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ARTIFICIAL INTELLIGENCE AND MATH TEACHING: AN ANALYSIS OF THE STATE OF THE ART IN LITERATURE

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Abstract: This article presents data from a survey on the use of Artificial Intelligence (AI) in math teaching, highlighting its potential, challenges and trends. The research adopts the state-of-the-art methodology, analyzing Brazilian academic productions published between 2019 and 2024 in the Brazilian Digital Library of Theses and Dissertations (BDTD) and the CAPES Journal Portal. The results show that AI has been used as a pedagogical tool to personalize teaching, facilitate problem-solving and improve students' logical reasoning. However, the implementation of these technologies in Brazil faces challenges, such as the need for qualified teacher training. The review of publications reveals that, although AI has transformative potential, its use is still incipient in mathematics teaching, being more explored in other areas of education.The study highlights the need for new research that deepens the impact of AI on teaching practice, developing effective methodologies to integrate these tools into mathematics teaching. Finally, the article reinforces the importance of the teacher's role in mediating learning, ensuring that AI is used in a critical and complementary way to traditional teaching.
Keywords: Artificial Intelligence. Teaching Mathematics. Personalized Learning.

INTRODUCTION

The integration of Artificial Intelligence (AI) into education has been a growing trend, driven by technological advances and the incessant search for more personalized, effective and inclusive teaching strategies. According to Russell and Norvig (2021, p. 2):

> Artificial Intelligence is the study of agents that receive perceptions from the environment and carry out actions. In this context, an agent is something that acts (a robot, a piece of software, a person, a company, etc.), and a rational agent is one that acts in such a way as to maximize its performance measure, based on what it perceives and the knowledge it possesses. AI covers a wide range of subfields, from expert systems that mimic human decision-making in specific domains to machine learning algorithms that allow systems to improve their performance through experience. The central goal of AI is to create systems capable of performing tasks that, if done by humans, would be considered intelligent, such as pattern recognition, complex problem solving, natural language understanding and autonomous decision-making.

In the educational context, AI offers a set of tools that can transform the way teaching is structured and how knowledge is built with students. In mathematics teaching, specifically, AI has the potential to optimize the teaching-learning process, offering solutions such as intelligent tutors, adaptive teaching systems, interactive educational games and problem-solving platforms. These tools help develop logical reasoning, solve mathematical problems and personalize learning, allowing students to progress at their own pace and according to their needs (Luo *et al.*, 2022; Holmes *et al.*, 2019). By promoting more student-centered learning, AI-based technologies have the power to provide experiences that adjust to the particularities of each student, something that is essential in an increasingly diverse educational context.

However, the implementation of AI in the Brazilian educational context faces significant challenges. Although Brazil has made progress in terms of access to technologies, inequality in access to technological resources between regions and education networks is still a reality. In addition, the successful integration of AI tools into pedagogical practice requires continuous and qualified teacher training, which is still a challenge for many educators. The successful implementation of AI depends not only on its availability, but also on the development of technological and pedagogical skills among teachers, so that they can mediate the

use of these tools effectively and critically (Moran, 2015). This mediation is fundamental, since the teacher plays an essential role in the learning process, even in technology-mediated contexts, as highlighted by Vygotsky's theory of the Zone of Proximal Development:

> The level of actual development characterizes mental development retrospectively, while the zone of proximal development characterizes mental development prospectively. The zone of proximal development defines those functions that have not yet matured, but are in the process of maturing; functions that can be called the 'buds' or 'flowers' of development, rather than the 'fruits' of development (Vygotsky, 1998 p. 37).

This article analyzed studies on the use of Artificial Intelligence in Mathematics teaching, with an emphasis on Brazilian academic production registered in the Brazilian Digital Library of Theses and Dissertations (BDTD) and the Portal of Periodicals of the Coordination for the Improvement of Higher Education Personnel (CAPES), over the last five years. The choice of this period is justified by the rapid evolution of educational technologies and the growing adoption of AI in pedagogical practices in this period, UNESCO has highlighted in several of its reports the rapid incorporation of AI in teaching and learning. In 2021, the organization approved the "Recommendation on the Ethics of Artificial Intelligence", a document to guide the responsible use of AI, both in education and in other areas. In 2023, it launched the "Guide to Generative AI in Education and Research", highlighting some tools such as ChatGPT that can help in this educational process The analysis of academic productions made it possible to identify the main approaches, trends and challenges observed in the application of AI in mathematics teaching. In addition, it was possible to map the existing gaps in research and the possible solutions proposed by scholars in the field, with a focus on adapting technologies to the specificities of the Brazilian educational context aimed at teaching mathematics. The review is in line with contemporary discussions on the role of technologies in education, in particular on the implications of AI for student learning and development. By connecting theoretical and practical advances, this study aims to contribute to the formulation of innovative pedagogical strategies that consider the needs of students and the role of the teacher as a mediator of knowledge.

This topic presents a theoretical survey of artificial intelligence used in math teaching and its contributions, addressing challenges and different methodologies used. Studies show that many students have difficulty understanding basic mathematical concepts , which hampers their development over the years. According to Freire (2011), math education requires different didactic approaches to ensure meaningful learning.

Artificial intelligence is in full development and is a much debated and complex contemporary subject. The challenge for teachers and the school context is to align it with the teaching and learning process, to teach students how to use it while developing their logical and critical thinking. By using it, the student will have to learn to do more complex mental tasks for what the machine cannot (yet) do. For example, improving our critical sense, adapting better to different everyday situations, broadening our intelligence and other human skills (Teté, 2023).

AI works by creating algorithms that allow machines to analyze data and make predictions. These algorithms are based on mathematics and statistics (Aplusplatform, 2023). In recent years, the use of this tool has gained unimaginable proportions, especially after the COVID-19 pandemic in 2020, digital technologies and AI have become very present in students' lives. The report "Reimagining

our futures together: A new social contract for education" (UNESCO, 2021) highlights that the COVID-19 pandemic has exposed and deepened educational inequalities, while accelerating the adoption of digital technologies, including Artificial Intelligence (AI), in the field of education. UNESCO points out that AI has transformative potential, capable of personalizing learning, supporting teachers and increasing the efficiency of education systems. The organization argues that AI should not replace the central role of educators, but rather act as a complementary tool, expanding pedagogical possibilities and promoting more inclusive learning environments.

Therefore, with this rapid evolution of AI, the challenge for teachers to use it in the classroom as an ally in the teaching and learning process has also grown. When it comes to learning mathematics, for example, students have many difficulties, from basic mathematics to more advanced content. This tool is an opportunity to try to improve this learning, personalizing this process, reinforcing content, creating contexts to understand the application of theory in practice.

However, studies on AI in mathematics teaching are still scarce in the academic literature; most research is focused on other topics related to mathematics. Thus, this study seeks to contribute to this theme by analyzing the theses and dissertations that explore the topic.

The following sections will present the methodological aspects adopted for data collection, as well as the presentation of this data and the analysis of the results obtained.

METHODOLOGY

This research follows the State of the Art approach, which consists of identifying and analyzing academic productions on a given subject, according to Ferreira:

> The State of the Art is characterized by the search, identification, reading, analysis and discussion of research and production already carried out on a given topic. It is a systematic survey of scientific and academic production, allowing the researcher to understand trends, gaps and advances in a specific area of knowledge (Ferreira, 2002 p. 258).

The methodology adopted comprises a number of stages, from the search, inclusion and exclusion criteria, to the selection and analysis of the studies. According to Polit and Beck (2018, p. 145), "the inclusion and exclusion criteria are fundamental to guaranteeing the relevance and quality of the studies selected in a systematic review or research".

The research was carried out in the databases of the Brazilian Digital Library of Theses and Dissertations (BDTD) and CAPES. The choice of these platforms is justified by the relevance of their studies in the academic sphere. The descriptors used were "artificial intelligence" and "math teaching". The search was filtered between 2019 and 2024, selecting only theses, dissertations and articles that specifically addressed studies on AI in math teaching. The analysis of the results showed some that did not correspond to the topic, only covered one or other descriptor, so these works were not included. Each selected paper was analyzed, at first by the scope of the topic through the title, keywords and objectives. Then, for a more thorough analysis, the abstracts of each paper were analyzed, identifying the main focus of each study, its contributions and conclusions. As there is no involvement with human beings, since this is documentary research, there is no need for approval by an Ethics Committee.

The following sections will present the results obtained and the discussions about these results.

RESULTS

The aim of the research was to map Brazilian theses, dissertations or articles that address the use of AI in mathematics teaching, from the perspective of contributing to teaching practice in mathematics teaching, by analyzing academic production in the databases of the Brazilian Digital Library of Theses and Dissertations (BDTD) and CAPES.

The search made it clear that dissertations represent the largest share of publications related to Artificial Intelligence in math teaching in Brazil in the BDTD repository. The search found 23 dissertations and 7 theses, out of the 30 results on this platform. In the CAPES repository, the search showed 10 results, all articles, of which 9 were national and 1 international. Of the 30 results from the BDTD platform, 8 were selected (Table 1), which specifically address the research topic, and 6 papers were selected from CAPES (Table 2). The results are shown in the following tables:

DISCUSSIONS

The analysis of the abstracts reveals a comprehensive overview of the use of Artificial Intelligence (AI) in math teaching, exploring different perspectives, methodologies and challenges in this relationship. In general, at the start of the research, there was a scarcity of studies aimed at this specific area. The studies found share a common interest in investigating the potential of AI to transform the teaching of mathematics, whether in primary or secondary schools, with applications ranging from mathematical modeling to the use of intuitive interfaces for learning. However, there are notable differences in the approaches adopted by each study, ranging from more theoretical and technological approaches to research with an emphasis on pedagogical practice and the direct impact on student learning.

One of the main convergences between the studies is the recognition that AI can play a fundamental role in education, promoting new forms of learning and engagement. In addition, there is a consensus that AI should not just be seen as a support tool, but as an element that can profoundly change the way mathematical concepts are taught and learned.

Another relevant aspect is the concern with pedagogical practice and teacher training for the use of AI in education. Some studies highlight the need to train teachers so that they can use these technologies effectively, ensuring that they are used in a critical and contextualized way. There is an emphasis on the importance of validating the results generated by AI and supervising its use in the classroom, preventing students from becoming overly dependent on these tools. This suggests that although AI offers many possibilities, its inappropriate use can generate challenges, such as the loss of student autonomy in the learning process.

Studies show that AI can act as a kind of tutor, helping students to solve mathematical problems and helping teachers to create more dynamic teaching activities. However, some studies point to concerns about the quality of the answers generated and the need for appropriate pedagogical mediation to avoid mistakes and ensure that learning is meaningful, thus highlighting the importance of teacher training for the use of this tool.

Another interesting point is the study that investigates the impact of AI on education in the post-pandemic period, as UNESCO studies and reports, for example, show a huge leap in the use of AI platforms after 2020. This work also shows how AI has been incorporated into remote teaching to help students learn mathematics, highlighting digital culture and new forms of interaction in the virtual environment. This study also reinforces the idea that AI can enhance learning when integrated with active methodologies and approaches that encourage student autonomy.

Title	Year	Key words	Author	Institution
Demystifying artificial intelligence for high school students: exploring fundamental concepts and mathematics	2024	Mathematics (High School). Neural networks (Computing). Artificial intelligence - Educational applications. Teaching. Applied mathematics.	Rodrigo César Mesquita Gomes	Federal University of Viçosa
In search of insights into artificial intelligence and intuitive programming in math education	2022	Artificial intelligence. Programming (Mathematics). Mathematics - Study and teaching. Mathematics.	Silvana Gogolla de Matos	Federal University of Paraná
The use of artificial intelligence, mathematical modeling and problem solving.	2024	Artificial intelligence. Mathematical modeling. 1st degree equations.	Julius Kahoru Yassaki Filho	Federal University of Santa Maria
Artificial intelligence and machine learning: from theory to ready-made algorithm in high school	2023	Artificial intelligence. Machine learning. Mathematics (high school).	Diogo Alves Brandão	University of Brasilia
A proposal for designing interfaces for mathematics educational platforms assisted by artificial intelligence	2023	Artificial intelligence - Educational applications. Educational software. Ergonomics. Mathematics - Study and teaching. Mathematics.	Renata Balbino	Federal University of Paraná
ChatGPT as a resource in the process of teaching and learning mathematics	2024	ChatGPT. Artificial Intelligence. Artificial intelligence in education. Teaching mathematics.	Romis de Souza Moraes	Federal University of Tocantins Palmas
Artificial intelligence & online education in public schools: possibilities and scope	2022	Artificial Intelligence. Mathematics. Modeling/ICTD Projects.	Lidiene Costa da Silva Matos	Federal University of Uberlândia
Symmetry of reflection, translation and rotation: an approach using educational robotics.	2022	Mathematics. Robotics. Artificial Intelligence. Symmetry. Translation. Rotation.	Marlise Seghetto	Federal University of the Southern Border

Table 1: Selected works from BDTD

Source: Prepared by the author (2025)

Title	Year	Key words	Author	Institution
Field theory and artificial intelligence integrated in the analysis of transitions between mathematical interfaces	2023	Learning Quantization, Decision Tree, Mathematical-Computational Modeling.	Dênis Carlos Lima Costa, Dener Francisco Ferreira da Silva, Renata Pinheiro chaves, Heictor Alves de Oliveira Costa.	RECIMA 21-Multidisciplinary Scientific Journal.
ChatGPT as a support resource for teaching mathematics.	2023	ChatGPT, Teaching, Learning, Mathematics, Artificial Intelligence.	Renan Pereira Santos, Claudinei de Camargo Sant'Ana	Journal of Mathematical Education of Ouro Preto.
Proposal for teaching mathematics with the aid of educational software: analysis of teaching practice.	2020	Chatbot, Sofware. Teaching mathematics.	Luís Enrique Fernandes Silva	Brazilian Journal of Development
Teaching math in the early years: chatbot tools in the construction of didactic sequences	2023	Artificial intelligence. Chatbot. Didactic sequence. Teaching/ learning.	Fábio José de Araújo, José Luiz Alvez, Zenayre Mendes de Oliveira, Carolina Dutra Marques, Débora Paz Maciel, Jonathas dos Santos Carretero, Jonatas da Silva, Fabiana Campos de Brito.	Contributions to the Social Sciences
The (r)evolution of Education 4.0 in the teaching of science and mathematics in state schools in Paraíba	2021	Education 4.0. Teaching. Science. Mathematics.	Pricila da Silva Santos, Priscila de Souza Maciel	New Technologies in Education Magazine
Chatting with the co-author, who didn't want to be, ChatGPT.	2023	ChatGPT. Artificial intelligence. Matrix equation. Error. Text production.	Catarina Alexandra Almeida Moreira, Pedro Filipe Pinto França, Patrícia Damas Beites, Ebru Ersari.	Revista Prática Docente.

Table 2: Selected papers from CAPES

Source: Prepared by the author (2025)

FINAL CONSIDERATIONS

Despite the progress shown by the research analyzed, it is clear that the field of AI applied to math teaching is still little explored in Brazil. There are few studies focused specifically on the application of AI to the construction of pedagogical methodologies and strategies that effectively integrate this technology into mathematics teaching in a systematic way. Most of the existing research focuses on more general areas of education or the application of AI in disciplines such as languages and the humanities, which indicates a gap that needs to be further investigated. This scenario suggests that there is great growth potential for future studies that can deepen the impact of AI on mathematics teaching, especially with regard to teacher training, curriculum adaptation and the creation of methodologies that use AI ethically and efficiently to enhance the learning and teaching of mathematics.

Finally, a detailed analysis of the abstracts leads to the conclusion that Artificial Intelligence is consolidating itself as a relevant tool for teaching mathematics, offering new possibilities for personalizing teaching, developing computational thinking and expanding pedagogical methodologies. However, its use must be planned carefully, taking into account both its benefits and its challenges, so that it can actually contribute to improving mathematical learning. The fact that there are few studies in the area reinforces the need for more research into how to integrate AI into math teaching in a structured way and with a solid theoretical basis , ensuring that this technology is used efficiently and really adds value to the educational process.

As a follow-up, it is recommended that future research deepen the investigation into effective teacher training strategies for the use of AI, applied exclusively to the teaching of mathematics, analyzing methodologies that can integrate these technologies in an ethical and pedagogical way. In addition, it is essential to understand how students interact with AI tools in math teaching, identifying positive impacts and possible limitations. Another relevant path is to analyze how AI can be incorporated into the National Common Curriculum Base (BNCC) and national curriculum guidelines, ensuring a systematic approach to its use in basic education.

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