

ARTIFICIAL INTELLIGENCE IN SCHOOL EDUCATION: OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS WITH EVIDENCE FROM UZBEKISTAN

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Abstract: Artificial intelligence (AI) is a revolutionary technology that has significantly made impacts on the educational fields including teaching, learning, assessment, educational support and school management in school education. Further, the emergence of generative AI has contributed significantly to this shift, offering teachers and students tools to create content, tailor learning, aid in instructional writing, and streamline mundane tasks. However, the integration of AI in school education also raises concerns related to academic integrity, data privacy, algorithmic bias, overreliance on AI, and institutional readiness. This research critically reviews contemporary literature on the opportunities and challenges associated with AI, integration in school education, with particular attention to the emerging context of Uzbekistan's school education. The review synthesizes international research alongside recent studies examining AI adoption among educators in Uzbekistan, while recognizing that direct evidence from school education remains limited. The literature suggests, that AI can improve personalized learning, feedback and assessment, teachers' lesson planning and professional learning, and minimize teachers' administrative burden. Meanwhile, AI literacy, professional development, ethical governance, and institutional support are key to effective implementation. Evidence from Uzbekistan demonstrates growing ac-

ceptance of AI among educators but also indicates, that school-level guidance and professional expertise remain underdeveloped. The study believes that Uzbekistan may learn from worldwide experiences while pursuing a context-sensitive, human-centered approach to AI integration in school education.

Keywords: artificial intelligence, school education, generative AI, educational technology, AI literacy, Uzbekistan, digital transformation, teachers, students.

**Maktab ta'limida sun'iy intellekt: O'zbekiston
tajribasi asosida imkoniyatlar, muammolar va
kelajak yo'nalishlar**

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Annotatsiya: Sun'iy intellekt (SI) maktab ta'limida o'qitish, ta'lim olish, baholash, ta'limiy qo'llab-quvvatlash va maktab boshqaruvi kabi akademik faoliyat sohalariga sezilarli ta'sir ko'rsatgan inqilobiy texnologiya hisoblanadi. Xususan, generativ sun'iy intellektning paydo bo'lishi mazkur o'zgarishlarni yanada jadallashtirib, o'qituvchilar va o'quvchilarga kontent yaratish, ta'limni individuallashtirish, o'quv-metodik materiallar tayyorlash jarayonini qo'llab-quvvatlash hamda takroriy

va kundalik vazifalarni soddalashtirish imkonini bermoqda. Biroq sun'iy intellektni ta'lim jarayoniga integratsiya qilish akademik halollik, ma'lumotlar maxfiyligi, algoritmik noxolislik, sun'iy intellektga haddan tashqari bog'lanib qolish va ta'lim muassasalarining tayyorgarlik darajasi bilan bog'liq qator xavotirlarni ham yuzaga keltirmoqda. Ushbu tadqiqot maktab ta'limida sun'iy intellektni integratsiya qilish bilan bog'liq imkoniyatlar va muammolarga bag'ishlangan zamonaviy ilmiy adabiyotlarni, ayniqsa O'zbekistonda shakllanayotgan kontekstga alohida e'tibor qaratgan holda, tanqidiy tahlil qiladi. Tadqiqotda xalqaro ilmiy izlanishlar hamda O'zbekiston ta'lim tizimi pedagoglari tomonidan sun'iy intellektdan foydalanishni o'rganuvchi so'nggi empirik tadqiqotlar umumlashtirilgan. Adabiyotlar tahlili shuni ko'rsatadiki, sun'iy intellekt individuallashtirilgan ta'lim, qayta aloqa va baholash sifatini oshirish, darsni rejalashtirish va pedagoglarning kasbiy rivojlanishini qo'llab-quvvatlash hamda pedagoglarning ma'muriy yuklamasini kamaytirish imkonini beradi. Shu bilan birga, sun'iy intellektidan samarali foydalanish uchun AI savodxonligi, kasbiy rivojlanish, axloqiy boshqaruv va institutsional qo'llab-quvvatlash muhim ahamiyatga ega. O'zbekistondagi dalillar pedagoglar o'rtasida sun'iy intellektidan foydalanishga qiziqish va qabul qilish darajasi ortib borayotganini ko'rsatadi. Biroq institutsional yo'riqnoma va kasbiy ekspertiza hali yetarli darajada shakllanmagan. Tadqiqotda O'zbekiston jahon tajribasidan foydalanigan holda, maktab ta'limida sun'iy intellektni integratsiya qilishga kontekstga mos va insonga yo'naltirilgan yondashuvni amalga oshirishi mumkinligi ta'kidlanadi. Bunda oliy ta'limda o'tkazilgan tadqiqotlar maktab ta'limi uchun bevosita dalil sifatida emas, balki o'qituvchi faoliyati, individuallashtirilgan ta'lim va mas'uliyatli foydalanish yo'nalishlarini belgilashga xizmat qiluvchi asos sifatida talqin qilinadi.

Kalit so'zlar: sun'iy intellekt, maktab ta'limi, generativ sun'iy intellekt, ta'lim texnologiyalari, AI savodxonligi, O'zbekiston, raqamli transformatsiya., pedagoglar, o'quvchilar.

Искусственный интеллект в школьном образовании: возможности, проблемы и перспективные направления на основе опыта узбекистана

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Аннотация: Искусственный интеллект (ИИ) является революционной технологией, которая оказывает значительное влияние на академическую деятельность в учреждениях высшего образования, включая преподавание, обучение, научные исследования, оценивание и институциональное управление. В частности, появление генеративного искусственного интеллекта значительно ускорило эти изменения, предоставляя преподавателям и студентам инструменты для создания контента, персонализации обучения, поддержки академического письма и оптимизации рутинных задач. Вместе с тем интеграция искусственного интеллекта вызывает ряд проблем, связанных с академической добросовестностью, конфиденциальностью данных, алгоритмической предвзятостью, чрезмерной зависимостью от ИИ и готовностью образовательных учреждений к его внедрению. В данном исследовании проводится критический обзор современной научной литературы, посвящённой возможностям и проблемам интеграции искусственного интеллекта в высшее образование, с особым вниманием к формирующемуся контексту Узбекистана. В обзоре обобщаются результаты международных исследований, а также недавних эмпирических исследований, посвящённых внедрению ИИ преподавателями высших учебных заведений Узбекистана. Анализ литературы показывает, что искусственный интеллект способен повысить эффективность персонализированного обучения, обратной связи и оценивания, научно-исследовательской деятельности, а также снизить административную нагрузку на

преподавателей. Вместе с тем для эффективного внедрения ИИ ключевое значение имеют ИИ-грамотность, профессиональное развитие, этическое управление и институциональная поддержка.

Данные по Узбекистану свидетельствуют о растущем принятии искусственного интеллекта преподавателями высших учебных заведений, однако институциональные рекомендации и профессиональная экспертиза в данной области пока остаются недостаточно развитыми. В

исследовании подчёркивается, что Узбекистан может использовать мировой опыт, одновременно реализуя контекстно-ориентированный и человекоцентричный подход к интеграции искусственного интеллекта в систему высшего образования.

Ключевые слова: искусственный интеллект, высшее образование, генеративный искусственный интеллект, образовательные технологии, ИИ-грамотность, Узбекистан, цифровая трансформация.

The rapid development of artificial intelligence (AI) is reshaping educational systems worldwide. Advances in machine learning, natural language processing, and generative AI have expanded the role of technology in education, from providing access to information toward actively supporting knowledge creation, teaching, assessment, and educational decision-making. AI is increasingly being incorporated into educational environments to personalize learning, automate routine processes, improve academic support, and enhance educational efficiency [1, 2]. Although some of the cited studies were conducted in higher education, the identified mechanisms are relevant to school education when adapted to learners' age, curriculum and pedagogical context.

This has been accelerated by the advent of generative AI. ChatGPT can create text, summarize information, help with academic writing, create instructional materials, and give immediate feedback, among other uses. However, these features provide opportunities for teachers to free up some of their time from repetitive tasks, to focus more on teaching, mentoring, and interacting with students. For instance, Hashem et al. [9] have shown how ChatGPT can support lesson planning and content creati-

on and reduce teachers' workload [9]. Although the study was conducted in higher education, this function is also relevant to school teachers' lesson preparation, provided that AI-generated materials are checked for accuracy, curriculum alignment and age appropriateness. Meanwhile, the advent of AI presents substantial challenges in the field of education and ethics. The rise in the use of generative AI has raised concerns around privacy issues, algorithmic bias, the reliability of information generated using AI and academic dishonesty, as students have become increasingly reliant on AI-generated content. UNESCO (2019) highlights the need to pay attention to the following issues, that must be considered when using AI in education: equity, inclusion, ethics and human capacity development. Likewise, more recent scholarship suggests that the adoption of technology must go hand in hand with the right governance and institutional readiness [4, 8].

These are especially important in the context of countries, that are experiencing fast digital transformation. Uzbekistan has implemented significant reforms in its higher education system to modernize it and promote the use of digital technologies. Empirical studies on the use of AI in universities of Uzbekistan, however, are still limited. Their findings provide use-

ful background for school education, but should not be treated as direct evidence of school-level effects. The education community also sees greater application of generative AI in the field of education, with worries about ethical issues, critical thinking, and a lack of institutional guidance [7, 11]. Therefore, this paper examines the opportunities and challenges associated with AI integration in education and considers how evidence from higher education can inform, without being mechanically transferred to, school education in Uzbekistan. The paper specifically focuses on the ways AI can support teaching, learning, research, assessment, and academic productivity, while also examining the ethical and institutional conditions required for responsible implementation.

1.1. Conceptualizing Artificial Intelligence in Higher Education

AI in education encompasses technologies capable of performing tasks. Traditionally associated with human cognitive abilities, including learning, reasoning, language processing, prediction, and decision-making. With the advent of more widely available machine learning, intelligent tutoring systems, learning analytics, and generative AI, its presence has grown significantly across education. Based on this potential, Pedro et al. (2019) highlighted the necessity to reflect on ethical and social issues. As well as to investigate the potential of AI for supporting personalized learning, enhancing educational management and extending access to educational opportunities.

An important development is the emergence of generative AI, which can be integrated directly into educational and academic activities. Generative AI can generate explanations, teaching materials, feedback, collation and other kinds of content, as opposed to just being able to retrieve it. George and Wooden (2023) suggest, that this should be considered as part of a

wider process of strategic transformation. With AI as part of the strategic changes that are occurring in universities, where intelligent technologies are making their way into the university's processes. Here, AI can support research, student services, administration, and institutional decision-making, in addition to enriching classroom learning.

This transformation also changes the competencies expected from educators, including school teachers. AI literacy involves more than knowing how to operate an AI tool. Educators must be able to evaluate AI-generated outputs, recognize limitations and biases, understand ethical implications, and determine when AI is pedagogically appropriate. Recent research indicates that educators' ability to integrate AI effectively is strongly influenced by institutional support and opportunities for professional development [1, 10]. UNESCO's AI Competency Framework for Teachers identifies human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning as core competency dimensions [17].

1.2. Applications and Opportunities of AI in Higher Education

One of the most significant opportunities associated with AI is personalized learning. AI systems can analyze student performance and learning patterns and subsequently provide individualized resources, feedback, and learning pathways. Intelligent tutoring systems can adapt instructional support to the student's needs and generative AI can offer instant explanations and conversational support. Indeed, Kuleto et al. [6] highlight the potential of AI and machine learning in enhancing adaptive learning, intelligent tutoring, and data-driven education decision-making [6]. Although the study focuses on higher education institutions, these mechanisms can inform school-level exploration

of adaptive support, formative feedback, and data-informed teaching.

AI can also be a direct aid to teachers. Generative AI applications can be used to help develop the syllabus, plan lessons, create instructional materials, design assessments, and provide feedback. This is especially significant because administrative and preparation can eat up a significant amount of educator time. Hashem et al. [9] reported that ChatGPT could serve as a teacher assistant in planning and content creation, which could alleviate teachers' workload and facilitate efficient teaching preparation [9]. For school education, this finding is potentially relevant to lesson planning and resource preparation, but requires teacher verification and age-appropriate adaptation. Conducted research on lecturer productivity, also reveals that AI can support administrative functions, teaching, assessment, research, and mentoring students [12].

Assessment is another crucial field where AI can be applied. AI-powered tools can aid in automated marking, feedback, adaptive testing, and performance analysis. These applications can offer students quicker feedback and assist teachers determine where students may be in need of extra help. But, automated assessment must be guided by human judgment and evaluation in education should be contextual and qualitative and cannot be completely captured by automated systems. Research productivity is another area where AI can help. AI can help researchers with literature search, data organization, text editing, data analysis, and integrating vast amounts of scholarly literature. Institutional applications of AI include admissions, scheduling, student services, predictive analytics, and strategic planning. The authors of the paper Khairullah et al. (2025) consider AI to be a transformation of the institution, and not a bunch of individual technological initiatives,

when it comes to integrating AI into academic and administrative work.

Evidence from Uzbekistan demonstrates that these opportunities are already beginning to emerge in higher education. Mirzayev et al. [7] found that Uzbek university EFL teachers viewed ChatGPT positively [7]. For school education, this evidence suggests potential teacher-level benefits, while also demonstrating the need for separate empirical studies of school teachers and students. Particularly because of its ability to provide real-time feedback, support autonomous learning, and assist with grammar and spelling. Saydazimova and Saydazimova [11], examining teachers across 34 higher education institutions in Uzbekistan, similarly found generally positive attitudes toward AI and reported that educators had developed into AI adopters and collaborators, although they had not yet reached the level of AI innovators [11]. This provides a useful starting point for designing school-focused professional development, but it should not be generalized to school teachers without additional evidence. The evidence is used here to identify mechanisms that may be explored in school education, not as direct proof of school-level outcomes.

1.3. Challenges of AI Integration in Higher Education

Despite its potential, AI integration creates substantial challenges. Academic integrity is among the most prominent. Generative AI can produce academic texts and responses, that students may submit without sufficient intellectual contribution. This complicates traditional approaches to plagiarism and assessment and requires universities to reconsider how learning is evaluated. Mulaudzi and Hamilton (2025) highlight the difficulty of maintaining academic integrity, while allowing students and educators to benefit from AI technologies.

Another concern is that students might rely excessively on AI. While AI can offer instant support, relying too heavily on it could limit the scope for independent thinking, creativity, and problem-solving skills. The study by Mirzayev et al. [7] revealed that EFL teachers in Uzbek universities were worried about student over-reliance on ChatGPT and its potential impact on critical thinking [7]. For school education, this concern is particularly important because critical thinking, independent learning and information verification are core developmental outcomes. This points towards the use of AI as an aid to learning, not a substitute for students' intellectual participation.

There are also ethical and governance issues. AI systems can mirror the biases in the data they are trained on, and can be used to handle significant amounts of personal information. UNESCO [13] raises the following principles for the development and use of AI: human oversight, transparency, fairness, and protection of human dignity. Ethical governance, algorithmic bias, data protection, and institutional responsibility are also major challenges highlighted by Khan et al. (2025) for the sustainable integration of AI in higher education.

Another significant problem is teacher preparedness. For the successful implementation of AI, teachers need to have technical expertise as well as pedagogical and ethical skills. If not properly supported through professional development and institutional guidance, teachers could employ AI in an inconsistent manner or even refuse to do so. The study in Uzbekistan suggests that teachers are more accepting of the use of AI, yet there still needs to be more knowledge and expertise development to move from adoption to more innovative uses and forms of AI-supported pedagogy [11]. This reinforces the importance of structured continuous professional development for school teachers.

1.4. Research Gap

Although research on AI in education has expanded rapidly, several gaps remain. Existing studies frequently examine individual applications of AI, such as personalized learning, ChatGPT, assessment, or faculty perceptions, rather than considering AI as a broader institutional transformation. Furthermore, much of the existing evidence comes from technologically advanced education institutions, since research in Central Asia is quite restricted. The Uzbek school context is notably understudied. Recent research have offered significant evidence regarding teachers' opinions of ChatGPT and broader AI acceptance among educators. Although the existing material is still fragmented across various disciplines and educational methods [7, 11]. There is relatively limited research combining the pedagogical, organizational, ethical and professional dimensions of AI in Uzbekistan's school education system.

This gap is important, since Uzbekistan may not be able to immediately adopt foreign models. Context-sensitive techniques are necessary. Due to variations in institutional capacity, infrastructure, educator readiness, policy contexts, and educational practices. Therefore, more research should look at how Uzbekistan may adopt international AI methods, while preserving human agency, ethical responsibility, and educational quality.

Artificial intelligence is increasingly becoming an important component of school education. With applications extending from personalized learning and assessment to research, administration, and faculty productivity. The literature reviewed in this study indicates, that AI can improve educational processes and reduce repetitive workloads when implemented appropriately. For educators in particular, AI can support activities such as syllabus de-

velopment, lesson planning, assessment preparation, feedback, and administrative documentation. Allowing more time to be devoted to mentoring students, fostering critical thinking, and conducting research. However, AI should not be viewed as a replacement for university teachers. Its instructional efficacy is dependent upon appropriate use, pedagogical judgment, and effective human oversight. Academic integrity, data privacy, algorithmic prejudice, student dependency, and inadequate AI literacy continue to be major issues. Which institutions need to address through professional development and institutional policies. According to the available evidence, educators in Uzbekistan are becoming more interested in AI; however, the evidence base for school edu-

cation remains limited. However, the system still lacks the institutional know-how needed for wider use. While avoiding the presumption that technologies can be exported without modification, Uzbekistan can learn from global experiences. Ultimately, the future of AI in Uzbekistan's school education should be based on a human-centred model. In which technology reduces unnecessary workload, expands educational opportunities, and supports—not replaces—professional expertise. Strategic investment in AI literacy, teacher professional development, ethical governance, child data protection, and appropriate technological infrastructure will be essential if Uzbekistan is to realize the educational benefits of AI while minimizing its risks [5, 17-18, [15].

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