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Research on the Possibility and Path of Artificial Intelligence for the Development of Mathematics Education

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Abstract. The rapid development of artificial intelligence (AI) is profoundly transforming the field of education, presenting unprecedented opportunities and challenges for mathematics education. Currently, the role of AI in promoting educational development has attracted widespread attention. However, existing literature mostly focuses on the macro-level discussions of AI in education, with relatively insufficient in-depth exploration of specific disciplines. This paper focuses on mathematics as a specific discipline, exploring how AI technology can empower mathematics education, systematically analyzing its potential possibilities and possible challenges, and exploring feasible implementation paths. The research finds that the core value of AI in mathematics education is significantly reflected in the precise customization of personalized learning paths and the deep innovation of teaching models. However, its wide application also faces key challenges such as the maturity of technology, the insufficient AI literacy of teachers, and data privacy and ethical risks. Based on in-depth analysis, this study proposes that the core path for the deep integration of AI and mathematics education requires technological iteration, the upgrading of teachers' educational concepts, and the construction of a teacher-student-AI collaborative classroom.

Keywords: Artificial intelligence, mathematics education, path

1. Introduction

In the 21st century, artificial intelligence (AI) has entered a new era of rapid development. New-generation AI software such as DeepSeek and ChatGPT have gradually come into the public eye, providing convenience for human life. The application scenarios of artificial intelligence are constantly expanding and gradually penetrating into various fields such as healthcare, education, and finance. For education, AI facilitating educational transformation has become a global trend in educational development. In 2025, China officially released the "White Paper on Artificial Intelligence Education", marking that China's education has officially entered a new era of deep empowerment by AI. As a fundamental discipline, mathematics is highly abstract, which has long led to problems such as low teaching efficiency, insufficient personalization, and weak innovation cultivation. Under the traditional teaching mode, teaching efficiency and students' individualized demands are easily restricted. Therefore, the rational application of artificial intelligence in teaching can not only provide assistance and reference for mathematics educators, but also promote the

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improvement of the quality and efficiency of mathematics education. Most existing research tends to focus on the macro-level exploration of AI in the field of education. For instance, taking ChatGPT as an example, the role and implications of artificial intelligence in education are studied. Artificial intelligence promotes the development of teaching towards greater efficiency, flexibility, and inclusiveness by enhancing efficiency, enriching resources, and achieving personalized teaching. Its core value lies in liberating teachers' creativity, stimulating students' autonomy, and providing technical support for educational equity [1]. For instance, artificial intelligence endows schools with educational value by developing vertical large educational models and constructing a "teacher-machine-student" trinity collaborative classroom model [2]. However, existing research has relatively focused on specific disciplines. This article, targeting a particular mathematics discipline, aims to explore the possibilities of AI in mathematics education and the key paths to drive its development.

2. Exploration of the possibility of artificial intelligence empowering mathematics education

2.1. Reshape the personalized learning experience

In the field of mathematics education, which is characterized by abstraction, complexity, and diversity, analyzing students' learning data through technology, conducting behavior prediction, learning recommendation, and creating an intelligent learning environment to build a personalized learning system is conducive to responding to the concept that a strong educational country should integrate personalized learning [3]. At the same time, the personalized learning system of artificial intelligence also plays a crucial role in reducing math anxiety by providing students with the emotional and cognitive resources needed to regulate and balance the challenges of learning mathematics [4]. In the past, traditional mathematics teaching, it difficult for teachers to provide personalized learning services based on each student's learning characteristics. At the same time, providing personalized learning also greatly increased the workload of teachers. Nowadays, artificial intelligence can precisely grasp the learning characteristics of students and has the potential to provide personalized learning experiences for them. For instance, it is possible to conduct a personalized analysis of students' academic performance curves, accurately identify their weak points in learning and learning behavior patterns, summarize the wrong answers, and provide targeted exercises that precisely match the students' levels, enabling them to draw inferences by analogy and create personalized wrong answer books. Provide personalized learning suggestions to help teachers dynamically adjust the difficulty of teaching content and the pace of teaching based on students' learning habits and progress, so as to meet the needs of different students. This will enhance classroom efficiency and achieve teaching based on individual aptitude.

2.2. Innovate teaching models

Artificial intelligence technology is gradually revolutionizing the model of mathematics education. Previous studies have shown that in higher vocational classrooms, virtual reality technology is utilized to break the teaching time and space boundaries of traditional classrooms. High-cost and high-risk practical training projects that cannot be achieved in traditional teaching are designed and made into virtual reality courseware and embedded in classroom teaching, helping teachers break free from the limitations of traditional lecture-based classrooms [5]. The specific manifestation in middle school mathematics education is to visualize abstract mathematical objects (such as three-dimensional solid geometry, surface equations, and probability distributions) and deepen

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understanding through dynamic demonstrations. For instance, when teachers explain the geometric meaning of an ellipse definition (where the sum of the distances to two fixed points is a constant value), they can use the dynamic geometry software GeoGebra (a lightweight AR) to generate a dynamic graph, more vividly demonstrating that the sum of the distances to two fixed points remains constant. Or have students drag two focal points to observe the changes in the shape of the ellipse, providing an intuitive scene for the concept of focal points and eliminating the conceptual abstraction caused by drawing static ellipses on the blackboard in the traditional teaching mode.

With the deep integration of artificial intelligence and education, the teaching model can also accelerate the transformation from the original "teacher-student" dual teaching structure to a "teacher-student - machine" ternary structure, where teachers, students, and artificial intelligence machines form a new interactive network. Teachers are no longer traditional transmitters but have transformed into guides who utilize advanced artificial intelligence technology for innovative learning and practice [2]. Artificial intelligence has brought about a structural transformation in the roles of teachers and students. On the one hand, the role of teachers has shifted from "knowledge transmitters" to "learning guides", with AI taking on mechanical tasks and freeing up teachers' energy to focus on the cultivation of higher order thinking in teaching. On the other hand, students' subjectivity has been enhanced, and AI-assisted autonomous learning systems have improved students' mathematical inquiry abilities [6].

3. The main problems and challenges currently faced

3.1. Technical limitations

When AI models (such as ChatGPT) handle mathematical problems, their outputs may contain hidden conceptual biases, logical breaks, or factual errors. This limitation stems from the model's tendency to confuse abstract mathematical objects and its loss of rigor in complex reasoning. When AI is asked to correct mathematical errors, it is prone to limited optimization, with core errors not being resolved, and it is easy to generate some contradictory steps, thereby misleading students. Sometimes, definitions and properties are even fabricated. When conditions are missing (such as when the expected variance is not given), parameters (default normal distribution) are forcibly assumed for calculation, thereby providing students and teachers with seemingly reasonable but incorrect knowledge. These deficiencies will hinder AI-assisted education and pose a risk to mathematics education [7]. In addition, algorithmic bias may also lead to distorted resource allocation, thereby exacerbating educational inequality [8].

3.2. Data security and privacy risks

Effective assistance with AI in mathematics education is highly dependent on the collection and analysis of data in the learning process. However, the widespread lack of digital literacy among students when using AI tools significantly magnifies the risks of data security and privacy. To deeply analyze problem-solving strategies and accurately identify learning obstacles, AI systems need to collect detailed process data far exceeding the final answers. This typically includes draft problem-solving steps input by students, interactive records of geometric drawing, intermediate derivations of algebraic operations, as well as explanatory text descriptions or voice inputs for specific concepts such as limits and vector Spaces. These data directly depict the unique thinking paths, cognitive habits, and even common error patterns of individual students. Students have weak cognitive and operational skills in data collection, and there are problems of excessive authorization and blind

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trust. They may easily authorize and agree to privacy terms without fully understanding how data is stored and utilized and lack vigilance against the exposure of sensitive information. In addition, students may also neglect privacy Settings and unconsciously input sensitive information. Once leaked or misused, the harm far exceeds that of a general learning record leak [4].

3.3. Limitations of teachers' digital teaching thinking

In the era of artificial intelligence, the integration of technology and teaching has become a trend. However, nowadays, many mathematics teachers have outdated teaching methods and conservative thinking. Their knowledge of artificial intelligence is only at a superficial level, and they are unable to integrate AI into the development of mathematics teaching. Even the knowledge and skills related to artificial intelligence in mathematics education are in a state of deficiency. This will make it difficult to stimulate students' interest and enthusiasm in learning mathematics. Because teachers unidirectionalize digital resources to students, technology is merely used as the "digital packaging" of traditional teaching, without reconstructing the teaching logic and applying standardized solutions. There is a lack of mechanisms to guide students in planning their learning paths, which leads to the suppression of students' divergent thinking, passive acceptance of knowledge, and difficulty in forming self-discipline habits [9].

4. The core path for promoting the integration of AI into mathematics education

4.1. Technical empirical evidence

The integration of AI into mathematics education is addressing the deep-seated pain points of mathematics education on a global scale. AI mathematics education tools should achieve the popularization of basic skills and promote the precision of higher-order thinking. Its technical effectiveness has been put into practice both at home and abroad, rather than being theoretically assumed. Some scholars abroad have demonstrated through experiments in Ghana that AI math tutoring tools (such as Rori) based on chatbot technology (LLM/NLP) and running on basic mobile devices can effectively, cost-effectively, and on a large scale improve students' math learning outcomes in resource-limited environments [10]. Domestic universities have also actively carried out practices in AI intelligent evaluation and real-time feedback. Take the exploration of Professor Wang Qingxian's team from the University of Electronic Science and Technology of China in the "Discrete Mathematics" course as an example. The team directly faced the core challenges of the course being "difficult to teach and difficult to learn" (such as abstract content and delayed feedback on assignments leading to the failure of filling in the gaps), and began to develop an AI teaching platform in 2018. The core breakthrough lies in the use of AI technology to intelligently correct students' handwritten homework, especially abstract question types such as propositional logic proofs. This application has completely addressed the pain points of traditional manual correction, such as long cycles and significantly reduced feedback value. It enables immediate correction and feedback of homework, greatly enhancing teachers' work efficiency [11]. The AI teaching platform should focus on helping students overcome the difficulties in learning mathematics. It should address the key pain points in the "practice - feedback - correction" closed loop in mathematics learning (such as the difficulty in evaluating abstract reasoning processes and feedback lag leading to learning disconnection), and prioritize the development of intelligent marking and feedback systems that can understand the mathematical reasoning process (especially logical proofs, complex operations, etc.).

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4.2. Address teachers' cognitive limitations

The integration of "artificial intelligence+education" has infused new connotations into mathematics education, gradually integrating new resources and tools such as micro-lessons and intelligent teaching platforms into teaching. However, problems such as the abuse and alienation of technology have also become prominent. To overcome these challenges, the development of mathematics education urgently needs to enhance teachers' adaptability to digital literacy and achieve the mutual growth of "technology and teachers".

Even in the context of powerful AI collaboration, the role of human teachers remains irreplaceable. Mathematics teachers need to recognize that technology is a tool serving people, not a panacea. Understanding the dual nature of AI technology in mathematics teaching (such as enhancing teaching efficiency and visualization ability, and restricting students' creative thinking) is a prerequisite for its reasonable application. The core of digital literacy lies in the safe and appropriate use of digital technologies to access, manage, understand, integrate, communicate, evaluate, and create information. Teachers should focus on enhancing their adaptability to digital literacy. In the era of artificial intelligence, mathematics teachers should recognize and master intelligent teaching tools (such as Geometer's Sketchpad, dynamic mathematics software, and AI problem-solving guidance systems) proficiently, and be clear that technology serves teaching goals and educational values, without abusing it. Make full use of technology to enhance the inspiration of mathematics teaching and help students understand' cognitive difficulties' [12].

4.3. Build an AI collaborative classroom

The AI-collaborative classroom is the core carrier and breakthrough point for implementing AI-empowered education and reshaping new advantages in education. It transcends the traditional classroom model, taking the "teacher-student-AI collaborative classroom" as the carrier, and builds a new teaching field characterized by "teacher-led, student-centered, and AI deep collaboration", creating a new teaching ecosystem of human-machine symbiosis. Relying on large model technology and intelligent platforms, it sets up introduction, discussion, and summary classes. The key task of AI collaborative education has been accomplished, carrying the innovation of educational content, ideas, and methods [13].

It is necessary and feasible to build such classrooms first in university mathematics courses in the AI era. The "AI+ Teacher" collaborative mathematics teaching model has been practiced in China. The School of Mathematics and Statistics at Southwest University has established a full-chain educational ecosystem covering "knowledge graph construction - intelligent teaching practice - disciplinary decision support", creating a deeply integrated classroom of "AI+ mathematics". The platform has innovatively launched an intelligent learning assistant, which actively recommends learning tasks through Socratic dialogue. Accurately identify students' weak knowledge points; The intelligent teaching assistant system answers abstract questions such as "Why are continuous functions on a compact set uniformly continuous?", helping students deeply understand mathematical principles [14].

5. Conclusion

In conclusion, artificial intelligence has brought unprecedented opportunities to mathematics education, demonstrating great potential and significance. Research shows that the core potential of AI in mathematics education is significantly reflected in three breakthroughs: it can significantly

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enhance the personalization of learning and resolve the contradiction between the scale and precision of traditional classrooms; Innovate teaching models to enhance the efficiency and accuracy of teaching. Despite the challenges at the technical, risk, cognitive and conceptual levels, such as data fraud, the intensification of data security and privacy risks, and the limitations of teachers' digital teaching thinking, this study proposes a "technology - concept - scenario" trinity integration path to address these challenges, focusing on breakthroughs in core technologies, strengthening teacher empowerment, and meticulously designing a human-machine collaborative smart classroom model. First, continuously promote the iteration and disciplinary adaptation of AI technology, and develop intelligent tools that are more in line with the characteristics of mathematical thinking; Second, guide the upgrading of educational concepts and enhance teachers' ability to integrate AI teaching. Third, build a new intelligent classroom ecosystem featuring human-machine collaboration and teacher-student interaction, and leverage the unique advantages of AI in assisting teaching, liberating teachers' energy, and deepening students' cognition. The path for integrating AI into mathematics education is clear and feasible. The active exploration both at home and abroad has demonstrated its huge application value. In the future, it should continue to deepen research and practice, constantly improve technology, optimize models, and prevent risks. It should give full play to the enabling role of AI to promote the high-quality development of mathematics education towards a smarter, fairer, and more efficient direction.

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