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Artificial intelligence in school mathematics education: awareness, readiness, and usage among mathematics teachers

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Abstract

Context and relevance. This article presents the results of the study conducted among mathematics teachers — the category of teachers particularly inclined toward critical thinking and evidence-based application of innovations in education. **Objective.** The objective of this study is to identify the awareness of math teachers about the AI capabilities and potential in teaching as well as the practice of their application in the educational process. **Methods and materials.** To achieve this objective, a questionnaire was developed, comprising three main sections: awareness, readiness, and practical application. The survey was conducted online using Yandex Forms. A total of 122 mathematics teachers from 44 regions of the Russian Federation, varying in age and teaching experience, participated in the study. **Results.** The results showed that approximately 70% of the respondents express a willingness to use AI in their teaching process. The directions in which math teachers are most and least inclined to trust AI have been identified. The proportion of teachers currently using AI technologies and specific software products based on AI ranges from 13% to 40%. **Conclusions.** A significant part of teachers is generally aware of AI's potential. However, their knowledge is fragmentary, covering only certain aspects and lacking systematic understanding. Promising directions for further research include examining the issues surrounding the use of AI technologies in the educational process while taking into account their specific characteristics. Special attention is recommended to improving teaching methodologies based on AI technologies and identifying effective ways to apply them for the development of students' cognitive abilities.

Keywords: artificial intelligence, AI in education, neural networks, neural networks in education, mathematics teachers, teacher readiness, digitalization of education

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Искусственный интеллект в школьном математическом образовании: осведомленность, готовность и использование учителями математики

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Резюме

Контекст и актуальность. В статье представлены результаты исследования, проведенного среди учителей математики — категории педагогов, наиболее склонной к критическому осмыслению и доказательно-обоснованному применению новшеств в образовании. **Цель**. Выявить осведомленность учителей математики о возможностях и потенциале искусственного интеллекта, готовность использовать технологии искусственного интеллекта в педагогической деятельности и практику их применения в образовательном процессе. **Методы и материалы**. В соответствии с поставленной целью была разработана анкета, включающая три содержательных раздела (осведомленность, готовность, практика применения). Анкетирование было реализовано онлайн с использованием Yandex Forms. В исследовании приняли участие 122 учителя математики из 44 регионов Российской Федерации, имеющие различный возраст и педагогический стаж. **Результаты.** Анализ результатов анкетирования показал, что порядка 70% учителей выражают готовность использовать искусственный интеллект в педагогической деятельности. Выявлены направления, в рамках которых учителя математики в наибольшей и наименьшей степени склонны доверять искусственному интеллекту. Доля педагогов, уже использующих технологии искусственного интеллекта и отдельные программные продукты, созданные на его основе, составляет от 13% до 40% в зависимости от направления применения. **Выводы**. Значительная часть учителей в целом осведомлена о потенциале искусственного интеллекта, однако знания педагогов обрывочны, затрагивают отдельные аспекты, носят бессистемный характер. Перспективным направлением дальнейших исследований является изучение вопросов использования в образовательном процессе технологий ИИ с учетом их специфических особенностей. Рекомендовано уделить особое внимание вопросам совершенствования методики обучения предмету на основе технологий искусственного интеллекта, а также поиску путей эффективного их применения для развития когнитивных способностей обучающихся.

Ключевые слова: искусственный интеллект, искусственный интеллект в образовании, нейросети, нейросети в образовании, учителя математики, готовность учителей, цифровизация образования

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Introduction

Artificial intelligence (AI) and its derivative technologies constitute a prominent focus of contemporary scholarly discourse, with accelerating adoption for pedagogical purposes across tertiary and secondary educational contexts in recent years.

The integration of AI technologies within instructional frameworks has been comprehensively examined in extant literature (Kovalchuk, Taranenko, Ustinova, 2023; Sysoev, Filatov, Sorokin, 2023; Kim, Cha, Kim, 2021; Kohnke, Moorhouse, Zou, 2023; Uygun, 2024). A critical analysis of research trajectories indicates predominant implementation within foreign language education. Scholars have documented diverse applications, including the development of linguistic competencies (Kovalchuk, Taranenko, Ustinova, 2023; Sysoev, Filatov, 2023), facilitation of online language instruction (Junaidi et al., 2020; Liu, Ma, 2023), and enhancement of oral proficiency in different languages.

However, scholarly investigations of AI applications in mathematical education remain comparatively limited. Current research examines AI's pedagogical impact of AI, particularly neural networks, on mathematics instruction (Urazaeva, Zamyadkin, 2024; Shpak, Semenova, Zaburdaeva, 2024; Gao, 2020; Voskoglou, Salem, 2020; Wu, 2021), prospects for the use of modern AI technologies in mathematical education at various levels, and explorations of AI-enabled mathematical problem-solving tools (e.g., MathGPT, ChatMathGPTPro). While AI is broadly conceptualized as facilitating personalized learning and reducing instructional burdens through the automation of routine assessments, extant scholarship insufficiently addresses the methodological implications for developing learners' cognitive capacities. Notably, Freeman (2015, p. 102) cautions that digital technologies may inadvertently "encourage superficial thinking rather than the desire to reflect on the meaning of the information received, having a negative impact on the mental development and interpersonal relationships of children."

Scholarly analysis further indicates that AI-based learning provokes debate, rejection, and concern among a wide range of teachers. Consequently, this research investigates educators' awareness of AI-based educational

technologies, their perceptions, implementation approaches, and barriers to utilizing AI tools for instructional purposes. (Kalitvin, Frolova, 2020; Cojean et al., 2023; Nazaretsky, Cukurova, Alexandron, 2022; Uygun, 2024; Xuan, Yunus, 2023). This is compounded by a prevalent "lack of systematic understanding of AI's organizational, didactic, and methodological potential" (Sysoev, 2023, p. 28). Meanwhile, researchers have observed predominantly favorable teacher attitudes toward AI in education, while noting significant concerns regarding ethical issues, confidentiality, and implementation workloads deemed disproportionate to educational gains. They concluded that technical and methodological support is essential to maximize AI's potential of AI. Further research is recommended to boost teacher confidence and refine the methodological frameworks for AI implementation. Consequently, researchers have emphasized the necessity of robust technical and methodological support structures.

Crucially, subject-specific receptiveness disparities are evident, with mathematics educators exhibiting pronounced criticality despite their comparatively advanced AI awareness. This disciplinary gap underscores the present study's objective of examining mathematics teachers' (1) AI competency awareness, (2) integration willingness, and (3) current implementation practices.

Materials and methods

An online survey of mathematics teachers was conducted using the Yandex Forms platform to collect data. Respondent recruitment was facilitated by the Association of Mathematics Teachers of the Republic of Karelia, which has engaged educators from multiple Russian regions during its decade-long operation.

The study involved 122 mathematics teachers from general education institutions across 44 constituent entities in the Russian Federation. The largest participant groups were from Moscow and Moscow Oblast (10,7%), the Republic of Karelia (8,2%), and Lipetsk Oblast (6,6%).

Regarding age distribution, the largest cohort comprised teachers aged 40-55 years (67 respondents, 54,9%), followed by those aged ≥56 years (30, 24,6%), 25-39 years (17, 13,9%), and <25 years (8, 6,6%).

The teaching experience distribution showed that most respondents had >20 years of experience (58,2%), while the smallest group had <1 year (0,8%). Teachers with 11–20 years of experience comprised 18% of the participants, 1-5 years: 13%, and 6-10 years: 9%.

Overall, the sample aligned with the national teaching workforce in the country (predominance of 40–55-year-old educators with substantial experience).

To achieve the research objective, a questionnaire was developed containing the following:

Respondent background section (age, work experience, region) and three substantive sections.

Section 1. Awareness of AI's potential in mathematics education.

Section 2. Willingness to implement AI technology in teaching.

Section 3. Practical applications of AI technologies in teaching.

The survey concluded with an open-ended question: «Additional comments» for remarks and free-form statements on the topic.

Sections 1 and 2 employed a Likert scale for statement evaluation (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Section 3 required dichotomous responses (yes/no) to specific statements and included multiple-choice questions.

The questionnaire design was informed by Sysoev's (2023, p. 13) framework of AI applications in education: 1) education management; 2) learning personalization; 3) teacher preparation optimization; 4) instructional process organization; and 5) discipline-specific learning optimization. proposed options.

Since Sysoev's framework targets university instructors, while this study examines school mathematics teachers, the instrument focused on three aspects: "learning personalization; teacher preparation optimization; instructional process organization" (Sysoev, 2023, p. 13). The survey questions incorporated modified statements from Sysoev's work, supplemented with mathematics-specific items.

The study results were analyzed using descriptive statistics and one-way repeated-measures analysis of variance. The database containing the research results is available in the MSPPU RusPsyData Repository (Kuzmenko, 2024).

Results and discussion

The results of the analysis of mathematics teachers' responses to Section 1 of the questionnaire (awareness of the potential of AI technologies) are presented in Table 1.

Table 1

Awareness of mathematics teachers regarding the capabilities and potential of artificial intelligence (N = 122)

Survey question	Response options, %					Statistical characteristics	
	1	2	3	4	5	M_x Mean	M_0 Mode
Organization of the educational and upbringing process and individualization of instruction							
AI can:							
1.1. develop an individualized educational trajectory for the student in learning the subject	7,4	23,0	30,3	37,7	1,6	3,0	4
1.2. develop individualized assignments in accordance with the students' interests, needs, and abilities, as well as determine the sequence of their completion	5,7	21,3	10,7	59,0	3,3	3,3	4

Survey question	Response options, %					Statistical characteristics	
	1	2	3	4	5	M_x Mean	M_0 Mode
1.3. помочь учителю в решении организационных вопросов (контроль посещаемости, выполнения заданий, проверка письменных работ на плагиат и т.п.) / help the teacher in solving organizational issues (e.g., attendance monitoring, assignment completion, plagiarism checking for written works, etc.)	4,1	12,3	17,2	51,6	14,8	3,6	4
1.4. be utilized in developing virtual assistants to provide immediate feedback on organizational issues (e.g., clarification of homework; clarification of assignment content, etc.)	4,1	7,4	13,9	59,0	15,6	3,7	4
1.5. conduct automated control and assessment of students' assimilation of material (knowledge acquisition, skill development, formation of competencies) or completion of assignments	5,7	22,1	20,5	44,3	7,4	3,3	4
Teacher preparation for lessons							
AI can help the teacher in:							
1.6. planning lessons (series of lessons)	4,1	13,1	29,5	47,5	5,7	3,4	4
1.7. creating teaching materials (textual, visual, presentations, videos, etc.); exercises and assignments	2,5	12,3	16,4	58,2	10,7	3,6	4
1.8. developing assessment tools	3,3	9,0	19,7	61,5	6,6	3,6	4
1.9. preparing and organizing students' project activities	4,1	12,3	28,7	46,7	8,2	3,4	4

The analysis indicates that the modal response for all Section 1 questions was 4. Overall, 37,7-61,5% of educators expressed positive attitudes ("agree" responses). In the "Organization of the educational and upbringing process and individualization of instruction" subsection, the means ranged from 3 to 3.7. The "Teacher preparation for lessons" subsection showed minimal variation (3,4-3,6).

To identify the significance of the differences in the average values of mathematics teachers' awareness of AI capabilities, the method of one-factor analysis of variance for connected selections was used. Analysis was conducted separately for awareness components: instructional process/personalization (items 1,1-1,5) and lesson preparation (items 1,6-1,9).

One-way analysis of variance revealed significant differences in awareness means for items 1,1-1,5: $F(4, 605) = 9{,}66$, $p < 0{,}0001$. As Table 1 demonstrates, the highest means concerned AI applications for:

Developing virtual assistants providing instant organizational feedback (Mx = 3.7; item 1,4)

Operational organizational feedback systems (Mx = 3,6; item 1,3)

The lowest mean (Mx = 3,0) was observed for AI's capacity to design individualized learning trajectories (item 1.1).

No significant differences emerged for items 1.6-1.9: F (3, 484) = 2,11, p = 0,098.

We now present the Section 2 questionnaire results (Table 2).

This willingness to adapt reflects their commitment to student-centered learning and continuous professional development. Teachers often seek innovative approaches to make complex mathematical concepts accessible and engaging for diverse learners. By embracing new

Table 2

Readiness of mathematics teachers to use ai technologies in pedagogical practice (N = 122)

Survey question	BResponse options, %					Statistical characteristics	
	1	2	3	4	5	M_x Mean	M_0 Mean
2.1. I am open to changes in the interest of the students and to using AI in the educational process	4,9	2,5	16,4	52,5	23,8	3,9	4
My use of AI in teaching mathematics is hindered by:							
2.2. lack of knowledge and skills	9,0	11,5	15,6	41,8	22,1	3,6	4
2.3. lack of appropriate equipment and software	9,0	8,2	16,4	45,1	21,3	3,6	4
2.4. a low level of trust in AI	6,6	20,5	31,1	29,5	12,3	3,2	4
2.5. I use AI in my teaching and do not see any obstacles to its use	16,4	27,9	34,4	17,2	4,1	2,6	3
I would like to and am ready to use AI in my educational activities for the following purposes:							
2.6. developing an individualized educational trajectory for students	6,6	9,8	14,8	53,3	15,6	3,6	4
2.7. developing individualized assignments in accordance with students' interests, needs, and abilities, as well as determining the sequence of their completion by students	3,3	6,6	13,1	61,5	15,6	3,8	4
2.8. developing teaching materials, including the selection of textual, visual materials, presentations, etc., on various topics	4,1	7,4	4,1	63,9	20,5	3,9	4
2.9.developing a system/collection of exercises, assignments, or tests	3,3	4,9	9,8	61,5	20,5	3,9	4
2.10. automated control and assessment of students' assimilation of material (knowledge acquisition, skill development, and competency formation) or task completion	7,4	9,8	12,3	52,5	18,0	3,6	4
2.11. preparation and organization of students' project activities	4,1	12,3	15,6	52,5	15,6	3,6	4
2.12. analytical activities aimed at modernizing the educational process	3,3	7,4	23,0	45,1	21,3	3,7	4
The following measures could increase my readiness to use AI in teaching:							
2.13. professional development courses	6,6	4,1	25,4	36,1	27,9	3,7	4

Survey question	BResponse options, %					Statistical characteristics	
	1	2	3	4	5	M_x Mean	M_0 Mean
2.14. seminars, webinars, and master classes	3,3	4,9	18,0	45,1	28,7	3,9	4
2.15. support from the administration	3,3	4,9	27,9	37,7	26,2	3,8	4
2.16. technical support	3,3	0,8	9,8	52,5	33,6	4,1	4
2.17. exchange of experiences with colleagues	2,5	1,6	12,3	46,7	36,9	4,1	4

pedagogical strategies, mathematics educators can create more inclusive and effective learning environments that cater to various learning styles and abilities of students. Regarding item 2,1, 52,5% agreed and 23,8% strongly agreed. The mean was 3,9 owing to negative responses: 4,9% strongly disagreed and 2,5% disagreed.

The lowest mean (Mx = 2,6) occurred for item 2,5: only 17,2% (agree) and 4,1% (strongly agree) reported unimpeded integration. A one-way analysis of variance for related samples was used to assess readiness differences across the two component groups.

Items 2,2-2,4 (barriers)

Items 2,6-2,12 (readiness)

Significant differences emerged for items 2,2-2,4 ($F(2, 363) = 4,50$, $p = 0,012$), with the lowest mean indicating that distrust hinders AI adoption (item 2,4). Knowledge deficits (M = 3,6) and inadequate resources (lack of appropriate hardware and software) were the most prominent barriers.

For items 2,6–2,12, the one-way repeated-measures analysis of variance showed no statistically significant differences ($F(6, 847) = 1,91$, $p = 0,076$).

Analysis of open-ended responses revealed three primary concern domains.

1. AI distrust: 41,8% cited distrust as a barrier (item 2,4). A representative comment was, “School implementation requires mature tools, not developmental-stage technologies.”

2. Professional development limitations: Teachers criticized the technical focus of training programs over pedagogical integration, citing time constraints for self-directed learning. Technical support (items 2,16-2,17) and peer collaboration were deemed essential.

3. Cognitive development concerns: The third dimension, deemed most critical and warranting targeted examination, reflects teachers’ predominant perception of AI as both an automation tool for “skill practice” and a supplementary instructional diversifier. Crucially, mathematics education requires “teaching students proper reasoning” (cit.). Educators have emphasized the pressing need to develop effective AI applications to enhance learners’ cognitive abilities.

Overall, most teachers expressed their readiness to implement AI in instruction and lesson preparation. Their pandemic-era remote teaching experience

with ICT (including their experience they got through distance learning during the pandemic) fosters optimism regarding future AI technology adoption. The focus now shifts to Section 3 of the questionnaire (Fig.1).

Survey analysis indicates that AI tool utilization among educators ranges from 13,1% to 40,2%. Teachers most frequently employed AI technologies for creating instructional materials (textual, visual, etc.) by topic (40,2%) and developing knowledge assessment tasks (32,8%). The lowest adoption rate was for designing individual learning trajectories (13,1%).

Analysis of generative neural networks utilized for educational purposes (Table 3) reveals YandexGPT (27,5%), ChatGPT (25%), Shedevrum (18,3%), and Kandinsky 3.1 (15,8%) as the most prevalent. Minimal utilization (<1%) was observed for Perplexity, Kaiber, Focus, Khroma, and Stable Diffusion. These disparities may stem from limitations in access, technical constraints, and complexities in implementation.

It should be noted that in the final question, additional comments, none of the teachers supplemented the proposed list of neural networks used.

Conclusion

This study successfully addressed all research objectives concerning mathematics teachers' awareness of AI capabilities and potential, their current readiness to master AI tools for professional practice, and identified problematic areas and future research directions.

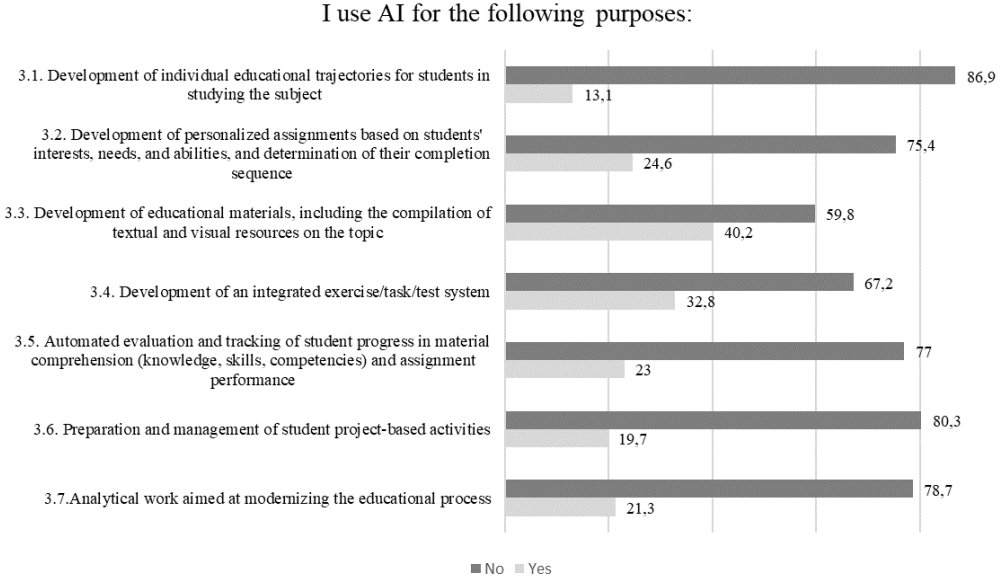

Fig. Practice of using AI technologies by mathematics teachers in pedagogical activities (N = 122)

Table 3

Neural networks used by teachers for educational purposes (N = 122)

Survey question	Response options, %		
4. I know/use neural networks:	I do not know and have not used it	I know it but have not used it	I know it and use it
YandexGPT	41,7	30,8	27,5
ChatGPT	42,5	32,5	25
Shedevrum	58,3	23,3	18,3
Kandinsky 3.1	62,5	21,7	15,8
Alice	55,8	35	9,2
Midjourney	77,5	14,2	8,3
GigaChat	64,2	28,3	7,5
Gamma	85	11,7	3,3
Lexica	80,8	16,7	2,5
Your Personalized AI Assistant	90,8	7,5	1,7
Perplexity	90,8	8,3	0,8
Kaiber	90	9,2	0,8
Fokus	88,3	10,8	0,8
Khroma	92,5	6,7	0,8
Stable Diffusion	90	10	0

1. The findings on mathematics teachers' awareness of AI applications in education revealed that a significant majority (over 50%) were familiar with core AI implementation areas. However, this knowledge remains fragmented, with varying levels of awareness across applications. One-way repeated-measures analysis demonstrated statistically significant differences in awareness components related to the instructional process organization. The highest mean scores reflect awareness of AI's potential for developing virtual assistants that provide instant organizational feedback, while the lowest correspond to AI's capacity for designing individualized learning trajectories. No significant differences were observed in the lesson preparation components.

2. A positive perception of AI was evidenced by approximately 70% of surveyed teachers expressing a willingness to implement AI in pedagogical practice. One-way repeated-measures analysis identified significant differences among barriers to AI adoption, with teacher distrust showing the lowest mean score. The readiness components showed no statistically significant differences.

3. Most teachers reported that full AI integration in mathematics instruction was hindered by knowledge gaps and insufficient technological resources. Teachers prefer to address these deficiencies through workshops, webinars, peer collaboration, and supported self-study. Educators express dissatisfaction with current professional development

programs due to the inadequate methodological components.

4. Current AI adoption rates range from 13,1% to 40,2% depending on the application areas, with YandexGPT, ChatGPT, Шедеврум, and Kandinsky being the most-utilized neural networks.

6. Promising research directions include investigating subject-specific AI implementation approaches, developing AI-enhanced pedagogical methodologies, and exploring effective applications for enhancing students' cognitive abilities.

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