

Research on Teaching Reform of University Mathematics Courses Based on Artificial Intelligence

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Abstract: Against the backdrop of the digital transformation of higher education, the teaching-reform orientation of university mathematics courses shall gradually move toward artificial intelligence. Taking the university Mathematical Analysis course as the research object, this paper focuses on exploring the great significance and practical paths of artificial-intelligence-empowered mathematics teaching reform. The study holds that with the empowerment of artificial intelligence, teaching and learning of university mathematics courses have shifted from the original standardization toward precision, which can bring students more intuitive cognitive experience. Meanwhile, it promotes the transformation of course evaluation from score-oriented assessment toward whole-process value-added evaluation. This paper summarizes and puts forward five aspects of teaching-reform strategies, including reconstructing the teaching-content system, innovating the “AI+Mathematics” blended-teaching mode, constructing an intelligent mathematics-teaching resource library and practical-training platform, systematically improving teachers’ artificial-intelligence literacy, and strengthening mathematics practice and application sessions. Research results indicate that artificial-intelligence empowerment is not a simple superposition of technology and education, but a systematic and in-depth transformation involving teaching ideas and educational ecology. Only through coordinated advancement in multiple dimensions can we facilitate the construction of smart mathematics classrooms in universities.

Keywords: Artificial intelligence; University mathematics; Teaching reform

Online publication: October 27, 2026

1. Introduction

With the continuous deepening of digital transformation in higher education, the rapid development of artificial-intelligence technology has brought unprecedented reform opportunities to education and teaching. For the university Mathematical Analysis course, it has long been plagued by problems such as abstract and tedious teaching content, a high cognitive threshold, and a single evaluation system, which can hardly stimulate students’ inquiry interest and go against cultivating their innovative thinking. As artificial-intelligence

technology becomes increasingly mature, exploring the in-depth integration of artificial intelligence and mathematics education has become the key to solving teaching problems and improving educational quality. This paper studies the integration of artificial intelligence and university mathematics-course teaching from two dimensions: significance and strategies, hoping to provide theoretical support and practical guidance for building a new intelligent, personalized and high-order mathematics-teaching ecology.

2. Great significance of artificial-intelligence-empowered teaching reform for university mathematics courses

2.1. Constructing a personalized learning system and realizing precise implementation of “teaching students in accordance with their aptitude”

In university mathematics teaching, it has long been the case that students have uneven foundations and different learning paces. The traditional “one-size-fits-all” teaching mode cannot satisfy individual needs of students. Relying on big-data analysis and learning-behavior tracking, artificial intelligence can generate personalized knowledge graphs for each student and accurately identify students’ weak knowledge points and ability deficiencies. When students learn calculus, AI systems can generate corresponding micro-lecture videos and stratified exercises according to students’ exercise data in modules such as limits, derivatives and integrals ^[1]. Students with weak foundations may receive concept-decomposition animations and basic training. Students with surplus learning capacity may gain access to application cases beyond textbook scope. Such personalized learning paths tailored for each individual can, on the one hand, improve students’ learning efficiency; on the other hand, truly implement the teaching philosophy of teaching students in accordance with their aptitude, so that every student can achieve personalized growth and development.

2.2. Innovating teaching scenarios and methods and promoting the classroom revolution of “human-AI collaboration”

Artificial intelligence can inject immersive and interactive teaching vitality into university mathematics classrooms. On the one hand, artificial-intelligence technology can visualize abstract mathematical concepts. Supported by Virtual Reality (VR), Augmented Reality (AR), and other technologies, students can gain a more intuitive understanding of surface morphologies and vector-field variations in three-dimensional space. They can even “step into” physical processes described by differential equations and acquire rich and concrete learning experiences ^[2-3]. On the other hand, AI teaching assistants can take over some highly-repetitive work for human teachers, such as homework grading and basic Q&A, thus freeing teachers’ energy. Teachers can quickly generate teaching plans of different difficulty levels with the help of AI tools, and devote more time and energy to organizing students to carry out group discussions, mathematical modeling and other in-depth activities. After class, teachers can also generate exclusive learning reports for students via AI systems and provide personalized guidance accordingly. The human-AI-collaboration mode emphasizes combining AI for mechanical labor with teachers for high-order guidance. While improving teaching efficiency, it further strengthens emotional interaction and idea collisions between teachers and students, transforming classrooms from knowledge-transmission venues into ability-incubating platforms.

2.3. Reconstructing the educational-evaluation system and realizing scientific assessment of “process-oriented + comprehensive evaluation”

Traditional mathematics evaluation mainly relies on final-term examinations, attaching importance to results while neglecting processes, and cannot fully reflect core competencies such as students' logical thinking and innovative awareness. Artificial intelligence can facilitate the construction of a brand-new teaching-evaluation system with the help of multi-modal data collection. AI systems can record the breakdown of students' problem-solving steps and traces of idea adjustment. Meanwhile, they analyze unstructured data such as facial expressions and voice interactions generated in the learning process, so as to obtain information including students' learning concentration and thinking-activity level. Taking the mathematical-modeling course as an example, besides assessing the accuracy of reports submitted by students, AI can also evaluate recessive competencies such as students' teamwork and algorithm-optimization capabilities according to data from collaboration platforms ^[4]. The “digital portrait” based on whole-process data shifts evaluation from “score-orientation” to “ability-orientation”. It can not only provide an accurate basis for teachers to optimize teaching, but also guide students to attach importance to thinking processes and the improvement of comprehensive abilities, and help realize the educational goal of “promoting learning and teaching via evaluation”.

3. Effective strategies for teaching reform of university mathematics courses based on artificial intelligence

3.1. Reconstructing teaching-content system and organically integrating AI tools and mathematical-modeling thinking

Traditional university mathematics courses attach great importance to rigorous logical deduction and theoretical proof, yet neglect the application and computational verification of mathematical tools. Against the background of the artificial-intelligence era, reconstructing the teaching-content system should break this limitation and flexibly integrate AI tools and mathematical-modeling thinking into every core chapter. Taking sequence limits and function limits as examples, in teaching practice, besides traditional ε - δ language proof, teachers should guide students to conduct numerical-approximation experiments with AI computing tools, so as to intuitively demonstrate variation processes of limits for students and build a bridge between perceptual cognition and rational proof ^[5]. Furthermore, in the teaching of Taylor formula and Fourier series, given the extremely tedious traditional deduction processes, teachers may shift teaching focus from manual computation to AI-based analysis of function-approximation effects, and guide students to study truncation errors and algorithm convergence. In addition, for chapters such as multivariable-function differential calculus and multiple integrals, teachers can set up special topics for AI-based mathematical modeling, allowing students to apply intelligent algorithms to process high-dimensional data or calculate volumes of complex geometric objects. The above-mentioned content reconstruction does not weaken theoretical depth. Instead, with the help of AI tools, it concretizes and engineers abstract mathematical theories, and expands teaching content from pure deductive reasoning into a closed-loop system of “theoretical deduction — algorithm implementation — result verification”, so as to satisfy new requirements for mathematics-application capabilities raised under the emerging-engineering background ^[6-7].

3.2. Innovating the “AI + Mathematics” blended-teaching mode and promoting classroom transformation from “knowledge imparting” to “ability cultivation”

The key to innovating the blended-teaching mode lies in reshaping classroom time-space structures and teacher-student roles with AI technology, assigning low-order knowledge memorization to AI-assisted work, and devoting precious class hours to cultivating students’ high-order thinking abilities. When teaching differential mean-value theorems (Rolle’s Theorem, Lagrange Mean-value Theorem), teachers may deploy the AI intelligent Q&A system as a pre-class preview assistant. Students can gain preliminary understanding of geometric meanings and algebraic conditions of theorems through interactions with AI. Teachers can allocate more class time to organizing inquiry-oriented discussions, for instance analyzing counterexample construction when theorem conditions are missing. In the teaching of indefinite integrals and definite integrals, teachers can use AI as students’ intelligent tutoring coaches. AI automatically grades basic integral exercises and points out logical errors in calculation processes ^[8]. Teachers mainly explain complex applications of integral ideas in various fields such as physics and economics. In such teaching modes, AI undertakes knowledge imparting and basic training, while teachers act as organizers of learning activities and thinking guides. After human-AI collaboration is introduced into classrooms, university mathematics teaching shifts from one-way knowledge imparting to problem-solving-oriented ability cultivation, which helps improve students’ capabilities of analysis and decision-making in complex mathematical scenarios.

3.3. Constructing intelligent mathematics-teaching resource library and practical-training platform to consolidate foundations for teaching reform

Underlying technical facilities constitute indispensable support for smoothly advancing teaching reform. Therefore, it is urgent to build an intelligent resource library and practical-training platform integrating knowledge retrieval, intelligent interaction and simulation. Such a resource library shall not be merely a digital accumulation of traditional courseware and exercises; instead, it shall be a dynamically-generated system based on knowledge graphs. For classroom teaching of the chapter “Real-number Sets and Functions”, teachers can call historical backgrounds, intuitive animations and stratified test questions related to teaching content according to students’ cognitive blind spots via the platform. For the construction of the practical-training platform for “Curve and Surface Integrals” (Green’s Formula, Gauss’s Formula, Stokes’ Formula), a three-dimensional visualization simulation engine shall be embedded. Students can freely adjust surface parameters and vector-field distributions, so as to gain a more intuitive understanding of the variation rules of flux and circulation ^[9-10]. In addition, the platform shall be equipped with natural-language-processing functions to support students in raising questions in colloquial expressions, for example, “How can I solve this parameter-dependent integral with AI?” After students put forward questions, the system shall immediately match corresponding algorithm codes and analytical procedures. Both the intelligent mathematics-teaching resource library and practical-training platform can provide massive teaching materials for teachers, and create an all-weather immersive mathematics-exploration environment for students, laying a solid material foundation for teaching reform.

3.4. Systematically improving teachers’ artificial-intelligence literacy and building high-quality mathematics-teaching teams

Teachers are primary implementers of teaching reform, and their artificial-intelligence literacy directly affects reform outcomes. Universities shall build a systematic teacher-training system to transform mathematics teachers from “experience-oriented” to “intelligence-empowered”. Training content shall not only cover

the operation of AI tools, but also include AI educational ethics, data-driven teaching decision-making, human-AI-collaborative instructional design, and other content. When teaching “Sequence of Functions and Function Series” or “Power Series”, teachers shall be capable of flexibly analyzing students’ homework data with AI, accurately locating common cognitive obstacles in judging uniform convergence, and further adjusting teaching strategies in a personalized manner ^[11]. In addition, mathematics teachers may take the initiative to set up interdisciplinary teaching-research groups with computer-specialty teachers, and jointly develop mathematics courses based on AI technology. When teaching abstract content such as the Implicit-Function Theorem, interdisciplinary teams can jointly design machine-learning-based parameter-sensitivity-analysis experiments ^[12-13]. Through the above-mentioned measures, teachers can gradually master the application of artificial-intelligence technology and give full play to the role of AI-empowered mathematics teaching.

3.5. Strengthening mathematics practice and application sessions and cultivating students’ core mathematics literacy in the AI era

The ultimate goal of mathematics education is to foster students’ core mathematics literacy. In the AI era, mathematics literacy keeps extending to computational thinking, data insight and interdisciplinary-innovation capabilities. Therefore, teachers shall further strengthen mathematics-application sessions. Taking the teaching of “Numerical Series” and “Improper Integrals” as examples, teachers may introduce convergence-acceleration technologies in AI algorithms as practical cases, enabling students to understand the guiding significance of mathematical theories for algorithm optimization ^[14]. Furthermore, in the teaching of “Limits and Continuity of Multivariable Functions”, “Directional Derivatives and Gradients”, teachers can carry out project-based learning combined with gradient-descent methods in machine learning. Students write code by themselves to solve extremum problems of high-dimensional functions. Teachers can also set up a “Mathematical-modeling Practical-training Week”, encouraging students to apply knowledge such as calculus and differential equations to solve practical problems, so as to realize knowledge internalization and apply what they have learned ^[15].

4. Conclusion

This paper conducts discussions from two aspects: significance interpretation and strategy construction. Only through coordination among content reconstruction, mode innovation, resource construction, teacher-team improvement and practice enhancement can we give full play to the educational potential of artificial intelligence. With the continuous development of large-language models, intelligent simulation and other technologies, the integration of artificial intelligence and mathematics education will grow deeper. Mathematics teachers shall actively keep up with technological-innovation trends, continuously explore new forms of human-AI-collaborative teaching, and inject constant vitality into the construction of smart mathematics classrooms.

Funding

Project of the Department of Science and Technology of Xinjiang Uygur Autonomous Region — Natural Science Foundation: Research on Extremum Problems of Chemical Indicators Based on Degree-Centrality (Project No. 2025D01C334); Special Project for High-level Talents: Research on Extremum Problems of Graph Indicators Based on Degree-Centrality (Project No.: 2024XGC040)

Disclosure statement

The author declares no conflict of interest.

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