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Research on Talent Cultivation in Advanced Mathematics Education Through Artificial Intelligence

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Abstract: In recent years, the rapid development of artificial intelligence (AI) technology has been driving profound transformations in higher education. As a fundamental course in science and engineering disciplines, Advanced Mathematics plays a crucial role in cultivating students' logical thinking and innovative capabilities. However, the current teaching models exhibit significant shortcomings in fostering students' ability to identify and solve problems, primarily reflected in the monotony of teaching content, the limitations of students' thinking, and the constraints of instructional methods. In response to these issues, this paper proposes an AI-based teaching approach for Advanced Mathematics. By utilizing scenario simulations to guide students in discovering problems and employing modeling tools to assist them in solving problems in real time, the study constructs a comprehensive teaching model that spans the entire process from problem identification to problem resolution. Research findings indicate that the application of AI technology can effectively enhance students' abilities in problem awareness, logical reasoning, and creative thinking. This study provides both theoretical support and practical reference for the reform of Advanced Mathematics education and the innovation of higher-level talent cultivation models.

Keywords: Artificial intelligence; Advanced Mathematics teaching; Problem-solving ability cultivation; Innovation in teaching models

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1. Introduction

Deepening comprehensive educational reform and integrating systemic changes in education, science, technology, and talent development are essential pathways toward advancing Chinese-style modernization. Such modernization has been continuously promoted through reform and opening-up, and will continue to gain momentum through it [1]. In recent years, the rapid development of artificial intelligence (AI) has significantly transformed traditional models in the field of education. In higher education, the integration of

AI has led to substantial changes in teaching formats, methods, and objectives, providing new technological support for improving students' competencies and learning efficiency [2].

As a core foundational course in science and engineering education, Advanced Mathematics plays a vital role not only in knowledge transmission but also in cultivating students' logical thinking, abstract modeling abilities, and complex problem-solving skills [3]. However, existing teaching models remain predominantly focused on knowledge delivery and problem-solving techniques, often neglecting the development of students' problem awareness and creative thinking. This one-dimensional approach is increasingly misaligned with the demand for innovative talent in contemporary society [4].

In current Advanced Mathematics teaching practices, students demonstrate clear deficiencies in the process of problem-posing. These include weak problem awareness, low-quality questions, and a lack of divergent and critical thinking. Simultaneously, the cultivation of problem-solving abilities faces significant challenges. Students are often confined to standardized problem-solving steps and lack the capacity to flexibly apply knowledge in complex, real-world scenarios. These limitations hinder the development of students' overall competencies and restrict their performance in engineering and research settings [5]. Therefore, enhancing students' abilities to identify and solve problems in Advanced Mathematics has become a key issue in the reform of higher education.

The rapid proliferation of AI technologies provides a new opportunity to address these challenges. Generative AI tools such as Wenxin Yiyan and Kimi offer real-time feedback, support mathematical modeling, and enable mathematical simulation in teaching practices. Through simulated complex scenarios, dynamic visualizations, and diverse learning resources, AI can not only stimulate students' curiosity and engagement but also help them understand and solve problems from multiple perspectives [6]. The release of the first batch of typical application cases under the "AI + Higher Education" initiative by the Ministry of Education in 2024 marks the entry of AI in education into a more systematic and in-depth phase, offering valuable references for teaching model innovation [7].

The core objective of this study is to explore the innovative application of generative AI technologies in Advanced Mathematics teaching, aiming to enhance students' problem-posing awareness, improve their problem-solving capabilities, and foster logical reasoning and creative thinking through systematic instructional design. This endeavor not only responds to the evolving needs of modern education but also carries significant theoretical and practical implications. On one hand, it provides theoretical support for the reform of Advanced Mathematics education; on the other hand, it accumulates practical experience in the deep integration of AI technologies and education, laying a solid foundation for cultivating innovative talent suited to the needs of future society.

2. Research objectives and questions

Higher education is currently undergoing a critical transformation from traditional knowledge transmission to competency-based learning. In response to the challenges in Advanced Mathematics instruction—such as students' weak problem awareness and limited ability to solve complex problems—this study aims to explore pathways for the deep integration of AI technologies into Advanced Mathematics education. By introducing AI tools and implementing innovative instructional designs, the study seeks to optimize and upgrade existing teaching models, thereby enhancing students' logical thinking, problem-solving skills, and innovative practices.

2.1. Research objectives

This study aims to investigate the in-depth application of AI technologies in Advanced Mathematics teaching to improve students' comprehensive abilities in both problem-posing and problem-solving. Through the integration of generative AI tools, dynamic modeling systems, and personalized feedback mechanisms, the study seeks to reconstruct both teaching content and methodology. A systematic instructional framework is proposed, encompassing the entire process from problem identification to resolution. The primary goals are to stimulate students' problem awareness, foster divergent and critical thinking, and reinforce their logical reasoning and modeling skills through practical tasks. Ultimately, the study aims to support the transformation of Advanced Mathematics instruction from a focus on knowledge transmission to one centered on competency development. This research also contributes to the broader goal of promoting deep integration between AI and education, providing scientific support for cultivating innovative talent aligned with future societal demands.

2.2. Research questions

To achieve the aforementioned objectives, this study addresses the following key research questions:

(1) How can AI technologies be effectively utilized to stimulate students' interest and abilities in problem-posing? Specifically, how can dynamic scenario design and the generation of open-ended problems help students actively identify and articulate mathematical issues?

(2) How can generative AI technologies assist students in efficiently solving complex problems in Advanced Mathematics? This involves analyzing the effectiveness of AI tools in modeling, visualization, and real-time feedback.

(3) How can a systematic instructional pathway be constructed to seamlessly integrate AI technologies with the educational goals of Advanced Mathematics? The study proposes feasible strategies through curriculum design and practical exploration to comprehensively enhance students' abilities from problem discovery to problem resolution, thus meeting the evolving needs of modern educational reform.

3. Current situation of cultivating problem-posing and problem-solving abilities

In current Advanced Mathematics education, the cultivation of students' abilities to pose and solve problems remains insufficient. This shortcoming is primarily reflected in the classroom's heavy focus on knowledge transmission and procedural problem-solving skills, while neglecting the development of students' awareness and initiative in identifying problems. In most classroom settings, students passively receive information from instructors, and learning is often confined to memorizing formulas and applying fixed methods. Opportunities to explore, inquire, or discuss problems are scarce. Such a one-way instructional approach limits students' cognitive flexibility and their ability to develop a deep understanding of complex problems.

The root cause lies closely with instructional design. Advanced Mathematics curricula are typically structured around concepts, theorems, and formulas, with a primary goal of delivering precise knowledge and application techniques. However, insufficient attention is given to guiding students in divergent thinking. The lack of contextual learning scenarios related to real-life or engineering problems makes it difficult for students to connect mathematical knowledge with practical applications. As the course progresses, students tend to focus on finding "standard answers," overlooking the multidimensional understanding of problems and the exploration of solution processes. This ultimately weakens students' problem awareness and leaves them unprepared when faced with open-ended or complex tasks.

The monotony of teaching methods further exacerbates the issue. In most classrooms, traditional lecture-based teaching remains dominant, with limited student engagement restricted to occasional questions and answers. Even when students ask questions, they typically revolve around the repetition or clarification of basic concepts, rather than deeper reflections on problem contexts or complex scenarios. While this approach may help students quickly grasp foundational knowledge, it contributes little to the development of their logical reasoning and creative thinking skills. Learning thus becomes a mechanical process, lacking in exploration and hands-on experience.

The current teaching landscape directly hinders the development of students' overall competencies. On one hand, students show clear deficiencies in independently analyzing and posing problems, which limits the growth of creative thinking in real-world contexts. On the other hand, an overemphasis on standardized drilling fosters rigid thinking and a lack of autonomy and adaptability. When confronted with authentic, open-ended tasks, students often struggle to synthesize their knowledge and propose effective solutions.

The advancement of AI technologies offers new hope for addressing these educational challenges. AI can facilitate the creation of dynamic learning scenarios and provide real-time feedback, enabling students to take an active role in problem-posing and problem-solving. Through AI-based simulations of real-world contexts, students are not only motivated by curiosity and the desire to learn but are also better equipped to grasp the practical significance of mathematical knowledge. This technological intervention helps shift the traditional teacher-centered model toward a student-centered, competency-based approach, thereby laying a strong foundation for enhancing students' logical reasoning and creative capabilities.

4. Designing a pathway for cultivating the ability to pose and solve problems

Against the backdrop of deep integration between AI technologies and Advanced Mathematics education, cultivating students' comprehensive abilities from problem-posing to problem-solving requires a restructured instructional pathway. The core of this pathway lies in breaking through the limitations of traditional teaching models and embedding the advantages of AI throughout the teaching process. Through contextual construction, tool-assisted learning, and task-driven strategies, students' problem awareness and problem-solving capabilities can be systematically developed.

Problem-posing is the starting point for logical reasoning and innovation. In the teaching process, AI technologies can be used to construct dynamic scenarios that help students identify the mathematical problems hidden beneath real-world phenomena. For instance, AI-powered simulations of real-life contexts—such as traffic flow prediction or economic market fluctuations—enable students to observe and analyze data, thereby discovering problems on their own. This scenario-based instructional approach not only stimulates student interest but also encourages multi-perspective thinking and divergent reasoning. The design of open-ended questions is equally crucial. Generative AI tools can produce exploratory or multi-solution problems and provide personalized feedback to help students refine their questions, ultimately enhancing their problem awareness and questioning skills.

Problem-solving, on the other hand, increasingly benefits from AI-assisted processes. In traditional instruction, students often acquire techniques through repetitive practice, yet they lack a deeper understanding of diverse solution strategies and reasoning frameworks. By incorporating dynamic modeling tools and visualization platforms, students can intuitively observe how complex problems are solved, thereby grasping the underlying logical structures. For example, AI platforms such as WolframAlpha or Python-based mathematical tools can guide students through the entire process of problem modeling, parameter adjustment, and result validation. This immediate feedback and interactive demonstration not only improve problem-solving efficiency but also deepen students' appreciation for the practical value of mathematical knowledge.

The design of practical tasks plays a key role in developing students' abilities across the entire process from problem identification to solution. Leveraging AI, educators can introduce more complex and authentic problem scenarios, such as building optimization models based on big data analysis or exploring interdisciplinary challenges involving physics or chemistry. Through collaborative group projects, students utilize AI tools to complete the full cycle—from problem discovery and mathematical modeling to solution verification. This not only strengthens their hands-on abilities but also fosters teamwork and interdisciplinary thinking. Such task-driven teaching integrates theory with real-world application, greatly enhancing students' comprehensive capabilities from theoretical understanding to practical implementation. In this redesigned pathway, instruction is no longer confined to knowledge transmission but focuses on guiding students through the entire process of questioning, exploration, and problem resolution. AI, as a supporting tool, not only helps students break free from the cognitive limitations of traditional instruction but also equips teachers with richer resources and methods, thus providing a strong foundation for achieving the competence-based goals of Advanced Mathematics education.

In practical applications, AI technologies can support students in cultivating full-cycle problem-solving competencies through dynamic scenario simulations and smart tools. For example, in teaching curve area calculation in calculus, instructors can use platforms like GeoGebra or the Matplotlib module in Python to create dynamic visual scenes, illustrating regions enclosed by irregular curves. Students are then encouraged to pose the question: How can the area of these regions be accurately calculated? Through interactive visual tools, students not only grasp the essence of the problem but also generate diverse solution strategies. With the help of AI tools such as WolframAlpha or Python's SymPy module, students can build mathematical models and perform computations. Utilizing AI's dynamic segmentation capabilities, they can experiment with grid-based discretization to approximate area, while comparing analytical integration and numerical integration results to understand the strengths and limitations of each method. Real-time AI feedback allows students to tweak parameters, optimize models, and verify accuracy through visual tools, thereby deepening their conceptual understanding.

Finally, extended tasks can help apply this knowledge in real-world scenarios. For instance, students may be assigned to calculate the cross-sectional area of an irregular riverbed. They would use Python's Pandas module to process raw data and combine visualization tools to analyze water flow variations. This full-cycle instructional model—from theory to practice—not only strengthens students' mathematical application skills but also enhances their logical thinking, modeling abilities, and innovative mindset.

5. Conclusion and future prospects

This study focused on the application of AI technologies in Advanced Mathematics education, exploring how AI can enhance students' comprehensive abilities in problem-posing and problem-solving. Using a calculus module on curve area calculation as a case study, the research demonstrated that AI technologies—through dynamic scenario simulations, intelligent modeling tools, and personalized feedback—can effectively stimulate students' problem awareness, improve the efficiency and depth of solving complex problems, and ultimately enhance their overall learning experience. The AI-driven instructional pathway innovation not only facilitates the transformation of Advanced Mathematics teaching from knowledge transmission to competency development but also provides theoretical and practical references for optimizing modern education models.

Despite the evident advantages of AI technologies in Advanced Mathematics teaching, the study also identified several challenges in their implementation. Some students exhibited over-reliance on AI tools, lacking deep, independent thinking about problems. Additionally, some instructors faced difficulties in effectively integrating AI tools with pedagogical objectives, highlighting the need for stronger adaptability and digital competence. Therefore, future research and practice should focus on how to balance technological assistance with the development of students' independent thinking skills. Further improvements in instructional design are also necessary to mitigate technology dependence. At the same time, enhancing AI literacy among educators and optimizing the integration of technology and pedagogy will be key to ensuring sustainable improvements in teaching effectiveness.

Looking ahead, the application of AI in education will continue to deepen—not only in Advanced Mathematics but across a wide range of disciplines and instructional contexts—injecting new vitality into the cultivation of interdisciplinary and innovative talent. The practical exploration presented in this study offers foundational insights for this trend. Future work should be oriented toward aligning AI applications with real teaching needs, investigating the adaptability of students at various levels, and refining AI-based teaching strategies. These efforts will help achieve a deeper synergy between educational technologies and pedagogical goals, laying a solid foundation for nurturing high-quality, innovative talent equipped to meet the demands of future society.

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Disclosure statement

The authors declare no conflict of interest.

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