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The Use of Artificial Intelligence in the Integration of Educational Technologies into Mathematics Teaching: Attitudes of Mathematics Teachers

Radoslav Bozic ^{1*}, Ahsen Filiz ²

¹ Faculty of Teacher Training, Educons University, Sremska Kamenica, Novi Sad, Serbia,  0000-0003-1128-8823

² Faculty of Education, Biruni University, Zeytinburnu, Istanbul, Turkiye,  0000-0002-8886-5572

* Corresponding author: Radoslav Bozic (radoslav.bozic@educons.edu.rs)

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Abstract

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In this paper, the attitudes of mathematics teachers about the use of tools based on artificial intelligence (AI-based tools) in mathematics education are analyzed. The research covered the teachers who work with 11-14 years old students in Serbia and Turkey. In total, 68 teachers completed the survey – 30 teachers in Serbia and 38 teachers in Turkey. The results have shown that the teachers in Turkey used AI-based tools more often than the teachers in Serbia. Also, they expressed different opinions about the benefits and challenges in using these tools in teaching and learning mathematics. However, they mostly agree that they generally consider that AI-based tools can accelerate teaching processes and facilitate learning through visualization but also make positive contributions in increasing student motivation and providing individualized learning. Most of the teachers, in both the countries, declared to be interested in professional development in the field of AI-based tools application and expressed the importance of the technical equipment in schools.

Keywords

Artificial intelligence
Educational technologies
Mathematics
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Introduction

Artificial intelligence (AI) is a technology that simulates human intelligence processes through machines, particularly in tasks such as problem-solving and learning, and has transformed educational practices. AI-based technologies refer to systems supported by AI algorithms that perform tasks such as personalized learning and automated assessment (Hwang & Tu, 2021). Moreover, generative artificial intelligence (GenAI), a subset of AI capable of creating content such as text, images, or videos in real time, offers innovative opportunities in education (Passey et al., 2024). In mathematics education, the use of AI-based technologies has attracted attention due to their potential to enhance the students' achievement and reduce the teachers' workload. However, the integration of these technologies depends on factors such as teachers' attitudes, technical support, and ethical concerns.

This study aims to investigate mathematics teachers' perspectives on AI-based technologies, their strategies for using these technologies in in-class and out-of-class activities, and the challenges they encounter. Additionally, the impact of AI tools on student achievement, motivation, and problem-solving skills, as well as the teachers' professional development needs, will be evaluated. The study seeks to compare the views of teachers in Serbia and Turkey to elucidate the influence of cultural and educational contexts on AI integration. The following literature review synthesizes the role of AI-based technologies in mathematics education, their advantages, limitations, and the need for teacher-focused research, thereby providing the theoretical foundation for this study.

Literature Review

In recent years, the presence of artificial intelligence in education has been steadily increasing (Hwang, & Tu, 2021; Opesemowo, & Ndlovu, 2024). There are numerous AI-based applications which have found their place in mathematics education and some of them have been specifically designed for learning mathematics. Some students use these applications in order to make their work easier (Cunskaa, 2020). The use of AI-based applications so far has shown that introducing such innovations into the teaching and learning process comes with both advantages and disadvantages. For these reasons, the use of AI-based technologies in education, including mathematics education, has been the topic of numerous research, especially in the last few years (Govender, 2023; Hwang, & Tu, 2021; Opesemowo, & Adewuyi, 2024; Wardat, Tashtoush, AlAli & Jarrah, 2023).

The AI-based applications can be used in mathematics teaching and learning processes in different ways. Some of these applications are created for solving mathematical problems, usually step by step, with a detailed explanation, while others can be used as assistive tools, assessment tools, etc. (Mohamed, 2022; Hwang, 2022; Wardat et al, 2023). In recent years, generative artificial intelligence (GenAI) has gained significant prominence due to its capability to produce content such as text, images, and videos in real time (Passey, Taggart, Leow, & Lee, 2024). The AI-based applications are finding increasingly widespread use in mathematics education, both at the university level and in primary and secondary schools (Opesemowo & Adewuyi, 2024).

Some of the AI-based applications, intended for solving mathematical problems, require the algebraic input – the students are required to create the algebraic representation on their own and then to input the created algebraic

equation in the appropriate field. The other applications enable facilitated input of the problems by taking a photo of the appropriate algebraic equation (Dimitriadou, & Lanitis, 2025). However, in recent years, the most attention was paid to the applications which enable communication with a chatbot. These applications enable the users to describe the problem in their own words and to ask the chatbot appropriate questions and sub-questions. The applications that use chatbots were the topic of many recent research studies (Mohamed et al, 2022; Opesemowo & Ndlovu, 2024).

Previous practice, as well as the research conducted in this field, has revealed numerous advantages, but also certain limitations in the application of artificial intelligence in mathematics education (Opesemowo, & Ndlovu, 2024; Passey et al., 2024). The numerous teachers recognize AI as a valuable tool for enhancing instruction, increasing student motivation, and adapting teaching to individual needs (Tashtoush, Wardat, Ali, & Saleh, 2024). In particular, AI can personalize learning by providing individualized instructional materials and feedback. This characteristic, in combination with different learning strategies, such as the use of open-ended tasks, visualization, associative learning, blended learning, real-world connections, etc., can significantly enhance mathematics education, making it more effective and better adjusted to the students' needs (Cunška, 2020).

Opesemowo and Ndlovu (2024) emphasize several advantages of the use of AI-based applications in mathematics education. According to these authors, AI-based applications enable personalized instructions, i.e., adapting the contents to the student's knowledge level. Also, they emphasize the importance of the tools that adjust task difficulty in real time, interactive learning environments, simulations, visualization, but also automated assessment and real-time feedback, including tracking the students' progress and identifying conceptual weaknesses during the learning process. The systems that adapt based on the students' interaction, better known as the reinforcement learning tutors, facilitate the students learning, but also can contribute to improving the students' communication skills, especially in terms of communication with the chatbot (Opesemowo, & Adewuyi, 2024; Opesemowo, & Ndlovu, 2024).

AI-based applications provide the explanation of difficult concepts and instant feedback, and, in recent years, their reliability has increased (Wardat et al, 2023). The use of these applications contributes to better students' motivation and increases their engagement during the mathematics lessons (Bawaneh, Al-Salman, Salem, & Faek, 2025). AI-based tools proved to be significantly helpful in improving the students' achievements in learning mathematics, if they are appropriately integrated into the teaching and learning process and adapted to the age and learning context (Hwang, 2022). AI-based applications with chatbots can be successfully used for explaining the mathematical concepts, generating example problems, identifying common errors in problem-solving, supporting independent learning and encouraging mathematical reasoning (Govender, 2023).

The use of AI in education offers the appropriate and inexpensive alternative to private lessons. That could reduce the impact of socio-economic factors in education. Also, most of the AI-based applications created for education can make a learning process more accessible to the students (Jancarik et al., 2022). Besides the benefits for students, Opesemowo and Ndlovu (2024) emphasize the benefits for the teachers, which are reflected in reducing the workload and the possibilities for professional development (Opesemowo, & Ndlovu, 2024). Also, there are

benefits for the schools' administration by the procedure automation. With regard to GenAI applications, they can provide support for teachers in lesson preparation, but also, albeit cautiously, have the potential to reduce the global teacher shortage. This kind of AI-based applications can assist students with specific needs by suggesting interventions, analyzing data, and enhancing instructional strategies (Passey et al., 2024).

Besides the observed advantages, during the use of AI-based applications in mathematics education some limitations and challenges came to the fore. Most of these issues are related to the accuracy and reliability of the AI-based applications, but also to the ethical acceptance of their use in some situations (Opesemowo, & Ndlovu, 2024; Passey et al., 2024; Wardat et al, 2023). The main challenges include the need for greater engagement compared to traditional methods, lack of technical support, and limited time for lesson preparation. Teachers with higher academic qualifications report more challenges in implementing AI, which may be attributed to higher expectations or a greater awareness of the technology's complexity. Less experienced teachers are usually more open to the use of AI tools, whereas more experienced educators encounter more difficulties in adapting to new technologies (Tashtoush et al, 2024).

Opesemowo and Ndlovu (2024), in their research, notice a lack of creativity and critical thinking as one of the most pronounced limitations of the AI-based applications. Also, excessive use of these applications can lead to losing the students' ability to solve tasks independently and cause the students' dependence on the AI tools. AI cannot replace human interaction and oversimplification of concepts may hinder deeper conceptual understanding (Opesemowo, & Ndlovu, 2024). Besides the mentioned, the limitations of the use of AI-based applications in education are reflected in the risk of misuse of the students' personal data, unequal access to technology, which can cause digital divide among students and curriculum rigidity – namely, most of the curricula cannot be adapted quickly to the technology innovations. Also, the use of AI tools in education raises important concerns regarding the issues of originality and academic integrity (Passey et al., 2024). Despite increasing reliability, AI-based applications can make mistakes. Accuracy of these applications usually depends on the input and the complexity of the task. Some of these applications have limited understanding of the geometric concepts and sometimes they make mistakes in basic concepts (Wardat et al, 2023).

It is expected that the use of AI-based applications in education, including mathematical education, will increase in the next years. In order to overcome the issues and improve the advantages of their use, it is necessary to provide adequate trainings for teachers and students. Integration of AI tools must be pedagogically designed and must not replace interactive learning. These tools should be used as a complement, not a replacement, for traditional teaching, and it is very important to ensure an ethical and safe approach to the use of AI in education (Govender, 2023; Opesemowo, & Ndlovu, 2024). According to Opesemowo and Adewuyi (2024), it is necessary to develop a pedagogical approach in which AI is not seen as a substitute for the teacher, but as a partner in the teaching process. More mixed research approaches are recommended in order to obtain a broader picture of the effects of AI on education (Opesemowo, & Adewuyi, 2024).

The use of AI-based applications can significantly improve student achievement in mathematics if they are well integrated into the teaching process and adapted to the age and learning context. More experimental studies, in

order to determine the lasting effects of AI on learning, are recommended (Hwang, 2022). Improving interdisciplinary collaboration and developing ethical standards for AI use in teaching are essential for successful implementation of AI in teaching and learning. (Hwang, & Tu, 2021). According to Bawaneh et al. (2025), it is necessary to introduce ongoing training programs for teachers, to develop institutional support for effective integration of AI, to involve teachers in the design and testing of AI tools, and to conduct more detailed evaluations of the impact of AI on student achievement.

There are many factors that impact the successful implementation of the AI tools in the teaching and learning process. One of the most influential factors is reflected in the attitudes of the teachers about the use of AI-based applications. Also, the results of the previous studies have shown that the teachers' attitudes vary in dependence on the country, region, education level, etc. (Mohamed et al, 2022; Tashtoush et al, 2024). It is necessary to conduct more studies about the use of the AI-based applications in teaching and learning mathematics, including the studies about the teachers' attitudes regarding this issue (Passey et al., 2024; Wardat et al, 2023).

Frequently Used AI-Based Tools in Mathematics Education

In recent years, numerous artificial intelligence (AI)-based tools have been integrated into mathematics teaching to support problem-solving, visualization, planning, and assessment activities. This study references a wide range of such tools, each offering unique functionalities suitable for different pedagogical purposes. Table 1 presents a categorization of these tools based on their primary use in educational settings.

Table 1. AI-Based Tools in Mathematics Education

Category	Tools	Description
Problem Solving / Computation	ChatGPT, DeepSeek, Math Solver, Socrative, SmartBoard	Helps students in solving problems with step-by-step explanations.
Visualization / Animation	GeoGebra, GeoGebra 3D, Prezi AI, Z Book, Suno	Supports the concretization of mathematical concepts, animations, and 3D modeling.
Lesson Planning / Preparation	Canva, Gamma, MagicSchoolAI, Fetchy, Copilot	Assists teachers in creating lesson materials, presentations, and instructional content.
Research / Literature Support	Elicit, Consensus	AI tools for academic search, summarizing texts, and evaluating sources.
Activities / Assessment	Ouizziz, Socrative, Z Book	Used for in-class quizzes, mini-tests, and enhancing student engagement.

The Present Study

This study aims to comprehensively address the perspectives of mathematics teachers towards using artificial intelligence (AI) systems and applications in teaching. The study aims to reveal how teachers evaluate the contributions of AI-based technologies in mathematics teaching, which strategies they use when using these technologies in in-class and out-of-class activities, and the main challenges they face. In addition, how teachers perceive the effects of AI tools on student achievement, motivation and problem-solving skills is analyzed.

Identifying which digital tools and platforms mathematics teachers use in AI-supported teaching can provide a roadmap for the effective integration of these tools. In addition, it is also addressed how the technical and pedagogical challenges teachers face when using AI tools shape their practices in teaching processes. The impact of AI tools on student-teacher interactions is also an important focus, as these technologies offer the potential to individualize and enhance teaching processes, while at the same time causing changes in interaction dynamics. Teachers' predictions on the long-term teaching outcomes of AI technologies will also be evaluated, and these views will contribute to the development of AI-based teaching strategies.

The study also aims to identify teachers' professional development needs and analyze the impact of these needs on the adoption of AI-oriented educational technologies. Understanding teachers' pedagogical practices in the context of the impact of AI in the educational process will provide the basis for developing innovative strategies. These strategies could encourage teachers to modify their current teaching methods in a way to integrate some useful AI applications. Another aim of the study is to examine the overall frameworks of education systems and curricula, especially in the context of the effects on learning outcomes. As the literature review shows, the applications of AI technologies in mathematics teaching have the potential to improve the learning process and encourage further research in this area (Tashtoush et al., 2024).

In this context, the importance of the study is two-fold: Firstly, teachers' views on AI-based technologies will provide guidance for integrating these tools more effectively into educational processes. Secondly, a detailed analysis of the role of AI in mathematics education will provide a strong basis for future research and educational policies. The results of the research will contribute to the development of innovative solutions for the effective use of educational technologies, while aiming at the introduction of AI-based mathematics education and the improvement of learning and teaching processes. In this framework, the study will also compare the views of prospective teachers in Serbia and Turkey towards using AI systems and applications. Existing literature shows that cultural context, educational policies, and teaching traditions significantly influence teacher attitudes towards AI in cross-country comparisons (Zawacki-Richter et al., 2019). While in some countries the importance given to innovation and experimentation is high, some countries prioritize more standardization and curriculum alignment. This makes it meaningful to compare countries with different contextual structures such as Turkey and Serbia.

This study examines the role and impact of Artificial Intelligence (AI) systems in the integration of educational technologies into mathematics teaching. The main objective of the study is to understand the views of mathematics teachers towards AI-based tools and their perceptions in the integration of these tools into pedagogical processes.

In addition, the challenges faced by teachers and their needs for these technologies are also evaluated. In this direction, answers to the following questions will be sought:

1. How do mathematics teachers evaluate the use of AI in educational technologies?
2. Which digital tools and platforms do mathematics teachers use for the use of artificial intelligence in education?
3. Which strategies do mathematics teachers prefer to use AI tools in in-class and out-of-class activities?
4. What are the contributions of AI systems in mathematics teaching?
5. What are the main challenges that mathematics teachers face when using AI tools?
6. How are the effects of AI tools on student-teacher interaction perceived by teachers?
7. How do mathematics teachers evaluate the effects of AI applications on student achievement, motivation, and problem-solving skills?
8. What are the professional development needs of mathematics teachers for using AI technologies in teaching?
9. How do mathematics teachers predict the effects of AI-based tools on long-term teaching outcomes?

Method

Research Design

This study was designed within the framework of a descriptive research design based on a qualitative research approach. In the study, a comparative case study approach, which is one of the case study methods, was adopted. According to Yin (2014), a case study is “an empirical inquiry that investigates a contemporary phenomenon (the case) in depth and within its real-world context, especially when the boundaries between phenomenon and context are not clearly evident.” In a comparative case study, multiple cases are examined, and the findings are compared and contrasted; this allows researchers to identify causal relationships, contextual influences, or generalizable patterns (Yin, R. K., 2014).

Participants

The participants of the study consist of mathematics teachers working in Serbia and Turkey. Participants are selected using purposive sampling, taking into account the diversity in their professional experience, levels of technological competence, and familiarity with AI-based educational technologies.

Data Collection Tools

In this study, a semi-structured interview form developed by the researchers was used as the data collection tool. The first section of the interview form includes questions regarding the demographic characteristics of the participants. The second section consists of questions aimed at exploring mathematics teachers' experiences, perceptions, strategies, and professional development needs related to the use of artificial intelligence (AI)-based educational technologies.

Results

Demographic Characteristics of Participants

The teachers who work with 11-14 years old students took participation in the research by completing the survey about AI-based educational tools. In Serbia, 30 teachers completed the survey, while in Turkey 38 teachers completed the survey. Table 2 shows their teaching experience and Table 3 shows how they rated the technical equipment of the school where they work. The data for both countries is provided.

Table 2. Teaching Experience of Respondents

Teaching experience	<5 years	5 – 10 years	10 – 20 years	20 – 30 years	>30 years
Number of answers (Serbia)	1	1	12	13	3
Number of answers (Turkey)	1	7	17	13	0

Table 3. Technical Equipment of the School by Teachers' Opinion

(1 – very poor, 5 – excellent)

Rate	1	2	3	4	5
Number of answers (Serbia)	1	4	13	7	5
Number of answers (Turkey)	0	8	6	22	2

In Serbia, eight respondents of the survey (approximately 27%) declared themselves to be familiar with AI-based educational tools, and 22 respondents (approximately 73%) declared themselves to be unfamiliar with these tools. In Turkey, seventeen respondents declared themselves to be familiar with AI-based educational tools (approximately 44,7%), while 21 respondents (approximately 55,3%) declared themselves to be unfamiliar with these tools.

Frequency of AI Use, Competence and Interest (Tables 4-6)

The answers about how often the teachers use AI-based educational tools in teaching are shown in Table 4. Table 5 shows the respondents' estimation of their competencies for using AI tools in teaching. In Table 6, the respondents rated their own interest in improving their competencies for using AI tools in teaching. 18 of 22 Serbian respondents, who declared themselves not familiar with the use of AI-based tools in teaching, stated that they would like to try the use of these tools. As regards four respondents, who stated that they don't want to use AI-based tools, they stated that the students should solve problems individually, without the help of technology, because of the possible negative consequences on their independence and mathematical thinking ability.

Table 4. How Often Do You Use AI based Educational Tools in Teaching?

(1 – very rarely, 5 – very often)

Rate	1	2	3	4	5
Number of answers (Serbia)	22	2	4	2	0
Number of answers (Turkey)	15	6	15	2	0

Table 5. How Do You Assess Your Competencies for Using AI Tools in Teaching?
(1 – too weak, 5 – very strong)

Rate	1	2	3	4	5
Number of answers (Serbia)	17	3	6	2	2
Number of answers (Turkey)	7	9	14	8	0

Table 6. To What Extent Are You Interested in Improving Your Competencies for Using AI Tools in Teaching? (1 – not interested, 5 – very interested)

Rate	1	2	3	4	5
Number of answers (Serbia)	9	5	6	2	8
Number of answers (Turkey)	2	5	16	10	5

Thematic Analysis on the Use of Artificial Intelligence Tools

As a result of the content analysis of teachers' opinions, seven main themes and sub-themes were identified. These themes are summarized in Table 7. The themes include both positive and critical evaluations of teachers regarding the effects of AI tools in education.

Table 7. Themes and Subthemes Based on Mathematics Teachers' Views on AI-Based Educational Technologies

Main Theme	Sub-Themes	Representative Participant Quotes
Motivational Enhancer	- Increased student motivation - Visualization and concretization - Time-saving in the teaching process	“The visual materials I created with AI tools captured students' attention and increased their motivation.” (TR Teacher)
Hindrance to Critical Thinking	- Overdependence - Focus on ready-made solutions - Weakening of problem-solving skills	
Interactional Effects	- Enhanced student-teacher interaction - Reduced attention to the teacher	“Some students now ask the AI instead of me, which weakens the connection.” (TR Teacher)
Technical and Pedagogical Challenges	- Lack of infrastructure - Inadequate digital literacy - Inaccurate AI outputs - Classroom management issues	“Our internet often disconnects during lessons, causing the AI activity to be interrupted.” (TR Teacher)
Impact on Student Achievement	- Improved academic performance - Opportunities for personalized learning	“When used regularly, AI tools help students grasp topics more quickly.” (TR Teacher)
Impact on Long-Term Learning Outcomes	- Importance of teacher guidance - Knowledge retention - Effects on independent learning - Potential risks of misuse	“If students become too reliant on AI, they may lose their ability to think independently.” (SR Teacher)

Main Theme	Sub-Themes	Representative Participant Quotes
Professional Development Needs	- Need for training - Lack of practical application knowledge	“I’d like to try these tools, but I don’t know where to start.” (SR Teacher)

Explanation of Themes and Sample Quotations

Which ai based educational tools have you been used?

Most of the respondents in Serbia, who declared themselves to be familiar with AI-based educational tools, answered that they used ChatGPT in teaching, but also AI tools like Dale, Copilot, Grok, Gamma, Canva, Prezi AI, MagicschoolAI, Fetchy, etc.

In Turkey, most of the respondents, who declared themselves to be familiar with AI-based educational tools, answered that they also used ChatGPT in teaching and, besides it, they used AI tools like Math solver, Gemini, Grok, GeoGebra, GeoGebra 3D, Suno, Fetchy, Elicit, Consensus, Canva, Ouizziz, Z Book, Socrative, Smart board, etc.

Please describe briefly in which activities in teaching (or extracurricular activities) have you been used AI based educational tools?

The respondents in Serbia gave different answers to this question. These answers showed that the most common application of AI tools in teaching mathematics is for creating tasks differentiated by the level of achievement, finding and examining different methods for solving mathematical problems and for checking the solutions. Two respondents stated that they have used AI tools for obtaining ideas for project-based learning, as well as planning and preparing the learning process. One respondent has used AI tools for finding the examples of the mathematical contents’ applications in real life and for improving the students’ skills for verbal expressions of the mathematical problems by using a chatbot.

The Turkish teachers also gave different answers to this question. These answers showed that among those who used AI-based educational tools, GeoGebra training, teaching geometry with mobile phone applications, learning with animated educational materials, parent-guided mathematics teaching, 3D puzzle games, project-based geometry learning, 3D modelling in mathematics, teaching the history of formulas, solving mathematical problems with documents, STEM project proposals, problem solving with ChatGPT and 3D simulations. In addition, some participants stated that they used these tools to analyze function graphs.

Which are, in your opinion, the contributions of the AI based tools in mathematics teaching?

Most of the Serbian teachers gave similar answers to this question. They emphasized that the most important contributions of the AI-based tools in mathematics teaching are enabling the acceleration of the teaching process (including the teachers’ preparation) without decreasing the quality, visualization of the mathematical concepts,

increasing the students' motivation and improving the students' digital competencies. However, some of the teachers stated that they don't have enough experience in using AI-based tools, so they couldn't answer this question. Only a few of the teachers consider that the use of AI-based tools would not have the positive effects on the mathematics teaching.

As regards the respondents in Turkey, there are various opinions about the contributions of artificial intelligence-based tools to mathematics teaching. Participants stated that these tools save time and facilitate comprehension, but they also stated that they did not have enough information on this subject. While it is thought that these tools attract attention and interest in mathematics subjects that are difficult for children, some participants shared the view that these tools increase children's abstract thinking and facilitate teaching. On the other hand, it was stated that teachers can improve lessons with a more positive attitude, but there are also those who do not have knowledge about this issue. It was stated that artificial intelligence tools facilitate learning and provide order, make mathematics more effective by concretization and visualization, arouse curiosity, and support learning in new generation geometry subjects by establishing dialogue with students. In addition, it was thought that these tools make the lessons more understandable, facilitate visual expression, make education more effective, and enrich the learning process by appealing to all senses. While some teachers stated that students like the use of technology and this can increase their desire to learn, others emphasized that these tools make the lessons more efficient and go one step further than imagination in mathematics teaching. However, there are also teachers who think that AI-based tools are not very suitable for students' learning in mathematics teaching. In general, there are opinions that these tools are useful, contribute to concretization by providing visualization and offer a positive visualization in general.

Which are, in your opinion, the main challenges that mathematics teachers face with in using AI based tools?

The respondents in Serbia stated several challenges that mathematics teachers face in using AI-based tools. Five teachers said that, in an attempt to reach the solution quickly, the students often rely on procedural shortcuts, thereby bypassing the essential cognitive processes involved in mathematical reasoning. Four teachers emphasized the possibilities of making mistakes by AI tool and, consequently, the importance of checking the solutions obtained by the AI tools. Five teachers recognized the lack of the students' and teachers' digital competencies, as well as inadequate equipment in the schools, as an important challenge in using AI-based tools in teaching. Three teachers pointed out the possibility of using AI tools for cheating on the tests. Some of the teachers couldn't point out the challenges because they did not use these tools enough.

Among the main difficulties encountered by mathematics teachers in Turkey, when using AI-based tools, lack of knowledge in the use of technology and inadequate technical equipment in schools are at the forefront. Participants emphasized problems such as lack of sufficient equipment, students' decreased interest in books due to screen addiction, and lack of technological adaptation between generations. In addition, factors such as lack of knowledge about artificial intelligence, not being able to generate enough time for a new subject, not knowing programming languages and not receiving the necessary training on this subject were also counted among the difficulties. It is also noteworthy that teachers are distant from technology, not knowing which applications are available, students'

difficulties, and insufficient infrastructure in some schools. Infrastructural problems such as insufficient smart board equipment in schools, difficulties in accessing the internet, and lack of technology classrooms were also mentioned. In addition, factors such as lack of knowledge of using artificial intelligence, difficulty of applications in crowded classes and lack of technology training make it difficult for teachers to use these tools effectively. In addition, the tendency not to use artificial intelligence tools and to conduct lessons with traditional methods is also among these difficulties.

How, in your opinion, the application of AI based tools in teaching, affect the student - teacher interaction?

Most of the Serbian respondents stated that the application of AI-based tools in teaching has positive effects on the student-teacher interaction. However, several teachers stated that the use of AI-based tools can lead to regression in the student-teacher interaction, i.e. to the decrease of the communication quality. Two respondents rated these effects as the neutral.

The respondents in Turkey provided more analysis. In their opinions, the application of artificial intelligence-based tools in teaching affects student-teacher interaction in various ways. Participants stated that these tools facilitate teaching by attracting students' attention and provide more interaction opportunities, and this situation creates positive effects by increasing students' interest. Some opinions emphasized that artificial intelligence contributes to the development of students by enabling them to gain a different perspective, can create a change in students' learning processes and makes teaching healthier. While some teachers thought that these tools facilitate the use of course materials and create positive effects, others stated that they can weaken the students' bond with the teacher and reduce their interest in the teacher because they can get the answer to the question they want instantly. However, there were also those who stated that they did not have enough knowledge or had not experimented with it, indicating that the dimensions of the interaction were not fully grasped. In general, the participants agreed that AI-based tools positively affect student-teacher interaction and are seen as a supportive element of teaching.

How, in your opinion, the application of AI based tools in teaching mathematics, affect the students' achievements?

A half of the teachers surveyed in Serbia stated that AI-based tools have no influence on the students' achievements, but the other half stated that, if used in the appropriate way, AI tools can contribute to increasing the students' achievements in learning mathematics. Most of these teachers consider that the use of AI tools could improve the students' individual work, emphasizing at the same time the importance of the teachers' role in that learning process (training the students for using AI tools in learning, monitoring of the learning process...).

According to the answers given to the questionnaire in Turkey, the application of artificial intelligence-based tools in mathematics teaching positively affects the students' achievement. Participants stated that these tools increase success by providing easier understanding, facilitating the learning process, and creating positive effects. It was stated that artificial intelligence improves the students' achievements when it is carefully controlled, provides

perspectives with different thinking methods, and offers features that increase success by teaching new methods when used correctly. In general, participants agreed that AI-based tools positively affect the students' achievements when used appropriately.

How, in your opinion, the application of AI based tools in teaching mathematics, affect the students' motivation?

Most of the respondents in Serbia emphasized the positive influence of the AI-based tools on the students' motivation. They stated that the difference of AI tools' characteristics and the possibility of verbal communication with chatbots (enabled by some of these tools), could make the learning process more dynamic and interesting to the students. Two respondents rated this influence as neutral, and three of them estimate that this influence depends on the student's individual characteristics – in their opinion, motivation of some students could be increased, but also, some of the students may not be interested in using new technology solutions.

According to the answers given to the questionnaire in Turkey, the application of artificial intelligence-based tools in mathematics teaching has a positive effect on students' motivation in general. Participants stated that these tools arouse curiosity by keeping the attention alive for a long time, increase interest in the lessons, and support motivation. In addition, it was stated that they contribute to the development of positive attitudes towards the lessons, increase motivation in some subjects, and make the learning process more attractive. However, there were also those who stated that there was no direct effect or that they did not have enough information on this subject; nevertheless, in general, the teachers' opinions were that these tools positively affected students' motivation, supported their learning processes, and strengthened their motivation.

How, in your opinion, the application of AI based tools in teaching mathematics, affect the students' problem-solving skills?

Most of the respondents in Serbia agree that the application of AI-based tools in teaching mathematics can cause negative consequences on the students' problem-solving skills, because the students usually use these tools only for obtaining the final solutions of the problems. But, in the respondents' opinions, if the AI-based tools would be used for analyzing the process of problem solving, they can have a positive influence on the students' problem-solving skills.

The Turkish teachers' views on the impact of AI-based tools on problem solving skills in mathematics teaching present a multidimensional picture that includes both positive and negative aspects. Many teachers stated that these tools improve students' problem-solving skills, especially their functions such as visualization and clearly presenting solution steps facilitate the students' understanding. In addition, it was stated that they support the learning process with advantages such as emphasizing unexplained points and providing different examples. However, some teachers are concerned that artificial intelligence may prevent creative and critical thinking and distract students from processes that require intellectual effort because it directs students to ready-made information. It was stated that if the tools are not used in a controlled and dosed manner, students may tend to

take the easy way out and therefore may pose an obstacle to active learning. Some teachers, on the other hand, were distant about the issue, stating that they had no experience in their use or were not sure of their effectiveness. In general, it is accepted that AI tools have the potential to support problem solving skills, but it is emphasized that in order to transform this potential into a positive one, they need to be integrated consciously, gradually, and in accordance with pedagogical principles.

Which effects, in your opinion, the application of AI based tools in teaching mathematics will have on long-term learning outcomes?

In Serbia, seven respondents expressed concern that the use of AI-based tools can cause a decrease in the students' independence in work. On the other side, five respondents stated that, if used in an adequate way, AI tools may have a positive influence on long-term learning outcomes. Two teachers stated that the use of AI-based tools enables the students to organize their learning in the way that is most appropriate for each student individually, emphasizing that such learning organization could have a positive effect on the long-term learning outcomes. Four respondents emphasized the importance of the thorough research in the area of the application of AI-based tools in teaching mathematics.

In Turkey, the teachers' views on the effects of AI-based tools on long-term learning outcomes in mathematics teaching are generally positive. Teachers stated that these tools improve abstract and algebraic thinking skills, provide better concretization of the subject, and thus make learning permanent. In addition, it was stated that students gained the habit of planned and disciplined work, adapted better to the requirements of the age by using technology effectively, and prevented negative feelings such as learned helplessness. It is emphasized that artificial intelligence, especially when used effectively and in accordance with its purpose, accelerates students' homework processes, gives them the ability to evaluate subjects from different perspectives, and increases motivation. However, some teachers emphasized the importance of careful integration, stating that in case of misuse or unconscious use, cognitive skills may weaken, and students may get used to readiness. In general, it is thought that AI-based tools, when used with the right planning and teacher guidance, support permanent learning in the long term and have positive effects on learning outcomes.

Discussion

In this research, the mathematics teachers' attitudes toward the application of the AI-based tools in Serbia and Turkey are examined. The numerous similarities, but also some differences between Serbian and Turkish teachers' attitudes are noticed. Both, Serbian and Turkish respondents had approximately the same work experience. Turkish teachers rated the technical equipment of their schools better than the Serbian teachers. Also, this survey results indicate that the Turkish teachers are more familiar with AI tools, including AI tools intended for use in teaching, than the Serbian teachers. They use AI tools in teaching more often, and they are more interested in improving their competencies for using AI tools. The fact that teachers in Turkey report higher familiarity with AI tools can be attributed to the country's policies towards digitalization in education in recent years, such as national initiatives like the FATİH project (Aslan, 2012). This project aimed to strengthen technological

infrastructure in schools, such as smart boards and internet access, and increase teachers' access to technology. In contrast, the lower familiarity of teachers in Serbia may be due to limited professional development opportunities or less emphasis on technology integration in the curriculum. These differences suggest that the regional context plays a critical role in the integration of AI tools. For example, the more frequent use of AI tools by teachers in Turkey can be attributed to the ease of access to technology and the support of education policies for innovative approaches. On the other hand, the more cautious attitude of teachers in Serbia can be explained by cultural or systemic barriers in the process of adaptation to technological innovations. These findings support the influence of cultural context on technology integration, emphasized by Zawacki-Richter et al. (2019).

When teachers' attitudes towards AI-based tools are evaluated within the framework of the Technology Acceptance Model (TAM), the higher frequency of use by teachers in Turkey indicates higher perceived usefulness and ease of use of these tools (Davis, 1989). In particular, Turkish teachers' more frequent use of tools such as GeoGebra and ChatGPT may reflect their perceptions that these tools offer advantages such as visualization and individualized learning in mathematics teaching. In contrast, the lower frequency of use by teachers in Serbia could be explained by a lack of technological knowledge (according to the TPACK framework) or limited awareness of the pedagogical integration of AI tools (Koehler & Mishra, 2009). The TPACK framework emphasizes that for teachers to use technology effectively, it requires a combination of content knowledge, pedagogical knowledge and technological knowledge. In this context, the low digital competence of teachers in Serbia may be a barrier to the pedagogical integration of AI tools. These findings suggest that teachers' technological and pedagogical knowledge levels need to be increased for the successful integration of AI-based tools.

Regarding activities in teaching, for which AI tools are used, both Serbian and Turkish teachers gave different responses. In Serbia, some teachers used AI tools for creating tasks differentiated by the level of achievement, which is in accordance with Passey et al. (2024) and Opesemowo and Ndlovu (2024). Also, some of the Serbian teachers used AI tools for finding and examining different methods for solving mathematical problems and for checking the solutions, while some of them used these tools as a help in planning and conducting project-based learning. This is in accordance with Govender (2023). Turkish teachers mostly used AI tools for visualization and different approaches in teaching and learning geometry, including problem solving and modelling, which is in accordance with Cunska (2020). Some of the Turkish teachers used this kind of assistance for inputting the problem in different ways, which corresponds to the results of Opesemowo and Ndlovu (2024).

Most of the Serbian teachers emphasized the acceleration of the teaching process, visualization of the mathematical concepts and increasing the students' motivation as the most important contributions of using AI-based tools in teaching mathematics. This is in accordance with Bawaneh et al. (2025) and Tashtoush et al. (2024). Turkish teachers mostly agreed with their Serbian colleagues on this matter but also pointed out the contribution of using AI tools in facilitating comprehension of the contents which are difficult to the students, which is in accordance with Govender (2023) and Hwang (2022). Both Serbian and Turkish teachers mostly agreed that the use of AI tools has a positive influence on the students-teachers interaction. However, some teachers also noted that the overuse of these tools can lead to a reduction in face-to-face interactions and a weakening of students'

dependence on the teacher. This can transform the teacher's traditional role of knowledge transmitter into that of a guide or facilitator, suggesting the need to maintain pedagogical balance. While AI's capacity to deliver individualized learning materials redefines the role of the teacher, the importance of human interaction should not be overlooked. Chan and Tsi (2024) emphasize that generative AI can enhance teaching, but the unique qualities of human teachers need to be integrated with AI for well-rounded learning experiences. By combining the technological advantages of AI with the guidance of human teachers, this integration can create an effective learning environment that supports students' individual and social development.

The use of AI-based tools in mathematics teaching raises important questions about ethics and academic integrity. In the study, teachers in Turkey also expressed concerns about the accuracy and reliability of these tools. This suggests that teachers need to develop pedagogical strategies to integrate AI tools in an ethical way. For example, establishing classroom rules for using AI tools only for analyzing problem-solving processes or exploring alternative solutions can support academic integrity. Moreover, it is important for teachers to encourage students to think critically, considering situations where these tools may provide inaccurate or incomplete information. In this context, the use of the set of AI in education ethical principles proposed by Nguyen et al. (2022) is a critical step for the development and implementation of ethical and reliable AI tools.

As regards the challenges in using AI-based tools, the respondents in Serbia emphasized the possibility of bypassing the essential cognitive processes involved in mathematical reasoning and the possibilities of making mistakes by AI tools. These challenges are also recognized in the research Opesemowo and Ndlovu (2024) and Wardet et al. (2023). Some of the Serbian respondents, as well as most of the Turkish respondents, emphasized the lack of the students' and the teachers' digital competencies, but also inadequate school equipment, as the most important challenges in using AI-based tools in teaching. This is in accordance with Tashtoush et al. (2024).

About a half of the Serbian and most of the Turkish teachers consider that the use of AI-based tools could have a positive influence on the students' achievements, which is in accordance with Hwang (2022). Also, most of the teachers in both countries stated that the use of AI-based tools could have a positive influence on the students' motivation. This result corresponds to Bawaneh et al. (2025) and Tashtoush et al. (2024). Most of the Serbian teachers consider that the use of AI-based tools can cause negative consequences to the students' problem-solving skills, if that use is not carefully planned and conducted. On the other side, the Turkish teachers are more optimistic in terms of this influence, which is in accordance with Govender (2023).

Conclusions

This study comprehensively examined the attitudes of mathematics teachers in Serbia and Turkey towards AI-based tools and their integration into teaching processes. The main findings addressing the research questions can be summarized as follows: (1) teachers generally consider AI tools as tools that accelerate teaching processes and facilitate learning through visualization; (2) teachers in Turkey use tools such as GeoGebra and ChatGPT more frequently, while teachers in Serbia show a more limited use; (3) AI tools make positive contributions in increasing student motivation and providing individualized learning; however, (4) technical infrastructure deficiencies,

limited digital competencies, and ethical use concerns stand out as the main challenges in the integration of these tools. Moreover, teachers' professional development needs are critical for the effective use of AI tools. While these findings reveal the potential of AI-based tools in mathematics teaching, they emphasize the need for pedagogical and technical support for successful integration.

For the effective integration of AI-based tools into mathematics teaching, education authorities and school administrations should establish structured professional development programs to enhance teachers' digital competencies. These programs should focus on the pedagogical integration of AI tools, provide guidelines for the ethical use of the tools, and provide teachers with opportunities for practical applications. For example, workshops should be organized for teachers to learn how to use tools such as ChatGPT or GeoGebra in classroom activities. In addition, investments should be made at regional and national levels to strengthen the technological infrastructure of schools. Especially in regions with limited technological infrastructure, such as Serbia, meeting basic requirements such as smart boards and internet access will support the diffusion of AI tools. School administrators should develop school policies that encourage teachers to use AI tools as a pedagogical complement and set clear rules to prevent misuse of these tools.

The findings of this study indicate that mathematics teachers in Serbia and Turkey express considerable interest in integrating AI-based tools into their teaching practices. However, a significant proportion of these educators, particularly in Serbia, require enhanced support and professional development to effectively utilize these technologies. Consequently, school administrations and educational authorities should prioritize the development of structured professional development programs tailored to these needs. The research further reveals that many teachers in both countries lack comprehensive knowledge regarding the capabilities, benefits, and limitations of AI-based tools. To address this, training programs must be meticulously designed to provide educators with a thorough understanding of the multifaceted aspects of AI integration in mathematics education, ensuring effective and ethical implementation in teaching practices.

This study provides important data to understand mathematics teachers' attitudes towards artificial intelligence-based educational tools and their integration into teaching processes. However, the study has some limitations. Firstly, the study was conducted with a relatively small sample (30 teachers in Serbia and 38 teachers in Turkey), which may limit the generalizability of the results. With a larger sample, including teachers from different regions and educational levels, it may be possible to reach more comprehensive results. In addition, the study was limited to teachers working with students aged 11-14 years; the attitudes of teachers at primary school, high school, vocational school, and higher education levels were not included in the study. In addition, the study was based solely on teachers' views; the perspectives of students, parents or administrators were not included. The use of only a semi-structured interview form as a data collection tool limited the diversity of data sources. Studies supported by more concrete data, such as students' academic achievement data, classroom observations, or practical experiments, may allow for more robust inferences. Moreover, the cross-sectional design of the study makes it difficult to evaluate the long-term effects of artificial intelligence tools on teaching processes. In this context, information on how variables such as learning retention, independent problem solving skills, or dependency on digital tools evolve over time cannot be presented. Since teachers' statements are based on their

own self-assessments, possible biases should also be taken into account. Another limitation is that the socio-economic characteristics of school environments (e.g. social status of students, location in rural or urban areas, technological infrastructure of the school) were not systematically analyzed in the study. The impact of these factors on teachers' technology use and attitudes should be examined in more depth. Finally, the study is limited to Serbia and Turkey. Given the different countries' educational policies, level of digital transformation, and cultural approaches, more comprehensive and multi-country comparative research would contribute to a better understanding of the effects of cultural context.

Taking these limitations into account, future research should deepen the body of knowledge in this area by conducting longitudinal comparative studies with larger and more diverse samples, including different levels of education and school environment factors, and covering more countries.

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