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REFORM OF THE "VISUALIZATION, CUSTOMIZATION, AND INTELLIGENT APPLICATION" TEACHING CURRICULUM IN ADVANCED MATHEMATICS

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Abstract: Advanced Mathematics is a compulsory and crucial foundational course for science, engineering, and some liberal arts majors, providing essential mathematical knowledge for subsequent mathematics and specialized courses. Due to the extensive and complex nature of the topics covered, Advanced Mathematics is widely recognized by students as a challenging and abstract subject. To enhance the applicability of its knowledge in cutting-edge technology, address its abstract nature, and achieve tailored teaching, this paper proposes a teaching model for Advanced Mathematics characterized by "visualization, customization, and intelligent application(VCI)." Practical implementation has demonstrated satisfactory teaching outcomes.
Keywords: Advanced mathematics; Curriculum reform; VCI teaching model

1 INTRODUCTION

As a highly important foundational course in higher education, Advanced Mathematics encompasses a wide range of topics and rich content, demanding and cultivating students' logical thinking, analytical generalization, and deductive reasoning abilities. In recent years, China has placed increasing emphasis on the education of fundamental disciplines. As the cornerstone of engineering, mathematics holds an undeniably critical position[1]. With the advent of the information age, the rapid development of fields such as data science and artificial intelligence has led to a growing demand for talents with solid mathematical foundations. How to effectively leverage digital tools to cultivate talents that meet contemporary needs, steering them toward innovation and application, has undoubtedly become a key issue in higher education today[2].
Innovation in technology is rooted in theoretical and foundational logical innovation. A robust theoretical base is a prerequisite for applied innovation. As technology evolves at an unprecedented pace, the significance of mathematics, as the mother of engineering, becomes increasingly prominent. In line with ongoing technological advancements, the teaching and learning models of mathematics should no longer be confined to monotonous lecturing, passive listening, and mechanical calculation. Instead, they must adapt to the trends of the times by integrating new methods and approaches into mathematics instruction. Emphasizing tailored teaching and practical application, Advanced Mathematics education should continuously explore reforms and innovations based on these principles[3-5].
To enhance the applicability of Advanced Mathematics knowledge in cutting-edge technologies, facilitate student learning, address its abstract nature, and achieve tailored instruction, the teaching team has explored and implemented innovations in the course pedagogy. A teaching model characterized by "visualization, customization, and intelligent application (VCI)" has been established. Specifically, this approach provides customized learning paths adapted to individual students' learning habits, employs visualization techniques to intuitively present abstract mathematical concepts in the classroom, and connects knowledge from Advanced Mathematics with the field of artificial intelligence to strengthen practical applicability.

2 CHALLENGES IN ADVANCED MATHEMATICS EDUCATION

(1) Many concepts in Advanced Mathematics are inherently abstract, requiring in-depth analysis and comprehension to master. However, during lectures and independent study, students are prone to distraction and mental fatigue, often leading them to prioritize memorizing conclusions and procedures over genuine understanding. Moreover, the diverse academic backgrounds, learning habits, and cognitive abilities among students are not adequately addressed in large-class teaching settings, where individualized instruction remains impractical. Over time, these issues result in uneven knowledge acquisition, stifle logical innovation, and diminish the motivation to engage with challenging content. Consequently, learning transforms into a burdensome task that students instinctively resist, reducing them to dispassionate "calculation machines" — a outcome fundamentally misaligned with the competencies essential for scientific inquiry.
The highly theoretical and abstract character of Advanced Mathematics constitutes the primary obstacle. Concepts such as limits, derivatives, and integrals are difficult to visualize and comprehend intuitively. When instructors focus heavily on theoretical proofs and formulaic deductions in class, students often struggle to grasp the underlying logic and practical significance. This leads to cognitive overload, mental fatigue, and a tendency towards rote memorization of

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procedures and conclusions, rather than genuine understanding. Consequently, many students lose interest and motivation, finding themselves unable to connect the abstract knowledge to real-world applications or their future professional fields.

(2) As a foundational course, Advanced Mathematics is highly theoretical, covers extensive knowledge points, and poses significant difficulty. Particularly during the explanation of theorem proofs, students often exhibit considerable learning anxiety and diminished motivation. Meanwhile, the teaching of Advanced Mathematics tends to underemphasize the practical application of knowledge, making it challenging to stimulate students' interest through real-world examples. This frequently results in learning that remains at a superficial level.

The prevalent large-class teaching model makes it difficult to implement individualized instruction. Students enter university with vastly different levels of mathematical preparedness, learning habits, and cognitive abilities. However, the "one-size-fits-all" approach, with its uniform pace and content, fails to address these disparities. Students with weaker foundations quickly fall behind and cannot keep up, while those with stronger backgrounds may find the pace too slow, leading to wasted potential and classroom disengagement for both groups[6-9]. This lack of personalization results in uneven knowledge acquisition and fails to cultivate each student's unique strengths.

(3) During the teaching process, the focus tends to be skewed towards knowledge transmission, with insufficient emphasis on holistic student development. Advanced Mathematics inherently contains abundant elements conducive to ideological and education; however, these elements remain underexplored and inadequately integrated with the subject matter, making it challenging to achieve an organic fusion of knowledge delivery and value cultivation.

The teaching content often remains isolated from cutting-edge technological developments, particularly in fields like artificial intelligence and data science. For instance, while gradients are fundamental to neural network training, this connection is rarely highlighted in class. This disconnection makes it hard for students to appreciate the modern relevance and power of mathematical tools, reducing their learning motivation to merely passing exams. Furthermore, while Advanced Mathematics is rich in elements of cultural, philosophical, and aesthetic value (e.g., the beauty of mathematical logic, the dialectical relationship between change and constancy in calculus), these are often underexplored. The missed opportunity to integrate such elements means the course falls short in fulfilling its potential for holistic student development, including fostering scientific spirit and innovative thinking.

(4) The assessment methods for Advanced Mathematics remain relatively uniform. While they effectively evaluate students' comprehension and mastery of key concepts, they lack innovative approaches. Learning is fundamentally a process of cumulative development—without sufficient quantitative accumulation, qualitative transformation can hardly occur. Similarly, without a solid foundation in underlying logic, the development of higher-order thinking remains elusive[10].

The assessment system predominantly relies on standardized final exams that heavily emphasize calculational procedures and formula application. This approach effectively tests memorization and routine problem-solving but largely neglects the evaluation of deeper comprehension, logical reasoning skills, and innovative application abilities. It inadvertently guides students towards superficial learning strategies and discourages exploratory and critical engagement with the material.

3 INNOVATIVE INITIATIVES IN ADVANCED MATHEMATICS TEACHING

Based on the requirements for cultivating innovative talents in the new era and in response to the challenges encountered in the teaching process, a tripartite teaching model characterized by "visualization, customization, and intelligent application (VCI)" has been established. This approach entails providing customized learning paths tailored to individual students' learning habits, employing visualization techniques to intuitively present abstract mathematical concepts in the classroom, and establishing connections between Advanced Mathematics knowledge and the field of artificial intelligence to enhance practical applicability, see Figure 1.

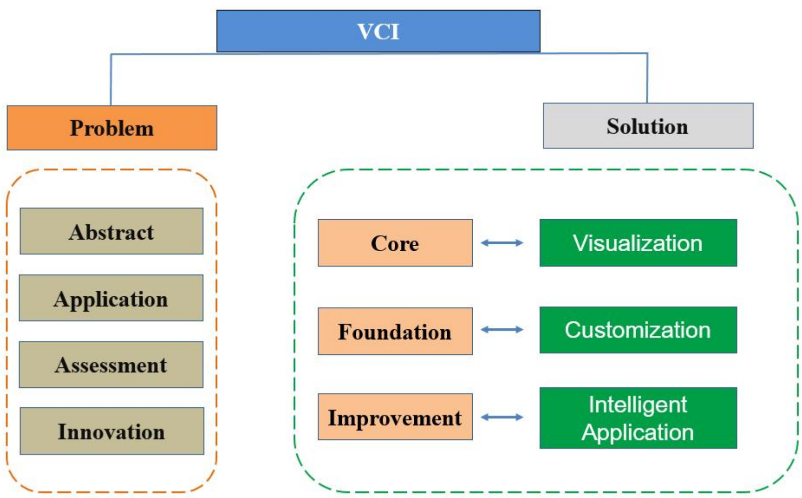

Figure 1 Framework for Teaching Innovation

3.1 Visualization-Based Teaching

The pedagogical restructuring of the Advanced Mathematics curriculum involves a deliberate simplification and refinement of content, scaffolded by an integrated lecture-practice model. Abstract knowledge components are deconstructed and delivered via multimodal visualization—encompassing whiteboards, PPT, and video—to enable intuitive comprehension. This methodology reduces the perceived difficulty and abstraction of the subject, simultaneously advancing students' capacities in logical reasoning and spatial visualization. Learners thereby acquire the skill to synthesize and convert between algebraic and geometric conceptual frameworks, promoting a multifaceted approach to problem-solving.

3.2 Customized Teaching

Students exhibit varied learning habits and foundational knowledge in mathematics, which consequently leads to differences in their ability to absorb and comprehend new concepts. Some students demonstrate strong mathematical aptitude and a solid grasp of fundamentals, enabling them to master new topics rapidly, while others, with relatively weaker preparedness, require more time to fully grasp the material. To address this divergence, a "customized instruction" strategy has been implemented. This approach involves administering diagnostic questionnaires to profile individual learning characteristics. Based on the collected data, personalized learning plans are developed and delivered, aligning teaching methods with each student's specific needs. This tailored framework aims to leverage students' strengths, address their weaknesses, stimulate intellectual curiosity, and build academic confidence – ultimately embodying the principle of teaching students according to their aptitude.

3.3 Teaching with Intelligent Applications

With the continuous advancement of technology, artificial intelligence has grown increasingly powerful and widely applicable. Today, a growing number of higher education institutions are incorporating AI as a general education course, empowering talent cultivation across fields such as engineering, agriculture, humanities, sciences, and medicine, thereby enabling all university students to engage with AI. As one of the most essential foundational courses, Advanced Mathematics must integrate its key concepts with artificial intelligence, applying them in AI contexts to stimulate students' interest in learning and exploration. Examples include gradient descent and the least squares method.

The gradient descent algorithm is a classic and widely applied method in AI. The concept of gradient, a crucial topic in Advanced Mathematics, can be effectively taught by introducing the gradient descent algorithm through visual aids such as videos. This connection between mathematical principles and AI applications significantly enhances student engagement.

While the least squares method is often an optional topic in Advanced Mathematics, it serves as a common mathematical tool in AI for building data models and making predictions. Therefore, in teaching Advanced Mathematics, the least squares method is introduced with theoretical analysis and explanation. Students are assigned an interesting task: using historical midterm and final exam scores as data, they apply the least squares method to predict results in subsequent examinations.

4 CONCLUSION

The Advanced Mathematics curriculum has been restructured to streamline content, integrate explanation with practice, and present abstract concepts intuitively through a triple-layer visualization approach—comprising blackboard diagrams, PPT animations, and instructional videos. Tailored to individual aptitudes, customized learning plans are designed to support students in mastering the course while integrating ideological elements from mathematical culture, philosophical principles, and aesthetic aspects into knowledge points or case studies, guiding them to establish sound worldviews and values. Furthermore, course content is connected with artificial intelligence by introducing smart application scenarios and cutting-edge scientific knowledge, emphasizing practical application alongside theoretical learning. This approach ensures alignment with contemporary advancements and fosters continuous knowledge renewal. Through practical implementation, a notable improvement in students' classroom engagement has been observed. They have demonstrated keen interest in the visualized teaching approach, leading to deeper comprehension and mastery of knowledge points. Beyond merely solving exercises, students are now able to apply knowledge to their specific professional domains and real-world scenarios, showing greater emphasis on cultivating their logical thinking, cognitive skills, and innovative capabilities. Leveraging AI-enabled higher education, a fully intelligent teaching model has been established. By collecting, analyzing, and utilizing comprehensive teaching process data, the system evaluates individual learning progress and habits to deliver customized education. This includes tailoring learning models and curating personalized resource recommendations for different students, supplemented by AI-generated adaptive question banks. This transformation shifts traditional experience-based instruction toward intelligent education centered on data interaction and information assessment.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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