

# Research on the Integration Path of Artificial Intelligence in College Mathematics Education: A Multi-source Literature Analysis based on ChatGPT

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**Abstract:** With the rapid development of artificial intelligence technology, generative AI tools represented by ChatGPT have gradually permeated college mathematics education. This phenomenon brings both opportunities and challenges. Based on ten of the latest research literatures, this article systematically analyzes its application status, advantages and problems. Research has found that ChatGPT can help enhance student engagement, promote personalized learning, and optimize teaching design. However, it also has problems such as insufficient problem-solving accuracy, academic integrity risks, increased student dependence, and difficulties for teachers to adapt. To this end, this paper proposes suggestions for integrated paths such as strengthening AI literacy education, improving ethical norms, promoting interdisciplinary collaboration and establishing feedback mechanisms.

**Keywords:** ChatGPT, Mathematics Education, Artificial Intelligence, Higher Education, Teaching Reform.

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## 1. Introduction

In recent years, artificial intelligence technology has developed rapidly, profoundly promoting the transformation and upgrading of the education sector. As a representative of generative artificial intelligence, ChatGPT, relying on the natural language processing capabilities of large language models, has been widely applied in teaching scenarios, especially demonstrating broad prospects in college mathematics education. The emergence of ChatGPT has prompted educational concepts to shift from resistance to standardized application, promoting practical innovations such as personalized learning, dynamic feedback, and collaborative teaching. However, while it enhances teaching efficiency, it also brings about problems such as students' dependence on technology and risks of academic integrity, which urgently require systematic responses at the policy, ethical and practical levels. Nowadays, the education sector both at home and abroad are paying close attention to the empowerment of teaching by ChatGPT. They are actively conducting research on issue such as its teaching effectiveness, application norms, and ethical mechanisms, and are committed to achieving a deep integration of artificial intelligence and education.

## 2. The Theoretical Background of the Integration of Artificial Intelligence and Mathematics Education

The integration of artificial intelligence and mathematics education stems from the dual evolution of educational concepts and technological paradigms. From a theoretical perspective, there are currently mainly three types of educational theories that provide support for AI technology, especially for the teaching application of ChatGPT. The first one is the theory of personalized learning, the second one is the constructivist learning theory, the third is that technology empowers educational theory.

### 2.1. Personalized Learning Theory

The theory of personalized learning emphasizes differentiated teaching based on students' cognitive levels, interests and learning paces. Artificial intelligence systems, especially ChatGPT, have the ability to understand semantics and generate feedback based on input content. They can adjust the feedback content and difficulty in real time according to the questions raised by students, the language style they use, and their knowledge mastery level. This feedback mechanism based on natural language interaction helps break the limitation of the "one-size-fits-all" approach in traditional teaching and achieve truly student-centered personalized learning.[1] Furthermore, in college mathematics courses, personalized support can effectively address issues such as significant differences in students' foundations and high learning anxiety, providing the possibility for enhancing overall learning outcomes.

### 2.2. Constructivist Learning Theory

Constructivist learning theory emphasizes that students actively construct knowledge in the process of solving real problems. As a language generation model, ChatGPT can simulate real interaction scenarios and generate open-ended questions, and guiding students to think through multiple paths and conduct independent exploration, which is conducive to cultivating their mathematical modeling ability and problem-solving ability. For instance, when students are studying abstract courses such as calculus or linear algebra, they can use ChatGPT to propose hypotheses, generate graphical explanations, or conduct symbolic reasoning, thereby forming an individual knowledge system through multimodal input and output.[6] This process also confirms to the core concept of "learning is construction" advocated by constructivism.

### 2.3. Technology Empowers Educational Theory

The theory of technology empowering education holds that

education should actively integrate advanced technologies to enhance the interactivity, visualization degree and resource acquisition efficiency of teaching. ChatGPT features 24-hour accessibility, natural language communication, and fast content generation, which establish new integration channels between teachers and students as well as between people and knowledge. This “conversational artificial intelligence” technology breaks through the traditional teaching’s reliance on time and space, enabling concepts such as “ubiquitous learning” and “collaborative learning” to be implemented.[5] In college mathematics education, teachers can use ChatGPT to design interactive tasks and formative assessment questions. At the same time, students can also use it to assist in practice and reflection, thus forming a new teaching ecosystem mediated by technology.

### **3. The Current Application Status of ChatGPT in College Mathematics Education**

With the continuous promotion of generative artificial intelligence technology in the field of education, the application of ChatGPT in mathematics education in colleges and universities has gradually unfolded that initially formed a practical pattern centered on “student learning assistance”, “teaching support”, and “intelligent problem-solving and thinking training”. Relevant researches indicate that ChatGPT has been widely applied in multiple aspects such as teaching assistance, course design, personalized tutoring, and assessment feedback, and has demonstrated certain teaching potential and innovative value.

#### **3.1. ChatGPT has Become an Intelligent Tutoring Tool for Students’ Learning**

As an intelligent tutoring tool for students’ learning, the most distinctive feature of ChatGPT lies in its “conversational” “immediate” and “diverse” response mechanism. Students can receive real-time personalized feedback on their questions during the use of ChatGPT, especially in the process of solving math problems, the system can provide multi-step derivation processes, reminders of common misunderstandings, and multiple problem-solving paths.[2] This has, to a certain extent, broken the predicament in traditional teaching where teachers find it difficult to provide “one-on-one” tutoring to all students. It offers remedial learning support for students with poor learning outcomes and more challenging extended training for those with excellent grades.

#### **3.2. ChatGPT has Become an Important Tool to Assist Mathematics Teachers in Course Design in Colleges**

Through its generative text capabilities, teachers can quickly obtain content such as course outline suggestions, lesson plan frameworks, teaching activity examples, and formative assessment questions.[5] Compared with traditional teaching materials and resources, the materials provided by ChatGPT are more flexible and contextual, which are able to be adjusted in real time according to different teaching objectives and course modules. It greatly improves the efficiency and quality of teachers’ teaching design. In addition, some educators have also attempted to incorporate ChatGPT into the teaching reflection section, identifying teaching blind spots by simulating students’ questions,

thereby improving teaching strategies.

### **3.3. ChatGPT Demonstrates Unique Advantages in Promoting Students’ Multi-strategy Problem-solving and Innovative Thinking**

Traditional mathematics teaching emphasizes standard answers and unique solutions, while ChatGPT can provide multiple problem-solving paths and variant training suggestions based on open-ended thinking. This plays a positive role in cultivating students’ transfer ability, diversity of mathematical thinking, and innovative consciousness.[7] Especially in applied mathematics courses (mathematical modeling, data analysis, etc.), ChatGPT can assist students in constructing problem-solving frameworks, simulating task scenarios and proposing problem-oriented approaches, which is helpful for students to complete comprehensive and exploratory learning tasks.

### **4. The Advantages of ChatGPT in Mathematics Education in Colleges and Universities**

As a representative tool of generative artificial intelligence, ChatGPT has demonstrated significant technical advantages and educational effectiveness in mathematics education in colleges and universities. Its comprehensive value has gradually attracted high attention from teachers, students and educational researchers. Specifically, the advantages of ChatGPT in the teaching process mainly lie in three aspects: stimulating learning motivation, improving teaching efficiency, and providing personalized learning support.

#### **4.1. Enhance Students’ Initiative and Interest in Learning**

The mathematics courses in colleges generally have the characteristics of strong abstraction and strict logic, which easily leads to common phenomena among students such as insufficient learning motivation, high learning anxiety and low classroom participation. ChatGPT provides students with human-like interaction experiences through natural language conversations, enabling them to obtain immediate responses and personalized feedback during the process of asking and answering questions, which can effectively stimulate their learning initiative.[3] Compared with the traditional cramming teaching method, ChatGPT creates a low-pressure and highly interactive learning environment. In this environment, students can raise questions and receive guidance at any time, thereby enhancing their learning motivation and increasing their interest and identification with mathematical content.

#### **4.2. Improve the Efficiency of Teachers’ Teaching Design and the Quality of Teaching**

Teachers in college mathematics teaching are confronted with practical challenges such as heavy teaching tasks, rapid content updates, and significant differences in students’ levels. The introduction of ChatGPT has effectively alleviated the pressure on teachers in aspects such as course design, generation of lesson preparation content, and case construction. Teachers can use ChatGPT to quickly generate teaching materials such as lesson plan structures, formative

assessment questions, and suggestions for classroom activities, thereby saving lesson preparation time and improving teaching efficiency.[5] Meanwhile, the open generation ability of ChatGPT also provides teachers with diversified teaching materials and expression methods, which helps to enrich teaching language, optimize content presentation, and further improve the overall teaching quality.

### **4.3. Promote Personalized Learning and Differentiated Teaching**

Personalized learning is one of the core goals of the current educational reform. ChatGPT conducts in-depth analysis of the semantics by students based on large language models, and can generate personalized learning content and feedback according to learners' knowledge levels, language styles, and cognitive logic.[7] This ability is particularly important in mathematics teaching in colleges. For instance, when dealing with students with weak foundations, ChatGPT can offer simplified problem-solving steps and visual explanations. For those with stronger abilities, advanced expansion tasks and challenging questions can be pushed to help students achieve optimal development within their respective zones of proximal development. Besides, ChatGPT's multi-language support capabilities also provide a more friendly learning platform for international students and non-native speaker, reducing the impact of language barriers on mathematical understanding.

## **5. The Challenges of ChatGPT in the Application of Mathematics Education in Colleges and Universities**

Although ChatGPT has demonstrated strong enabling potential in college mathematics teaching, its wide application in actual teaching scenarios still faces a series of problems that need to be solved urgently. These challenges not only concern the maturity of the technology itself, but also involve multi-dimensional factors such as educational ethics, student development and teacher capacity building. Summarizing the existing research results, the main challenges can be summarized into the following four aspects.

### **5.1. The Accuracy and Reliability of Handling Mathematical Problems are Insufficient**

ChatGPT performs well in handling natural language tasks, but its capabilities still fall short in rigorous mathematical logical reasoning and higher-order symbolic operations. Several studies have pointed out that ChatGPT often encounters problems such as interrupted reasoning chains, logical jumps, misuse of symbols and incorrect conclusions when solving complex mathematical problems.[4][8][10] Especially in disciplines such as advanced mathematics, probability theory and statistics, and linear algebra, ChatGPT has difficulty achieving stable and accurate multi-step calculations and proofs. This not only limits its credibility as an "authoritative source of knowledge", but also may mislead students' learning paths and cognitive judgments when they lack the ability to distinguish.

### **5.2. The Risks of Academic Integrity and Educational Ethics Have Intensified**

With the popularization of AI technology, it has become

increasingly common for students to use ChatGPT to generate answers, assignments, and even graduation theses, leading to an upward trend in academic misconduct. Researchers pointed out that ChatGPT's ability to "generate non-original content" but "evade plagiarism detection systems" has become a major threat to academic integrity governance in universities.[9][1] Furthermore, some universities have not yet established a complete set of norms and disciplinary mechanisms for the use of AI tools, which leads to difficulties for teachers in making identifications in classroom management and teaching evaluations. This problem is particularly serious in courses such as mathematics that mainly produce "problem-solving results", and it is urgent for the education system to regulate the boundaries and behavioral norms of AI usage at the policy level.

### **5.3. Students' Cognitive Abilities and Thinking Qualities May Be Impaired**

Although ChatGPT helps students improve their learning efficiency, if students overly rely on this tool for problem-solving and task completion, it may weaken their abilities of independent thinking, logical reasoning and critical judgement.[2] Mathematics, as a discipline that emphasizes abstract modeling and rigorous reasoning, places more emphasis on the thinking process rather than the final answer. If students often turn to ChatGPT for help when encountering problems becomes a habit, it can easily lead them to form a dependent pattern of "passive response and lack of analysis", which in turn affects the development of their problem-solving abilities and innovative thinking. This problem of "technology-dependent cognitive degeneration" has attracted great attention in the field of educational psychology.

### **5.4. Teachers are Hard to Adapt and Integrate Teaching**

Although ChatGPT has significant advantages in assisting teaching, most university teachers still have a shallow understanding and mastery of it, and the actual integration of teaching faces multiple challenges. On the one hand, educators lack systematic training on AI educational tools and are not familiar with their ability boundaries and operation norms. This situation can easily lead to problems such as misuse of tools or low value when teachers use AI educational tools. On the other hand, the current teaching evaluation system has not fully considered the teaching changes brought about by "AI intervention", and teachers lack clear application guidance and policy support.[5] Especially in mathematics course, how to originally integrate ChatGPT with the existing textbook system, teaching objectives and assessment standards remains an unsolved practical problem.

## **6. Suggestions on the Path for the Deep Integration of ChatGPT and College Mathematics Education**

The wide application of ChatGPT in mathematics education in colleges and universities has demonstrated good potential for teaching assistance. However, to achieve its deep, continuous and systematic integration, long-term plans still need to be formulated from multiple aspects such as concept guidance, institutional guarantee, teaching practice and technical support. Based on the current research results, this paper, on the basis of summarizing the existing problems, puts forward the following seven suggestions for the integration

path and demonstrates them in combination with the cutting-edge literature.

### **6.1. Enhance the Artificial Intelligence Literacy of Teachers and Students and Build a Capability Foundation**

Colleges and universities should incorporate artificial intelligence literacy into teachers' professional development and students' general education courses. When pre-mathematics teachers use ChatGPT for instructional design, their teaching creativity and technical confidence are significantly enhanced, indicating that artificial intelligence literacy has a direct impact on teachers' teaching effectiveness.[5] At the same time, students gradually acquire digital critical thinking skills in interacting with AI and are able to distinguish between high-quality and low-quality AI outputs.[1] Therefore, strengthening the cultivation of teachers' and students' cognition of AI tools, operational skills and judgement abilities is a prerequisite for integration.

### **6.2. Formulate a Systematic Teaching Integration Model and Optimize the Application Path**

To achieve the deep integration of ChatGPT in the teaching process, it is necessary to build an integrated model with a clear division of teaching functions. ChatGPT can play a role in guiding students to understand mathematical principles, providing immediate feedback, and generating multi-strategy problem-solving solutions.[2] However, its educational effectiveness depends on whether teachers can organically integrate it into the instructional design process. Therefore, in the early stage of curriculum design, it is necessary to clarify the intervention nodes, goals, and evaluation criteria of AI, so as to promote the transformation of mathematics teaching from "tool trial" to "teaching embedding".

### **6.3. Establish Ethical Norms to Prevent Risks of Academic Integrity**

In educational practice, although the "human-like output" feature of ChatGPT has enhanced teaching efficiency, it has also brought about the potential risk of academic misconduct. Ethical risks that generative AI might induce students to plagiarize and evade independent thinking.[9][1] Therefore, universities should issue guidance manuals for the use of AI tools, clearly defining the norms for noting AI-assisted content in academic writing, establishing an integrity evaluation mechanism for AI usage and incorporating ethical awareness throughout the entire process of students' academic training.

### **6.4. Establish a Teaching Feedback Mechanism and Promote Continuous Optimization**

The effect of teaching integration needs to be adjusted through dynamic data feedback. Collecting students' feedback on the use of ChatGPT in mathematics classrooms continuously is helpful to identify its actual effectiveness and limitations in different teaching links.[3] Therefore, it is suggested that colleges and universities establish a data collection mechanism, such as analyzing the end-of-term learning behavior data, collecting immediate feedback questionnaires, teaching observation reports, etc., to promote the continuous iteration and upgrading of teaching applications.

### **6.5. Promote Interdisciplinary Collaboration and Facilitate Integrated Innovation**

Colleges and universities should enhance collaborative cooperation among related disciplines such as mathematics, education, and artificial intelligence, and jointly develop AI-assisted solutions that are in line with teaching realities. In AI mathematics teaching tasks, the collaborative design of teachers, technicians, and assessment experts helps to enhance the educational adaptability of AI systems.[4] Interdisciplinary cooperation is not only conducive to resource sharing, but also can enhance the pertinence of AI applications and the effectiveness of teaching.

### **6.6. Strengthen the Collaboration among Government, Industry, Academic and Research Institutions to Build an Innovative Ecosystem**

The educational application of AI tools such as ChatGPT cannot do without policy guidance and enterprise technical support. Many Asian countries (such as China, Japan, and South Korea) are actively piloting AI educational applications and promoting cooperation among governments, universities, and technology companies to build teaching platforms.[1] Colleges and universities should seize the policy opportunities, apply for pilot projects, and jointly develop "customized models for mathematics education" with AI enterprises, transforming teaching demands into systematic solutions.

### **6.7. Encourage Teachers to Participate in Teaching Research and form a Practical Community**

Teachers are the direct promoters of integrated practice. Involving teachers in the research and design process of AI-assisted teaching can enhance their confidence in practice and promote innovation in teaching behaviors.[5] Universities can establish mechanisms such as the "AI Education and Teaching Innovation Fund" and "Classroom Laboratories". Encourage teachers to conduct teaching experiments and case summaries around ChatGPT to promote the transformation from individual practice to collective wisdom.

## **7. Conclusion**

This study systematically reviews the current application status, advantages and challenges of ChatGPT in college mathematics education. It is pointed out that ChatGPT has achieved remarkable results in stimulating students' interest, realizing personalized learning and optimizing teaching design, injecting new vitality into teaching. However, there are still obvious challenges in terms of the accuracy of answering complex questions, academic integrity risks, students dependence and teacher adaptation. In order to achieve deep relationship between AI tools and college mathematics education, it is suggested to strengthen the training of AI literacy for teachers and students, construct a systematic teaching model, improve ethical norms, and promote cross-border collaboration and teachers' practical innovation. In conclusion, ChatGPT provides strong support for mathematics education in colleges and universities. Only through the collaboration of multiple parties and standardized guidance can help the integration and mutual progress of education and technology will be achieved.

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