

CHALLENGES AND OPPORTUNITIES FOR THE USE OF CHAT GPT IN
MATHEMATICAL EDUCATION RESEARCH

*DESAFIOS E OPORTUNIDADES PARA O USO DO CHAT GPT NA PESQUISA EM
EDUCAÇÃO MATEMÁTICA*

*DESAFÍOS Y OPORTUNIDADES PARA EL USO DE CHAT GPT EN
INVESTIGACIONES DE EDUCACIÓN MATEMÁTICA*



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ABSTRACT: The aim of this article is to identify the main challenges and opportunities related to the use of Chat GPT as a support tool in Mathematical Education research. For this purpose, we conducted an interview with the Artificial Intelligence, Chat GPT4. The findings suggest that Chat GPT is an encouraging tool based on artificial intelligence with the potential to assist in both research and teaching in mathematics. However, its ethical and responsible use calls for a thorough examination of its challenges, limitations, and opportunities. Human oversight and the integration with other research methodologies are vital to balance the application of this technology with pedagogical approaches. Ultimately, promoting equity and inclusion is essential to ensure all students have access to technology and can harness its potential.

KEYWORDS: GPT Chat. Mathematics education. Artificial intelligence. Information and communication technologies.

RESUMO: O objetivo desse artigo é identificar os principais desafios e oportunidades associados ao uso do Chat GPT como ferramenta de apoio à pesquisa em Educação Matemática. Para tanto, realizamos uma entrevista com a Inteligência Artificial Chat GPT4. Os resultados indicam que o Chat GPT é uma ferramenta promissora baseada em inteligência artificial com potencial para auxiliar na pesquisa e ensino em educação matemática. Entretanto, seu uso responsável e ético requer consideração cuidadosa de seus desafios, limitações e oportunidades. A supervisão humana e a integração com outras metodologias de pesquisa são fundamentais para equilibrar o uso dessa tecnologia com abordagens pedagógicas. Por fim, promover a equidade e a inclusão são essenciais para garantir que todos os alunos tenham acesso à tecnologia e se beneficiem de seu potencial.

PALAVRAS-CHAVE: Chat GPT. Educação Matemática. Inteligência Artificial. Tecnologia da Informação e comunicação.

RESUMEN: *El propósito de este artículo es identificar los principales retos y oportunidades vinculados con el uso de Chat GPT como herramienta de apoyo en investigaciones de Educación Matemática. Para ello, realizamos una entrevista con la Inteligencia Artificial Chat GPT4. Los resultados señalan que Chat GPT es una herramienta alentadora basada en inteligencia artificial con potencial para asistir en la investigación y enseñanza matemática. Sin embargo, su empleo responsable y ético demanda una reflexión detallada sobre sus desafíos, limitaciones y oportunidades. La supervisión humana y la combinación con otras metodologías investigativas son esenciales para equilibrar el uso de esta tecnología con enfoques pedagógicos. Finalmente, fomentar la equidad y la inclusión es crucial para asegurar que todos los estudiantes accedan a la tecnología y aprovechen su potencial.*

PALABRAS CLAVE: *Chat GPT. Educación Matemática. Inteligencia Artificial. Tecnologías de la Información y Comunicación.*

Introduction

The progressive evolution of Artificial Intelligence (AI) has provided a myriad of innovations and benefits across multiple domains. In the sphere of medicine, the strategic use of AI has been observed to increase the accuracy of diagnosis and prognosis of pathologies, providing more effective and personalized therapies.

Within the automotive industry, AI has been a revolutionary force, especially with the advent of autonomous vehicles, which have the potential to increase road safety and alleviate congestion. According to Bojarski's analysis *et al.* (2016), Tesla, an innovative corporation, has stood out in the use of AI in its fleet of electric vehicles. This technology plays a vital role in developing and enhancing the autonomous driving capabilities of your vehicles, contributing to safety, efficiency and user experience. Although such technology is not yet widely available in Brazil, it is already noticeable how much AI can increase the quality of automobiles.

In the financial sector, AI has also had a significant impact, with the design of trading algorithms capable of processing vast volumes of data and making decisions in minimal time. These algorithms help optimize market transactions, manage risks and discover investment opportunities.

In the artistic domain, AI has been used to create original works, exploring new forms of expression and challenging the intersection between human and machine. Additionally, AI has been used in the entertainment sector to develop scripts and special effects, making content more immersive and attractive to the audience.

In the educational sphere, AI systems have enabled adaptive learning programs, which identify the individual needs of students and adapt the content and pedagogical methodology. This can culminate in more meaningful learning and better knowledge construction (Koedinger *et al.*, 1997).

Artificial Intelligence (AI) systems employed in designing adaptive learning programs are crucial components of technological progression in the educational field. These systems offer personalized instruction to students, adapting to their individual requirements and skills. There are a multitude of applications and platforms that use AI to provide adaptive learning experiences. Among these, we can mention *DreamBox Learning*, an online mathematics teaching platform that uses adaptive algorithms to adjust the content and speed of learning based on student performance; *Knewton*, which uses AI to analyze student performance and adapt learning content and activities to individual needs; and the ALEKS (*Assessment and Learning in Knowledge Spaces*) platform, another example of an adaptive learning system based on AI.

Briefly, AI systems used to develop adaptive learning programs are reshaping the way students learn and interact with educational content. These platforms and applications provide personalized instruction, enabling students to reach their maximum learning potential.

The adoption of AI in postgraduate courses in Mathematics Education has intensified, bringing benefits to both students and educators. As already indicated, one of the ways in which AI is being used in postgraduate courses in Mathematics Education is through the development of intelligent tutoring systems and virtual mathematics learning environments. Such systems can provide students with personalized and adaptive learning opportunities, adjusting to their specific needs and encouraging a deep understanding of mathematical concepts (Woolf, 2009).

In the current scenario, Chat GPT is one of the most recent and sophisticated Artificial Intelligence (AI) tools developed by OpenAI, demonstrating the ability to perform various tasks efficiently. The term "Chat GPT" designates an AI-based language model that is employed to generate text and perform natural language processing tasks. "GPT" is the acronym for "*Generative Pre-trained Transformer*", which describes the architecture and training technique employed to create these language models.

In the current scenario, where we witness an almost incessant incorporation of Artificial Intelligence (AI) technologies in almost all spheres of society, it is crucial to investigate the challenges and emerging opportunities for the use of this tool in the field of research in mathematics education.

Such a domain, characterized by a deep need for personalization and adaptation, can benefit significantly from the progress made by AI. Therefore, in this article, we ask ourselves: "How is it possible to implement the responsible use of Chat GPT as a tool to support research in mathematics education, taking into account its challenges and opportunities?" To this end, we aim to: Identify the main challenges and opportunities associated with using Chat GPT as a tool to support research in mathematics education.

A Historical Analysis of the Advances and Impacts of Artificial Intelligence in Research in Mathematics Education

The history of technologies is a fascinating exploration that stretches from the earliest tools and inventions of antiquity to the contemporary advent of Artificial Intelligence (AI). We begin with the Neolithic revolution, when the first agricultural societies designed rudimentary stone and wooden instruments to assist in their daily tasks. We proceed to classical antiquity, where innovative technologies such as the Roman aqueduct and the Chinese printing press

emerged.

The contemporary era, however, was a period marked by accelerated and constant innovation. The Industrial Revolution of the 18th and 19th centuries introduced steam machinery and mass production, transforming global economies and societies (Moll, 2021). The invention of electricity in the 19th century paved the way for a series of new technologies, including electric light, the telegraph, and eventually the telephone.

In the 20th century, the creation of digital computers represented a milestone in the technological trajectory. The first computers were gigantic machines, used mainly for military and scientific purposes, but the invention of integrated circuits and microprocessors in the 1960s allowed the miniaturization of computers and their dissemination for domestic and commercial use (Belusso; Peruchin, 2018).

With the spread of the Internet in the 1990s, the world became increasingly interconnected, ushering in a new era of digital information and communication. These technological advances have generated a vast amount of data, which in turn has driven the development of algorithms and machine learning techniques. It is in this context that Artificial Intelligence comes into play. Based on machine learning algorithms, AI has the ability to learn from data, make predictions and make decisions.

AI is currently present in a wide range of applications, from virtual assistants on *smartphones* to autonomous vehicles and advanced medical diagnostics. It represents the culmination of thousands of years of technological progress and continues to open new horizons for future innovations, including educational environments, such as research in Mathematics Education.

Artificial Intelligence (AI) has assumed an increasingly relevant role in research in Mathematics Education over the years. From the advent of the first educational *software* to the latest innovations in AI, technology has been a strategic partner in promoting new methods and approaches in mathematics teaching and research.

The first steps towards the integration of AI in Mathematics Education occurred with the emergence of personal computers and educational *software* in the 1980s. These programs enabled the exploration of mathematical concepts in an interactive and visual way, encouraging students to develop problem-solving skills and understanding abstract concepts (Ellington, 2003; Belusso; Peruchin, 2018).

According to Ellington (2003), as time passed, AI evolved and began to be incorporated into portable devices, such as graphing calculators. These calculators provided students with

tools to solve complex problems and visualize mathematical functions in a more intuitive way. This evolution has brought new opportunities for research in Mathematics Education, allowing researchers to investigate the impacts of these tools on learning and teaching mathematics.

The development of the internet and online learning platforms also represented a significant milestone in research in Mathematics Education. With increased connectivity and access to *online* resources, researchers began to investigate how interaction and collaboration in virtual environments could impact mathematics learning (Sutherland *et al.*, 2004). In addition, online learning platforms have provided access to a variety of interactive resources and activities, providing new opportunities for research in Mathematics Education.

Currently, AI and adaptive learning systems are playing an increasingly important role in Mathematics Education (Woolf, 2009). These AI tools have been employed to create programs that adapt to individual students' needs, providing personalized instruction and allowing researchers to investigate new approaches and methodologies in teaching and learning mathematics.

In Brazil, the implementation and study of Artificial Intelligence (AI) in Mathematics Education has not yet been established as a specific field of study. This finding highlights a significant gap in the country's educational research, especially considering the continuous advancement of AI and its multiple applications in various areas, including education.

Currently, the closest field that addresses, in some way, the intersection between technology and education is Digital Information and Communication Technologies (TDICs) in Education. This field of study focuses on the exploration and implementation of various digital technologies, such as the internet, mobile devices and educational *software*, to improve and transform educational practices.

Although TDICs in education involve the use of technology to facilitate and improve teaching and learning, they do not specifically focus on AI. However, given the ever-evolving nature of TDICs and the revolutionary potential of AI, it is reasonable to predict that AI may soon become a focus of study within the broader field of TDICs in education.

TDICs have played an increasingly important role in Brazilian society, impacting various aspects of everyday life, including work, communication, entertainment and education. In the field of education, TDICs are transforming the way teachers and students interact and learn, providing new opportunities and challenges. A survey carried out for this article (table 01) shows ten relevant research studies published between 2017 and 2022, which explore the use of TDICs in Mathematics Education:

Table 1 – Table title Publications between 2017 and 2022, which explore the use of TDICs in mathematics education

AUTHORS	RESEARCH SUMMARY
SR Binti Ahmad Bakri, S. -E. Ling, NH Binti Julaihi, C.-Y. Liew and S. -C. Ling (2017).	Explores the application of mobile applications to improve pass rates in mathematics courses at higher education institutions. Using a qualitative approach, the study analyzed final exam reports from seven consecutive semesters and collected data from mathematics teachers at Universiti Teknologi MARA, at Sarawak Branch.
Soares, FR, Santana, JR, & Santos, MJC dos. (2022).	The authors investigated Augmented Reality (AR) as a pedagogical strategy for learning Spatial Geometry, using the GeoGebra software and the Fedathi Sequence (SF). The qualitative exploratory research analyzed virtual training meetings and concluded that AR and GeoGebra engage students and support the teaching of Spatial Geometry;
Webber, C., De Cesaro, C., Guder, D., Flores, D., & Becker, J. (2022).	The authors investigated teacher training and the integration of computational thinking and artificial intelligence in education. They analyzed the use of the App Inventor environment in planning teaching sequences.
Powers, J., & Azhar, M. (2020).	Covers an introductory computational thinking (CT) lesson applied to 88 students at an American university. The activity involved the basic design of robots in different course formats. Collaboration between education faculty and a computer science professor generated discussions about integrating CT into teacher training.
Videla, R.; Rossel, S.; Muñoz, C.; Aguayo, C. (2022).	Analyzes the implementation of the mathematics curriculum by elementary school teachers in Chile during the COVID-19 pandemic, focusing on teaching strategies and educational resources. The results reveal relationships between technical knowledge, experience and adopted strategies, as well as differences between rural and urban educators.
Ma, J. (2021).	The study applies the neural network algorithm to data mining of educational resources and presents new ideas for the intelligent development of teaching evaluation. The Apriori algorithm is modified based on the decision tree and applied to the analysis of correlations between teaching evaluation results and factors such as age, gender, professional title and academic qualification. The results indicate that the Apriori algorithm and the DEA-BP algorithm extract laws and potential knowledge from teaching evaluation data, offering decision support and promoting the intelligent development of decision-making systems.
Bayerl Cesana, V., Dalbó Durães, F., & Cezar Cardoso, V. (2022)	It presents a literature review on the use of WhatsApp in the interaction between mathematics teachers and students during teaching and learning in the period from 2019 to 2020, addressing the influence of the COVID-19 pandemic. The results indicate that mobile technologies help in learning mathematics and WhatsApp promotes collaborative environments, bringing teachers and students closer together.
Parreira, A., Lehmann, L., & Oliveira, M. (2021).	investigates teachers' perceptions of the impact of first- and second-generation technologies, including artificial intelligence, on teaching. Through questionnaires, the research seeks to understand how teachers see and deal with the challenges of these innovations in education.

Source: Prepared by the authors

The research mentioned above addresses the use of TDICs in Mathematics Education. This research explored a variety of aspects, such as the use of mobile applications, augmented reality, *geocaching*, interactive videos, artificial intelligence, and communication platforms. Such studies share the ideal of improving the quality of teaching and students' learning experience and identifying effective and innovative strategies for Mathematics Education.

These studies cover diverse educational contexts, from elementary school to higher education, and investigate the impact of TDICs on specific skills, such as proportional reasoning, understanding geometric concepts, and learning algebra. They also consider the implications of these technologies for student engagement and motivation, as well as promoting collaborative learning.

Some research focuses on specific contexts, such as teaching in rural schools and the use of technologies during the COVID-19 pandemic, highlighting the role of TDICs as support tools in challenging situations. Other studies, on the other hand, analyze trends, critical points, and future perspectives in the field of artificial intelligence applied to mathematics teaching.

Overall, studies indicate that the use of TDICs in Mathematics Education can bring significant benefits, such as improvements in academic performance, increased involvement and motivation, and greater understanding of mathematical concepts. However, it is also crucial to consider the challenges associated with implementing these technologies, such as the need for adequate training for teachers and issues related to equity in access to technologies.

Materials and methods

This article aligns with the qualitative research approach, as established by Bogdan and Biklen (1994). This approach assumes that the data is generated directly from the source, with the researcher being the main agent of its generation. In other words, the researcher's direct contact with the researched individual, the context, the environment, among other factors, are valued from the researcher's direct and introspective perspective, given that “human behavior is considerably influenced by the context” (Bogdan; Biklen, 1994, p. 48, our translation).

As explained by Bogdan and Biklen (1994), the qualitative researcher uses several instruments to produce research data, this demonstrates the breadth of research possibilities that arise within the scope of qualitative research. In this sense, the instrument adopted to construct the data for this research was the semi-structured interview.

Regarding data analysis, this was carried out using Discursive Textual Analysis (DTA), according to the method proposed by Moraes and Galiuzzi (2007), as it is the one that most adequately provides a more detailed analysis of the object of investigation. Discursive Textual Analysis is characterized as an exercise in producing metatexts, derived from a set of texts (Gonçalves *et al.*, 2020).

In this process, category structures are constructed which, when converted into texts, provide descriptions and interpretations capable of highlighting new ways of understanding the

investigated phenomena (Moraes; Galiazzi, 2007, p. 89). ATD consists of a methodology distributed in four stages - deconstruction and unitarization, categorization, emerging new, self-organized process - of great depth, demanding meticulous attention from the researcher when going through each stage of this process. This enables a better understanding of information that could rarely be revealed through other methodologies.

Generative's main challenges and opportunities Pre-trained Transformer (GPT) to mathematics education research

Chat GPT is a technology designed by OpenAI, an artificial intelligence research institution, created in December 2015 by a group of renowned experts such as Elon Musk, Sam Altman, Greg Brockman, Ilya Sutskever, John Schulman and Wojciech Zaremba, among others. GPT Chat is anchored in the GPT (*Generative Pre-trained Transformer*), which consists of a lineage of linguistic models that are trained using voluminous amounts of text, being capable of producing congruent and pertinent answers to a varied range of questions and themes. GPT-3, to illustrate, represents the third generation of this architecture and has achieved notoriety due to its remarkable performance and ability to generate high quality texts.

This term has the following meanings:

- i-"Generative" refers to the model's ability to design new texts based on the textual corpus used in its training.
- ii - " Pre -trained" alludes to the fact that the model was previously trained with an extensive data set before being calibrated for specific tasks.
- iii - "Transformer" is a neural network architecture that serves as the foundation for the model, enabling parallel processing and selective focusing on relevant parts of the text.

Chat GPT is an innovative and powerful resource that may be relevant in the field of research in Mathematics Education. However, it is essential to remain vigilant regarding the risks associated with its use and adopt precautionary measures to minimize them. Researchers must ensure the preservation of their capacity for critical reflection and development of autonomous solutions, ensure the protection of privacy and data security, in addition to being aware of issues of bias and lack of transparency in AI. Furthermore, it is crucial to foster academic integrity, preventing plagiarism and ensuring complete understanding of the solutions suggested by Chat GPT.

Below, we have chosen some of *Generative 's main challenges Pre-trained Transformer (GPT) to mathematics education research*, based on GPT Chat responses. To do so, we access

the OpenAI platform, available at: <https://www.openai.com/> we register for GPT-4 Chat and pay for a PLUS subscription. Then, after familiarizing ourselves with the platform's tools, we interviewed directly with **IA-Chat GPT-4**. The interview data will be described below:

Researcher: What is GPT Chat and how does it work?

IA- GPT-4 Chat:



ChatGPT é um modelo de linguagem avançado, treinado pela OpenAI, que utiliza um processo chamado aprendizado de máquina para entender e gerar texto humano. Funciona com base na arquitetura GPT (Generative Pretrained Transformer), na qual o modelo é treinado com uma grande quantidade de dados textuais, aprendendo a prever a próxima palavra em uma frase, dada a sequência de palavras anterior. Ao processar trilhões de palavras, o ChatGPT aprende gramática, fatos sobre o mundo, e até mesmo alguns estilos de escrita, embora não seja perfeito e possa cometer erros. Importante lembrar que o modelo tem um conhecimento limitado até uma data de corte, no meu caso, setembro de 2021, o que significa que ele não está ciente de eventos no mundo real ocorridos após essa data.

The intelligent platform, designated as ChatGPT-4, identifies itself as a linguistic model based on Artificial Intelligence, establishing its respective operational processes and the boundaries of its operation. In view of this, researchers Urretavizcaya and Onaindía (2002) highlight the plurality of relevant aspects to be explored regarding the teaching of Artificial Intelligence. Urretavizcaya and Onaindía (2002) emphasize the relevance of employing AI tools, such as ChatGPT, in domains not typically associated with computer science, such as mathematics. This proposition is corroborated by the ability displayed by ChatGPT in understanding and generating texts, thus demonstrating the potential to assist in the instruction of mathematical concepts.

Additionally, Urretavizcaya and Onaindía (2002) propose the idea of establishing a type of "supply and demand market" with regard to specialized subjects and teachers. This concept aligns with ChatGPT's ability to provide scalable educational support, potentially expanding access to specialized mentors. This premise also suggests the feasibility of using ChatGPT in a wide range of instructional scenarios, such as videoconferences or in-person classes.

Nevertheless, it is imperative to consider the limitation of ChatGPT, as its knowledge pool is restricted to a specific date. This aspect reiterates the need for permanent and updated learning, as elucidated by Urretavizcaya and Onaindía (2002). This limitation also emphasizes the relevance of the presence of human educators in the instructional process, providing personalized and adaptive guidance, in addition to being up to date with the latest innovations in their respective areas of specialization.

Researcher: Do you consider yourself relevant in research in mathematics education?

IA- Chat GPT-4:



Sim, o ChatGPT pode ser uma ferramenta valiosa na educação matemática. Como um modelo de linguagem de alta capacidade, pode auxiliar na explicação de conceitos matemáticos complexos, oferecer ajuda com problemas matemáticos e até mesmo gerar problemas de prática. Além disso, o ChatGPT pode fornecer feedback imediato, facilitando o aprendizado autodirigido e o estudo individual. No entanto, é importante lembrar que, enquanto o modelo pode ser um recurso educacional útil, ele não substitui o valor inestimável de um professor humano qualificado e experiente, que pode fornecer orientação personalizada e adaptativa.

Researcher: What are the main technical and pedagogical challenges of using it in mathematics education research?

IA- Chat GPT-4:



Os principais desafios técnicos do uso do ChatGPT na educação matemática incluem o fato de que, embora seja capaz de entender e gerar texto, o modelo pode lutar com problemas matemáticos complexos que exigem um entendimento profundo e abstrato ou a visualização de conceitos. Além disso, o modelo pode gerar respostas imprecisas ou incorretas, pois não tem uma compreensão contextual do mundo como um humano. Pedagogicamente, a principal preocupação é que a dependência excessiva de ferramentas de IA pode resultar em falta de desenvolvimento de habilidades de pensamento crítico e resolução de problemas em estudantes. Além disso, o ChatGPT não é capaz de entender a linguagem não-verbal ou a emoção do estudante, que são elementos-chave na educação presencial. Portanto, o uso do ChatGPT na educação matemática deve ser complementar a outras abordagens pedagógicas e não um substituto para elas.

Artificial intelligence addresses the importance of ChatGPT in the context of mathematics education, highlighting its competence in helping to elucidate complex concepts, providing assistance with mathematical challenges and generating practical questions. This opinion emphasizes the potential value of this tool, however it recognizes that AI is not capable of replacing a qualified human educator. This thoughtful analysis reinforces the need to integrate ChatGPT as a complement to the teacher, not a replacement. However, the effectiveness of this implementation lies in the incessant development of AI to expand its ability to provide quality instructional support.

In the third manifestation, artificial intelligence addresses the technical and pedagogical challenges regarding the use of ChatGPT in mathematics education. In technical terms, the challenges focus on the model's limited ability to deal with complex mathematical problems, while the pedagogical challenges are related to the excessive dependence on AI tools and the lack of critical thinking skills on the part of students.

This statement offers a more considered view on the use of ChatGPT in mathematics

education, remembering that the successful implementation of such tools demands careful consideration of their possible negative impacts. In short, these manifestations suggest that, although ChatGPT has the potential to improve mathematics education, its use must be managed judiciously to maximize benefits and minimize risks.

Researcher: How can the contextual understanding and knowledge limitations of Chat GPT affect its effectiveness in Mathematics Education?

IA- Chat GPT-4:



A falta de compreensão contextual do ChatGPT pode criar desafios na educação matemática. Por exemplo, ele pode não entender plenamente as nuances ou ambiguidades que podem estar presentes na maneira como um estudante formula uma pergunta. Adicionalmente, seu conhecimento é limitado até a data de corte em 2021, o que significa que quaisquer avanços ou mudanças no campo da educação matemática após essa data não estão dentro de seu escopo. Isso pode levar a respostas desatualizadas ou imprecisas. Além disso, o ChatGPT pode falhar ao explicar conceitos de maneira progressiva e adaptativa ao nível do aluno, já que não pode avaliar o entendimento do aluno ao longo do tempo. Portanto, essas limitações podem afetar a eficácia do ChatGPT como uma ferramenta de ensino de matemática.

Researcher: What are the main risks associated with dependence on technology and bias in the application of Chat GPT in mathematics education?

IA- Chat GPT-4:



A dependência excessiva da tecnologia na educação matemática pode inibir o desenvolvimento de habilidades importantes, como a capacidade de resolver problemas de forma independente e o pensamento crítico. Pode também criar uma lacuna digital entre os alunos que têm acesso a tais recursos e aqueles que não têm. Em relação ao viés, como o ChatGPT é treinado em grandes volumes de texto, ele pode inadvertidamente perpetuar e amplificar vieses presentes nos dados originais. Isso pode se manifestar de várias formas, como a promoção de estereótipos ou a tendência a favorecer certas abordagens de resolução de problemas em detrimento de outras. Além disso, pode haver um risco de privacidade e segurança, pois as perguntas dos alunos sobre problemas de matemática podem ser armazenadas e usadas de maneiras que não são totalmente claras ou transparentes para o usuário.

The concern expressed by artificial intelligence with the challenges inherent to its application in mathematics education is evident, highlighting the limitations of these technologies, such as the lack of contextual understanding and knowledge restricted to the end date of training. Artificial intelligence suggests that these restrictions may compromise the effectiveness of these tools as teaching instruments.

Subsequently, artificial intelligence expands this discussion, elucidating additional concerns, such as the excessive dependence on technology in the scope of mathematics education and the possible impacts of this dependence on the development of critical skills, such as critical thinking and autonomous problem solving. Furthermore, the issue of bias and

student data privacy are also highlighted as potential challenges.

Several authors (Conceição; Chagas, 2020; Urretavizcaya; Onaindía, 2002) advocate the thoughtful and critical use of artificial intelligence to advance the fields of education and scientific research. Urretavizcaya and Onaindía (2002) call on the academic community to encourage discussions about the application of artificial intelligence in education, while Conceição and Chagas (2020) propose that artificial intelligence can be a valuable ally in scientific research.

This denotes the emergence of a continued debate about the benefits and challenges of artificial intelligence in mathematics education. Therefore, it is crucial to navigate this field with caution, seeking strategies to maximize the benefits of AI and simultaneously minimize the possible harms. The conscious integration of artificial intelligence into mathematics education and scientific research can be a crucial part of this strategy.

Researcher: What are the main opportunities and potential benefits of using Chat GPT in research in Mathematics Education?

IA- Chat GPT-4:



O uso do ChatGPT na pesquisa em educação matemática apresenta uma série de oportunidades e benefícios potenciais. Primeiramente, pode proporcionar uma forma acessível e escalável de assistência tutorial, ajudando os estudantes a resolver problemas e a entender conceitos fora do ambiente de sala de aula. Em segundo lugar, pode oferecer oportunidades para aprendizado personalizado, adaptando-se às necessidades individuais do estudante. Além disso, o ChatGPT pode servir como uma ferramenta para a prática de problemas, gerando automaticamente problemas matemáticos para estudo individual. Do ponto de vista da pesquisa, o uso de assistentes de IA como o ChatGPT pode fornecer insights sobre como os alunos interagem com a tecnologia para aprender matemática, abrindo novas avenidas para o estudo de métodos pedagógicos inovadores.

Researcher: How can Chat GPT be used to improve learning and engagement for mathematics education researchers?

IA- Chat GPT-4:



O ChatGPT pode ser uma ferramenta valiosa para melhorar a aprendizagem e o engajamento dos pesquisadores em educação matemática de várias maneiras. Primeiramente, pode ser usado como uma fonte de consulta rápida para conceitos e teorias matemáticas, ajudando os pesquisadores a acessar informações de maneira eficiente. Em segundo lugar, pode facilitar a discussão e a colaboração, simulando diálogos e apresentando diferentes pontos de vista sobre tópicos matemáticos. Além disso, pode ser usado para gerar novas questões de pesquisa, permitindo que os pesquisadores explorem diferentes direções em seus estudos. Finalmente, como uma ferramenta de IA, o ChatGPT também pode fornecer um estudo de caso para os pesquisadores explorarem a interseção de IA e educação matemática, ajudando-os a entender melhor como a tecnologia pode ser usada para melhorar a aprendizagem matemática.

Artificial Intelligence (AI) highlights the remarkable value of ChatGPT in the field of mathematics education. From this perspective, ChatGPT can be used as an instructor, enabling personalized teaching, as well as a resource for immediate consultation of mathematical concepts and theories. Furthermore, it promotes interaction and cooperation between academics and encourages the emergence of new research topics.

However, Borges Neto and Borges (2007) emphasize the lack of pedagogical planning in the computerization of Brazilian educational institutions, highlighting the relevance of a meticulously articulated plan before the integration of digital technology in the educational field. This serves as a warning that AI itself is not the definitive answer, but rather an instrument for improving education. Technology must be amalgamated with clear and well-established pedagogical strategies for it to be effective.

In line with Borges Neto and Borges (2007), we can state that AI can be an influential tool for education. These authors identify digital technology as a vehicle for the dissemination of knowledge, providing specific representations of knowledge, facilitating handling and providing feedback. Additionally, it allows you to monitor student progress remotely.

The essentiality of a pedagogically targeted and meticulously planned implementation of AI in education stands out. This technology holds vast potential to improve research in mathematics education, if properly used. However, it is essential that educators and institutions understand how to optimize the application of these technological tools to support and increase learning. This encompasses training researchers, adapting technology to student demands, and creating dynamic, student-centered learning environments.

Researcher: What are the possible applications of Chat GPT for developing research in mathematics education?

IA- Chat GPT-4:



O ChatGPT pode ter várias aplicações significativas no desenvolvimento de pesquisas na educação matemática. Pode ser usado para analisar e compreender padrões em como os alunos se engajam com problemas matemáticos, com base nas perguntas que eles formulam ao modelo. Também pode servir como um ambiente de teste para pesquisas sobre a eficácia de diferentes abordagens pedagógicas, já que as respostas do modelo podem ser ajustadas e testadas. O ChatGPT também pode ser uma ferramenta para explorar novas maneiras de representar e comunicar conceitos matemáticos, dado que ele pode gerar explicações em linguagem natural. Por fim, o ChatGPT pode ajudar a informar pesquisas sobre a integração da IA na educação matemática, fornecendo insights sobre como os alunos interagem e aprendem com a IA.

Researcher: How do you see future prospects and developments in the use of GPT Chat in mathematics education research?

IA- Chat GPT-4:



As perspectivas futuras para o uso do ChatGPT na pesquisa em educação matemática são bastante promissoras. À medida que a tecnologia de IA avança, podemos esperar melhorias na capacidade do modelo de entender e responder a perguntas matemáticas complexas, tornando-o ainda mais útil como ferramenta de ensino. Também podemos ver mais pesquisas sobre como a IA pode ser integrada de maneira eficaz e ética na educação matemática, abordando questões de viés, privacidade e dependência da tecnologia. Além disso, o ChatGPT e outros assistentes de IA podem se tornar uma parte cada vez mais importante das salas de aula digitais e dos ambientes de aprendizado online, permitindo a aprendizagem personalizada e o acesso a tutoriais em qualquer lugar e a qualquer momento. Com a devida consideração e gestão das suas limitações e desafios, o ChatGPT tem o potencial de ser uma ferramenta valiosa na educação matemática do futuro.

The answers elucidated by the Artificial Intelligence known as Chat GPT-4 during this interview are representative of the most modern technology in natural language processing, potentially applicable to research in the field of mathematics education. GPT-4 Chat demonstrated the possibilities and potential advantages derived from implementing AI in mathematics educational research, emphasizing individualized assistance offered to students, improved access to information, and collaboration among researchers.

When examining the responses, we consider it essential to pay attention to the ethical aspects and dangers related to plagiarism intrinsic to this application. Such concerns must be conducted in parallel with the analysis of the challenges, opportunities and future perspectives already discussed. Ethical dilemmas encompass the conscientious use of GPT Chat, ensuring that researchers are aware of the model's limitations and challenges, including potential biases and inaccuracies. Human supervision is essential to mitigate such risks and to ensure that GPT Chat is used in an ethical and responsible manner.

The threat of plagiarism is another important concern when using GPT Chat in mathematics education research. The model is capable of generating texts from its training, which may result in unwanted similarities with pre-existing sources. To mitigate the risk of plagiarism, it is crucial that researchers verify the originality of work produced by Chat GPT and properly attribute sources when necessary. Furthermore, it is essential that educators instruct students on how to use GPT Chat ethically, as a support tool, and not as a substitute for critical thinking and original research.

In the current scenario, authors such as Gomes, Almeida and Junior (2019) propose an intriguing contemplation about the emerging role of artificial intelligence (AI) in society and the perception of a human desire to generate constructions "superior to ourselves". The authors postulate that the search for AI may be a reflection of a human need to overcome its own limitations, insinuating that what is strictly human is no longer enough. This idea is interconnected with the belief that the salvation of humanity no longer lies in the hands of human beings.

AI technologies must be used as instruments to preserve life and sustain human interests. AI could supplant humans in unhealthy tasks, allowing for the application of science for the benefit of humanity. However, there are domains of knowledge, such as art, philosophy, psychology, science and mathematical education itself, where human presence is irreplaceable (Gomes; Almeida; Junior, 2019).

Simultaneously, Gomes, Almeida and Junior (2019) present a critique of anthropocentrism, arguing that this view could direct humanity towards a self-destructive path. The creation of AI is seen as a response to this human unpredictability and the predatory behaviors associated with anthropocentrism. AI thus represents a reconstruction of possibilities based on the non-human.

In summary, Gomes, Almeida and Junior (2019) invite a reflection on the role of AI in the contemporary world, emphasizing the need to balance its use with understanding the areas where human presence remains fundamental. Furthermore, the authors encourage us to question anthropocentrism and look for new possibilities for coexistence and survival through technology.

The creative potential of Chat GPT in research in Mathematics Education

By analyzing the broad scopes of human language, Chat GPT demonstrates a significant potential for innovation, notably in the field of academic research in Mathematics Education, of which the following stand out:

Personalized Teaching Resources: With the ability to understand and respond to complex requests, GPT Chat can be used to create personalized teaching materials, adapting to students' individual needs, making the teaching of mathematical concepts more accessible and relevant.

Problem Solving Assistance: GPT Chat can serve as a tool to help solve mathematical problems, offering solutions, suggestions or even proposing additional challenges to deepen the student's understanding.

Research Collaboration: Researchers can benefit from Chat GPT as a *brainstorming tool*, helping to formulate hypotheses, suggest methodologies or even review relevant literature (Pereira, 2023). Furthermore, Chat GPT can be integrated into *online teaching platforms*, acting as a virtual tutor, facilitating discussions in forums and providing instant *feedback* on work and projects.

In summary, Chat GPT offers promising opportunities to innovate in Mathematics Education research. However, like any tool, it must be used with discernment and in conjunction with other pedagogical methodologies to maximize its potential while minimizing its limitations.

Final remarks

In this study, the general objective was to identify the main challenges and opportunities associated with using Chat GPT as a tool to support research in mathematics education. However, when analyzing the answers provided by the Artificial Intelligence called Chat GPT-4, we took into account not only the challenges and opportunities, but also the ethical aspects and the danger of plagiarism. We conclude that, to maximize the applicability of Chat GPT in mathematics education, it is imperative that users are aware of these concerns and implement measures to ensure the ethical and responsible use of this technology.

We recognize that artificial intelligence has evolved dramatically in recent years, presenting opportunities and challenges in multiple domains, including mathematics education. Chat GPT is a promising tool with the capacity to assist researchers and educators, but its

conscious use requires a careful analysis of its challenges and opportunities.

It is crucial that researchers and educators are aware of the limitations and challenges of Chat GPT, including limited contextual understanding, potential biases, and ethical and privacy concerns. Training users in relation to the responsible and ethical use of Chat GPT is essential to ensure that the tool is used appropriately and complementary to the research and teaching process.

Furthermore, the conscious use of GPT Chat in mathematics education research implies human supervision and integration with other research methodologies. This includes checking the quality and originality of the information produced by the model, as well as balancing the use of technology and traditional pedagogical approaches.

We also consider that, to make the most of Chat GPT's potential in mathematics education, it is important to adapt the model to the specific needs of students and researchers. This may involve training and refining the model based on specific educational contexts, improving Chat GPT's ability to provide personalized and effective support.

In general terms, responsible use of Chat GPT must also address issues of equity and inclusion. This means ensuring that all students have access to technology and can benefit from its potential, regardless of their socioeconomic background or specific skills. Therefore, this article has demonstrated that Chat GPT offers significant opportunities to improve research and teaching in mathematics education.

However, it is critical to proactively address its challenges and limitations to ensure its responsible and ethical use. By promoting user awareness and empowerment, ensuring human oversight, adapting the model to specific needs, protecting data and privacy, and promoting equity and inclusion, we can maximize Chat GPT's potential as a valuable tool supporting research in mathematics education.

REFERENCES

- ALEKS. **Assessment and Learning in Knowledge Spaces**. Available at: <https://www.aleks.com/>, 2023. Access: 02 Dec. 2022.
- BAKRI, S. R. B. A.; LING, S.-E.; JULAIHI, N. H. B.; LIEW, C.-Y.; LING, S.-C. Improving low passing rate in mathematics course at higher learning education: Problem identification and strategies towards development of mobile app. *In: International Conference on Computer and Drone Applications (IConDA)*, 2017. **Proceedings** [...]. Kuching, Malaysia, 2017. p. 77-81. DOI: 10.1109/ICONDA.2017.8270403.
- BAYERL, C. V.; DALBÓ, D. F.; CARDOSO, C. V. Investigações sobre o whatsapp nos processos de ensino e de aprendizagem: refletindo sobre o uso das tecnologias digitais durante a pandemia da COVID-19. Kiri-kerê: **Pesquisa em Ensino**, [S. l.], n. 12, 2022. DOI: 10.47456/krkr.v1i12.37087.
- BELUSSO, R.; PERUCHIN, D. Modificações no processo de aprendizagem com a inserção de tecnologias digitais na educação. #Tear: **Revista de Educação, Ciência e Tecnologia**, Canoas, v. 7, n. 1, p. 1-17, 2018. DOI: 10.35819/tear.v7.n1.a2701.
- BOGDAN, R. C.; BIKLEN, S. K. **Investigação qualitativa em educação**. Porto Codex. Portugal: Porto Editora, 1994.
- BOJARSKI, M.; DEL TESTA, D.; DWORAKOWSKI, D.; FIRNER, B.; FLEPP, B.; GOYAL, P.; JACKEL, L. D.; MONFORT, M.; MULLER, U.; ZHANG, J.; ZHANG, X.; ZHAO, J.; ZIEBA, K. **End to end learning for self-driving cars**. 2016. Available at: <https://arxiv.org/abs/1604.07316>. Access: 23 Apr. 2023.
- BORGES NETO, H.; BORGES, S. M. C. As tecnologias digitais no desenvolvimento do raciocínio lógico. **Linhas Críticas**, [S. l.], v. 13, n. 24, p. 77-88, 2007. DOI: 10.26512/lc.v13i24.3344.
- DREAMBox Learning. **DreamBox Learning Math**. 2023. Available at: <https://www.dreambox.com/>. Access: 10 Dec. 2023.
- ELLINGTON, A. J. A Meta-Analysis of the Effects of Calculators on Students' Achievement and Attitude Levels in Precollege Mathematics Classes. **Journal for Research in Mathematics Education**, [S. l.], v. 34, n. 5, p. 433-463, 2003. DOI: 10.2307/30034795.
- GONÇALVES, T. V.; LEBREGO, R.; BARREIRA, J.; SIQUEIRA, I. Instrucciones de enseñanza expresadas por profesores de ciencias en cartas a sus alumnos. **Campo Abierto. Revista De Educación**, [S. l.], v. 39, n. 2, p. 207-219, 2020.
- KNEWTON. **Adaptive Learning Platform**, 2023. Available at: <https://www.knewton.com/>. Access: 23 Apr. 2023.
- KOEDINGER, K. R.; ANDERSON, J. R.; HADLEY, W. H.; MARK, M. A. Intelligent tutoring goes to school in the big city. **International Journal of Artificial Intelligence in Education**, [S. l.], v. 8, p. 30-43, 1997.

MA, J. Intelligent Decision System of Higher Educational Resource Data under Artificial Intelligence Technology. **International Journal of Emerging Technologies in Learning (iJET)**, [S. l.], v. 16, n. 5, p. 130–146, 2021. DOI: 10.3991/ijet.v16i05.20305.

MOLL, I. The Myth of the Fourth Industrial Revolution: Implications for Teacher Education. In: MARINGE, F. (ed.). **Higher Education in the Melting Pot: Emerging Discourses of the 4IR and Decolonisation**. Cape Town: Aosis, 2021. p. 91–110.

MORAES, R.; GALIAZZI, M. C do. **Análise Textual Discursiva**. Ijuí, RS: Unijuí, 2007.

PARREIRA, A.; LEHMANN, L.; OLIVEIRA, M. O desafio das tecnologias de inteligência artificial na Educação: percepção e avaliação dos professores. **Ensaio: Avaliação e Políticas Públicas em Educação**, [S. l.], v. 29, n. 113, p. 975-999, 2021. DOI: 10.1590/S0104-40362020002803115.

PEREIRA, J. **A Inteligência Artificial e o Processo Educacional: desafios e possibilidades na era do ChatGPT**. Pelotas: Rubra Cinematográfica, 2023.

POWERS, J.; AZHAR, M. Preparing Teachers to Engage Students in Computational Thinking through an Introductory Robot Design Activity. **Journal of Computers in Mathematics and Science Teaching**, [S. l.], v. 39, n. 1, p. 49-70, 2020. Available at: <https://www.learntechlib.org/p/213891>. Access: 10 Apr. 2023.

SHUTE, V. J.; RAHIMI, S. Review of computer-based assessment for learning in elementary and secondary education. **Journal of Computer Assisted Learning**, [S. l.], v. 33, n. 1, 2017.

SOARES, F. R.; SANTANA, J. R.; SANTOS, M. J. C. dos. A realidade aumentada na aprendizagem de Geometria Espacial e as contribuições da Sequência Fedathi. **Revista de ensino de ciências e matemática**, [S. l.], v. 13, n. 4, 2022. DOI: 10.26843/rencima.v13n4a11.

VIDELA, R.; ROSSEL, S.; MUÑOZ, C.; AGUAYO, C. Online Mathematics Education during the COVID-19 Pandemic: Didactic Strategies, Educational Resources, and Educational Contexts. **Educ. Sci.**, [S. l.], p.12, 2022. DOI: 10.3390/educsci12070492.

WEBBER, C.; CESARO, C.; GUDER, D.; FLORES, D.; BECKER, J. Experiências do pensamento computacional no ensino de ciências e matemática. **Revista Brasileira De Ensino De Ciências E Matemática**, v. 5, n. esp., p. 120-134, 2022. DOI: 10.5335/rbecm.v5iespecial.12853.

WOOLF, B. P. **Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning**. [S. l.]: Morgan Kaufmann, 2009. DOI: 10.1016/B978-0-12-373594-2.X0001-9.

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