI & use tools in teaching	190 of 471 school teachers (≈40%)	110 of 475 school-level respondents (≈23%)
National AI strategy	Digitalisation programme; AI embedded in school curricula	'AI Technologies Development Strategy until 2030' approved Oct 2024 — regulatory & HEI focus
Primary obstacle	Low digital literacy among educators; insufficient qualified staff	Low digital literacy; limited advanced-technology access; rural–urban divide
Government AI teacher training	324,000 teachers reached via UNESCO-ICHEI micro-certificate courses (2024)	Samarkand State University AI/IS dept. launched; Uzbek-language content shortage (45%)
AI readiness index	72nd / 193 (Oxford Insights 2023)	Data not reported in Nurgazina et al. (2025)
Dominant AI integration pattern	Curricular embedding — AI tools used in geography lesson delivery	Platform development & AI research — less classroom application documented

For comparative perspective: a large-sample study in Hungary (n = 1,103 teachers from 13 disciplines, University of Budapest, 2025) found that AI literacy functions as a significant predictor of readiness to integrate AI into teaching — teachers with high AI literacy showed markedly more positive attitudes and integration intentions. A parallel survey in Turkey [11] established that academics with short teaching experience (1 month to 2 years) had higher digital competence than those with 15+ years. If this pattern applies in Kazakhstan and Uzbekistan, demographic renewal of the geography teacher workforce may partially address the readiness gap documented by Nurgazina et al. (2025) without requiring separate training interventions.

*Classification of AI Tools in Geography Teaching (Table 3) and the SAMR Model (*Table *4).*

Table 3 below systematises the AI tools identified across the reviewed literature by tool category, geography domain, pedagogical function, and documented examples.

Table 3 - Classification of AI tools in geography teaching by domain and pedagogical function

Tool Category	**Geography Domain**	**Pedagogical Function**	**Example / Representative Tool**
GIS Platforms	Physical & Human	Spatial data analysis, map visualisation, spatial thinking development	ArcGIS Online, QGIS, Google Earth Engine [10,6]
CNN / SVM / Random Forest	Physical geography	Land-use classification, soil analysis, climate data, disaster risk assessment	Classification of satellite imagery in land-cover mapping lessons [2]
GeoAI / Location-based systems	Human geography	Analysis of migration, urbanisation, cultural geography, geopolitics	GeoAI for urban growth modelling; geotagged social-media analysis [2]
Large Language Models (LLMs)	Both / Cross-domain	Content personalisation, automated feedback, question answering, essay assessment	ChatGPT for personalised geography content; LLM-grading pilot with 18 essays [12]
NLP chatbots	Both / Cross-domain	Student-initiated query-response during GIS tasks; vocabulary support	Intelligent tutoring chatbots in GIS courses, Singapore (Web GIS study, 2023)
Intelligent Tutoring Systems (ITS)	Both / Cross-domain	Real-time adaptive content adjustment based on student performance	Adaptive geography e-learning platforms in KZ & UZ [7]

Retrieval-Augmented Generation (RAG)	Physical & Human	Up-to-date environmental simulation, real-time data retrieval for fieldwork	RAG-based environmental simulation tools [2]

Table 4 applies the SAMR model (Lee et al., 2025) to GenAI integration in geography education. The model stratifies AI use from lowest to highest transformative potential. Rows are ordered from highest transformative impact (Redefinition) to lowest (Substitution). The principal empirical finding is that most currently documented practices in geography classrooms operate at the Substitution level — that is, GenAI replaces a prior tool (textbook, search engine) without changing the nature of the learning task.

Table 4 - SAMR model applied to Generative AI integration in geography education (based on Lee et al., 2025)

SAMR Level	Definition	GenAI Application in Geography Education
REDEFINITION	*Tasks previously inconceivable become possible with GenAI*	Students co-analyse real-time satellite feeds and generate climate scenario narratives using LLMs; global fieldwork collaboration across continents
MODIFICATION	*Significant redesign of tasks through AI affordances*	AI-powered adaptive feedback on student GIS maps; automated grading of open-ended geography essays with LLMs [12]
AUGMENTATION	*Functional improvement over traditional method*	GenAI generates personalised geographic content aligned to student performance; NLP chatbots answer spatial queries during GIS exercises
SUBSTITUTION	*Direct digital replacement — no functional change*	GenAI used as a search engine substitute for geography definitions; ChatGPT replaces textbook summaries (documented majority of current practice)

A pilot study on LLM-based assessment of geography essays in German, conducted with 18 student texts scored on a 0–15 point scale [11], demonstrated that advanced LLMs show acceptable precision for short written responses but incur substantially higher token costs and reduced accuracy for longer analytical essays. The study's conclusion positions

LLMs as supplementary tools for teachers — not autonomous grading systems — representing the Augmentation rather than Redefinition level of the SAMR model.

Conclusions

The combined body of evidence confirms that AI tool use in education statistically significantly raises academic achievement (d = 0.924, Dong et al., 2025; 29 studies, 2,657 participants). In geography specifically, this effect is reproduced in the only available subject-specific quasi-experiment (Almelweth, 2022; 60 students, p = 0.05) across both achievement and higher-order thinking skills. The scope for extrapolation is constrained: the sample is gender-homogeneous and geographically singular, and no independent replication exists. Researchers should treat Almelweth's result as a directional indicator rather than an established population-level finding.

The working hypothesis is confirmed by the convergence of sources. Structured AI use — where the tool serves as a cognitive scaffold and the student retains interpretive agency — generates gains in higher-order thinking (Almelweth, 2022). Unstructured AI use, in which the student accepts generated output without independent evaluation, produces a documented risk of eroding critical thinking: 83% of participants in Szmyd & Mitera (2024) identified this as a concrete concern, and the Bloom's Taxonomy analyses by Lee et al. (2025) and Gonsalves (2024) explain the mechanism — GenAI underperforms at the three upper levels (Analyse, Evaluate, Create) precisely because those levels require the student's own reasoning. This is not a paradox but a predictable property of a system optimised to generate plausible text rather than to model the user's reasoning.

The SAMR framework clarifies the gap between AI's theoretical potential and current practice in geography education. As of 2025, most documented uses remain at the Substitution level (Lee et al., 2025). Moving to Modification and Redefinition requires teachers to design tasks where AI handles data retrieval and simulation while students perform spatial analysis, causal argumentation, and critical evaluation — roles that the AI cannot occupy. This task-design requirement is itself a pedagogical competency that the reviewed literature consistently identifies as underdeveloped in geography teachers globally, and specifically in Kazakhstan (≈40% of school geography teachers using AI tools) and Uzbekistan (≈23%), as documented by Nurgazina et al. (2025).

Successful AI integration in geography education requires simultaneous progress on three interdependent fronts: (1) expansion of digital infrastructure to narrow the urban-rural access gap, which in Uzbekistan produces a 3–4-fold adoption difference between Tashkent and regional schools; (2) targeted teacher training in subject-specific AI pedagogy — not generic digital literacy, but geography-specific scenarios for integrating GIS, GenAI, and GeoAI tools with tasks that retain student cognitive agency; and (3) development of culturally responsive, localised content, which is a documented bottleneck in both Uzbekistan (45% of teachers cite insufficient Uzbek-language AI content) and other non-Anglophone contexts identified by Şanlı (2025). The data available as of 2025 are sufficient to identify the direction of effective integration but insufficient to specify which combinations of AI tools, instructional designs, and assessment formats maximise critical thinking outcomes in geography — a gap that requires purpose-designed longitudinal experiments with pre-registered protocols.

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Қалдыбаева М.Қ., Гайсин И.Т., Құмарбекұлы С.

ЖАСАНДЫ ИНТЕЛЛЕКТТІ ГЕОГРАФИЯ ПӘНІН ОҚЫТУ ӘДІСТЕМЕСІНДЕ ПАЙДАЛАНУ: ЗАМАНАУИ ТӘСІЛДЕР, ЦИФРЛЫҚ ҚҰРАЛДАР ЖӘНЕ ОҚУШЫЛАРДЫҢ СЫНИ ОЙЛАУЫН ДАМЫТУҒА ЫҚПАЛЫ

Андатпа. Бұл мақала орта және жоғары білім деңгейіндегі география пәнін оқытуда жасанды интеллект (ЖИ) технологияларын қолдануды талдайды. 2022–2025 жылдар аралығында жарияланған эмпирикалық және аналитикалық деректерге сүйене отырып, мақала география білімінде тіркелген негізгі ЖИ құралдарын — географиялық ақпараттық жүйелерді (ГАЖ), генеративтік тіл модельдерін және бейімделгіш оқыту

жүйелерін — зерттейді, сондай-ақ олардың оқушылардың сыни ойлауын дамытуға ықпалын қарастырады. Зерттеу жиынтық іріктемесі 2 657 қатысушыны қамтитын 29 эмпирикалық жұмыс бойынша жүргізілген мета-талдауға, сондай-ақ Қазақстан мен Өзбекстанның 966 география мұғалімін қамтыған аймақтық салыстырмалы сауалнама нәтижелеріне негізделген. Зерттеудің орталық мәселесі — ЖИ-дің білім беруге тигізетін оң әсерінің дәлелденген деректері мен мұғалімдердің оны тиімді кірістіруге дайын еместігі арасындағы қайшылық болып табылады. Зерттеулер арасындағы қарама-қайшылықтар нақты анықталған: бір зерттеулер ЖИ-ді құрылымдалған оқу сценарийлерінде қолданғанда академиялық жетістіктер мен жоғары деңгейлі ойлаудың өскенін тіркесе, басқалары ЖИ-ді құрылымсыз пайдаланудың оқушылардың дербес аналитикалық ойлауын тежеу қаупін құжаттайды.

Кілт сөздер: білім берудегі жасанды интеллект, география пәнін оқыту әдістемесі, сыни ойлау, ГАЖ, генеративтік ЖИ, цифрлық құралдар, SAMR моделі, Қазақстан, Өзбекстан.

Қалдыбаева М.Қ., Гайсин И.Т., Құмарбекұлы С.

ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ В МЕТОДИКЕ ПРЕПОДАВАНИЯ ГЕОГРАФИИ: СОВРЕМЕННЫЕ ПОДХОДЫ, ЦИФРОВЫЕ ИНСТРУМЕНТЫ И ВЛИЯНИЕ НА РАЗВИТИЕ КРИТИЧЕСКОГО МЫШЛЕНИЯ УЧАЩИХСЯ

Аннотация. В статье анализируется применение технологий искусственного интеллекта (ИИ) в преподавании географии на уровне среднего и высшего образования. На основе эмпирических и аналитических источников, опубликованных в 2022–2025 годах, рассмотрены основные инструменты ИИ, задокументированные в географическом образовании, — геоинформационные системы (ГИС), генеративные языковые модели и адаптивные системы обучения, — а также их влияние на развитие критического мышления учащихся. Исследование опирается на метаанализ, охватывающий 29 эмпирических работ с совокупной выборкой 2 657 участников, и результаты регионального сравнительного опроса 966 учителей географии из Казахстана и Узбекистана. Центральной исследовательской проблемой является противоречие между задокументированными положительными образовательными эффектами ИИ и ограниченной педагогической готовностью учителей к его эффективной интеграции. Противоречия между исследованиями выявлены в явном виде: одни работы фиксируют прирост академической успеваемости и навыков мышления высшего порядка при применении ИИ в структурированных учебных сценариях, тогда как другие документируют риск подавления самостоятельного аналитического мышления при неструктурированном использовании ИИ.

Ключевые слова: искусственный интеллект в образовании, методика преподавания географии, критическое мышление, ГИС, генеративный ИИ, цифровые инструменты, модель SAMR, Казахстан, Узбекистан.