Research on the Cross-Integration of University Mathematics and Artificial Intelligence Based on the Concept of Cultivating New Domain and New Quality Talents

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Abstract. With the rapid development of artificial intelligence technology, the boundaries of disciplines are gradually blurring. Interdisciplinary integration and the cultivation of compound talents have become important directions for higher education reform. University mathematics, as the theoretical cornerstone of artificial intelligence, provides a solid support for intelligent algorithms, data analysis and optimization. However, at present, there are still problems such as fragmented courses, insufficient integration depth, and an incomplete practical system in university mathematics and artificial intelligence education, which are difficult to meet the demands of new quality productivity and intelligent society for innovative talents. Starting from the theoretical logic of two-way empowerment, this article analyzes the talent ability requirements for the integration of university mathematics and artificial intelligence, and proposes to "consolidate the foundation and highlight application;" Emphasize intersections and integration. Emphasize practice and highlight innovation; The construction idea of the integrated curriculum system guided by the principle of "stratified classification and flexible elective courses". This paper constructs a four-layer progressive curriculum framework of "basic support - cross-integration - innovative practice - verification and improvement", and introduces a modeling competition and verification mechanism, forming a training closed loop of "course learning - modeling competition - practical innovation - result verification". Meanwhile, through teaching innovations such as blended teaching, flipped classrooms, and AI-assisted adaptive learning, a talent cultivation path for the deep integration of mathematics and artificial intelligence has been explored, providing theoretical references and practical solutions for universities to build a new domain and new quality talent cultivation system.

Keywords: New domain new quality; Talent cultivation; College Mathematics; Artificial intelligence; Cross-integration

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1 Introduction

With the rapid development of artificial intelligence technology, the boundaries between traditional disciplines are becoming increasingly blurred, and interdisciplinary and compound talents have become the core driving force for scientific and technological innovation and industrial transformation. Mathematics, as the fundamental discipline of artificial intelligence, provides strong theoretical support for intelligent algorithms, data analysis and optimization. At present, in terms of talent cultivation, the deep integration of mathematics and artificial intelligence still faces problems such as fragmented curriculum design and disconnection between theory and practice, which cannot meet the demands of the intelligent era for innovative and high-end compound talents[1-3]. Therefore, the cultivation model for new domain and new quality talents urgently needs innovation. The cross-integration of mathematics and artificial intelligence can cultivate talents with a solid foundation in mathematics and the ability to apply cutting-edge artificial intelligence technologies, promote the flow and sharing of knowledge among disciplines, and foster compound talents with systematic thinking, innovation ability and cross-disciplinary collaboration ability. This is not only the key to the reform of higher education, but also an urgent need to address the challenges of the future intelligent society[4-5].

In recent years, the research on the cross-integration of college mathematics and artificial intelligence has gradually become an important direction of higher education reform. Some scholars have explored the auxiliary application and inspiring value in college mathematics teaching, while others have investigated the comprehensive experimental platform for teacher-student-artificial intelligence collaborative classrooms and other intelligent teaching platforms integrating artificial intelligence technologies[6-7]. However, on the whole, The current research and practice are still in their infancy: the curriculum system of mathematics and artificial intelligence is scattered and lacks sufficient integration depth. Students lack a continuous interdisciplinary learning path, and the practical platform and evaluation system are not yet perfect. Against the backdrop of the accelerated transformation of new quality productivity and industrial intelligence, universities urgently need to build a more systematic and forward-looking integrated training model for mathematics and artificial intelligence. Therefore, systematically studying the development path of the cross-integration of mathematics and artificial intelligence is not only an inevitable choice for improving the quality of talent cultivation, but also a practical demand to support national scientific and technological innovation and industrial transformation[8-10].

This paper, guided by the cultivation of new domain and new quality talents, systematically studies the integration path of university mathematics and artificial intelligence, and constructs a comprehensive training framework centered on "curriculum system construction - teaching mode innovation - ability generation mechanism". By analyzing theoretical logic, ability requirements and practical framework, the principles and implementation strategies of integrated curriculum design are proposed, providing references and practical basis for universities to deepen interdisciplinary research and cultivate compound innovative talents.

2 The Internal Logic and Demand Analysis of the Cross-integration of College Mathematics and Artificial Intelligence

The deep integration of university mathematics and artificial intelligence constitutes the core logic of cultivating new quality talents. On the one hand, mathematics provides theoretical support and methodological foundation for artificial intelligence; On the other hand, artificial intelligence injects new research objects and application scenarios into mathematics. The two empower each other and develop in a coordinated manner, not only promoting disciplinary innovation but also laying a solid foundation for cultivating compound talents with mathematical and physical thinking, intelligent practice and cross-border innovation capabilities.

2.1 The Theoretical Logic of Mutual Empowerment Between University Mathematics and Artificial Intelligence

Mathematics is the core language and logical support of artificial intelligence, and its basic courses together form the foundation of the theoretical system of artificial intelligence. Advanced mathematics provides a theoretical basis for continuous optimization, function approximation and gradient calculation in artificial intelligence, and is the key to understanding the training mechanism of neural networks. Linear algebra provides formal tools for matrix operations, feature extraction and dimension transformation in deep learning, and is the computational core of algorithm implementation. Probability theory and mathematical statistics lay the foundation for uncertainty modeling, data distribution analysis and model evaluation in machine learning. Through systematic study of these mathematics courses, artificial intelligence can operate within a rigorous logical framework, achieving scientific reasoning from data to knowledge. Mathematics is not only the fundamental language of artificial intelligence but also the theoretical support that ensures the stability, interpretability and generalization ability of its algorithms, enabling the development of artificial intelligence to be based on scientific rationality and verifiability. The rapid development of artificial intelligence has, in turn, injected new impetus into mathematical research. The introduction of artificial intelligence technology has broadened the research objects of mathematics, expanding from traditional symbolic and numerical analysis to data-driven model Spaces. Machine learning and intelligent algorithms have emerged as new research methods, promoting the deepening of fields such as computational mathematics, optimization theory, and complex system analysis. Meanwhile, the extensive application of artificial intelligence in fields such as image recognition, natural language processing, and quantum computing has also provided mathematics with rich application scenarios, promoting mathematical research to shift from pure theory to a balance between theory and application. The development of artificial intelligence has transformed mathematics from a "tool discipline" into an "innovation engine", achieving the regeneration and expansion of the discipline.

2.2 Analysis of the Competency Requirements for New Domain and New Quality Talents

The cultivation goal of new domain and new quality talents is no longer limited to the mastery of single knowledge, but emphasizes comprehensiveness and innovation. Mathematical abstraction ability is the foundation for understanding complex systems. Algorithmic thinking embodies the logical path from problem to model and then to solution. Cross-domain modeling ability requires students to integrate mathematical theories with artificial intelligence technology and use modeling methods to address engineering and social issues. The computing implementation capability ensures the practical application of theories and the transformation of technologies. These four core competencies constitute the ability structure of talents who integrate mathematics and artificial intelligence. They not only reflect a solid foundation in mathematics and physics but also highlight the characteristics of intelligent thinking oriented towards practice. They are the compound qualities urgently needed for future scientific and technological innovation and industrial upgrading. In the face of the demand for cultivating new types of talents, university mathematics education urgently needs to shift from knowledge imparting to ability generation. Traditional mathematics teaching emphasizes the deduction of formulas and theorems, while neglecting application scenarios and algorithm implementation. Future courses need to strengthen the two-way integration of mathematics and artificial intelligence. Educational reform should highlight the concept of "mathematical support and intelligent empowerment", cultivate students' innovative consciousness and comprehensive application ability, and make mathematics truly become the disciplinary engine supporting the development of artificial intelligence.

3 The Design of an Integrated Curriculum System for University Mathematics and Artificial Intelligence

The construction of integrated courses of university mathematics and artificial intelligence is a key path to cultivating new domain and new quality talents. By optimizing the curriculum system and teaching mode, the theoretical support of mathematics and the practical application of artificial intelligence can be deeply integrated. This not only strengthens students' mathematical logic and intelligent thinking, but also promotes cross-disciplinary innovation and ability generation, thus establishing a new model for cultivating compound talents that supports the future development of science and technology. The structure is shown in Figure 1:

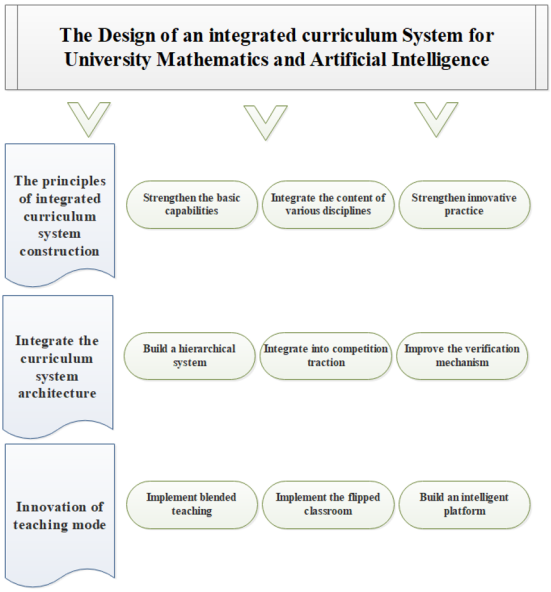

Fig. 1. Design structure diagram of the integrated curriculum system.

3.1 The Principles of Integrated Curriculum System Construction

Facing the goal of cultivating talents in new domains and new qualities, the construction of an integrated curriculum system for university mathematics and artificial intelligence must be based on interdisciplinary studies, serve national strategies, and meet the demands of industrial transformation. It is necessary to build a systematic teaching framework that can support students' theoretical learning, ability cultivation, and innovative practice. This system should adhere to the principle of "consolidating the foundation and highlighting application;" Emphasize intersections and integration. Emphasize practice and highlight innovation; The construction principle of "stratified classification and flexible elective courses" ensures the systematicness and scientificity of mathematics education while achieving the technological orientation and innovation-driven development of artificial intelligence knowledge, thereby cultivating compound innovative talents with profound mathematical literacy and intelligent practical ability. Strengthening the foundation and highlighting application are the core starting points of course construction. College mathematics serves as the language and logical framework for artificial intelligence. Basic courses such as advanced mathematics, linear algebra, probability theory, and mathematical statistics jointly form the theoretical support for the algorithm system of artificial intelligence. In the course design, by strengthening the systematic teaching of mathematical principles, it helps students master mathematical abstraction, logical reasoning and model-based thinking. At the same time, through algorithm practice, programming simulation and case analysis, students can transfer mathematical theories to the practical application of artificial intelligence,

achieving an effective connection from "theory to algorithm, from model to implementation", and truly realizing the application of what they have learned. Emphasizing intersections and integration is the structural core of the curriculum system. In the traditional education model, college mathematics and artificial intelligence often belong to different teaching modules, resulting in a fragmented knowledge chain and making it difficult for students to form a systematic cognition. The integrated curriculum system should break down disciplinary barriers, reconstruct the knowledge structure, and organically combine mathematical theories, computer algorithms, data modeling and engineering practice to form a complete learning path from basic theories to intelligent applications. Meanwhile, the courses can be combined with research projects or competition activities, such as the National College Students' Mathematical Modeling Contest and the Artificial Intelligence Innovation Competition, enabling students to apply the knowledge they have learned and test their learning outcomes in the competitions, truly achieving "promoting learning through competitions, promoting innovation through competitions, and promoting teaching through competitions". Finally, stratified classification and flexible elective courses are important mechanisms for achieving personalized cultivation and diversified development. Students vary in their professional foundation, learning interests and development directions. The integrated curriculum system should be designed hierarchically based on the characteristics of students. The curriculum system should also set up elective modules, allowing students to freely combine and study based on their career plans and interest directions, to achieve a flexible training mechanism of "compulsory courses as a foundation and elective courses for expansion".

3.2 Integrate the Curriculum System Architecture

The integrated curriculum system of university mathematics and artificial intelligence should be constructed into a four-layer progressive framework of "basic support - cross-integration - innovative practice - verification and improvement". Through competition-driven, project-driven and evaluation feedback, a complete closed loop of talent cultivation should be formed. Firstly, the basic mathematics module serves as the foundation of the entire system, encompassing courses such as advanced mathematics, Linear Algebra, Probability Theory and Mathematical statistics, and Numerical Analysis. It focuses on cultivating students' mathematical logical thinking and abstract modeling abilities. This module emphasizes the systematic nature of theory and the transferability of knowledge, enabling students to possess the mathematical literacy necessary for understanding artificial intelligence algorithms and providing a solid support for subsequent integrated learning. Secondly, the basic module of artificial intelligence is aimed at cultivating intelligent computing and data analysis capabilities, covering courses such as Python programming, data structures and algorithms, fundamentals of machine learning, and data visualization. By combining theoretical instruction with programming practice, we help students transform mathematical models into algorithmic implementations, thus establishing a logical link between "mathematics - programming - intelligence". Thirdly, the interdisciplinary module of mathematics and artificial intelligence is the core part of the integrated system, including courses such as mathematical

Modeling and Simulation, mathematical foundations of deep learning, Optimization methods and algorithms, Stochastic Processes and Intelligent Decision-making, etc. This module emphasizes the integration of knowledge and the connection of applications, guiding students to understand the mathematical essence of artificial intelligence algorithms through modeling thinking, and to master the entire process from theoretical derivation to intelligent implementation through experiments and cases. In particular, by taking events such as the National College Students' Mathematical Modeling Contest and the Artificial Intelligence Innovation Competition as the driving force, the competition content is deeply integrated with the course tasks, enabling students to exercise their comprehensive abilities and verify their learning outcomes in real problem situations, and achieving "promoting learning, teaching and innovation through competitions". Finally, the practical innovation and verification module, as a link for enhancing capabilities and testing achievements, includes course project-based systems, real data analysis, interdisciplinary innovation competitions, industry-education integration projects, and model verification experiments. This module combines project-based learning with innovation competitions, enabling students to continuously iterate and optimize throughout the entire process of "problem proposal - model construction - algorithm implementation - result verification", ultimately achieving an organic unity of theoretical knowledge and engineering practice. Meanwhile, the curriculum system introduces a learning portfolio and ability assessment mechanism to dynamically track and comprehensively evaluate students' modeling skills, algorithmic thinking, and innovative achievements. Overall, the integrated curriculum system, through a closed-loop design of "course learning - modeling competition - innovative practice - result verification", has formed a compound training structure that emphasizes both the foundation and innovation, as well as both theory and practice. This system not only deepens the intersection of mathematics and artificial intelligence, but also, driven by competitions and verifications, achieves the educational goals of stimulating learning motivation, deepening knowledge transfer and optimizing ability generation, providing systematic support for cultivating new domain and new quality talents with mathematical thinking, intelligent practice and innovation capabilities.

3.3 Innovation of Teaching Mode

In the implementation process of the integrated curriculum system, the innovation of teaching models is a key link in promoting the deep integration of university mathematics and artificial intelligence. The traditional teaching method mainly based on teachers' lectures has become difficult to meet the requirements of comprehensive ability, innovative thinking and intelligent practice for the cultivation of new domain and new quality talents. To this end, it is necessary to fully utilize information technology and artificial intelligence means to build a multi-dimensional teaching model centered on students and oriented towards ability cultivation, so as to achieve personalization, intelligence and innovation in the teaching process. First of all, blended teaching should become the main form of teaching. This model, through the combination of "online self-study + offline classroom interaction", breaks the limitations of time and space, enabling students to master mathematical and artificial intelligence knowledge at their

own pace. During the online learning stage, students can independently master the fundamentals of mathematical principles and algorithms through micro-lectures, MOOCs and visual learning resources. In offline classrooms, teachers focus on the analysis of core concepts, case studies and problem discussions, with an emphasis on cultivating students' logical reasoning ability and knowledge application ability. The advantage of blended teaching lies in its balance of autonomy and guidance, enabling students to gain a deep understanding while learning flexibly, thereby enhancing their initiative in learning and the interactivity of the classroom. Secondly, the flipped classroom teaching model can effectively promote students' active learning and innovative thinking. Unlike the traditional "classroom lecture - after-class practice" model, the flipped classroom moves the knowledge transmission stage forward. Students complete theoretical learning through teaching videos, online materials, etc. before class, while the class time is used for algorithm derivation, model construction and case practice. Teachers in the classroom are no longer "knowledge transmitters", but "learning facilitators" and "problem guides". This teaching method helps students deepen their understanding in the process of solving problems and achieve "applying what is learned and integrating knowledge with action". Thirdly, the combination of artificial intelligence and virtual simulation experiments in mathematics offers students an immersive and interactive learning experience. The virtual experiment platform utilizes visualization technology and intelligent simulation systems to present abstract mathematical concepts and artificial intelligence algorithms in an operational form, enabling students to conduct algorithm training, model debugging, and mathematical experiments in a simulation environment. In addition, the adaptive teaching model of intelligent learning platforms is becoming an important trend in future education. This system is based on artificial intelligence technology. By analyzing students' learning behaviors, answering data and knowledge mastery curves, it dynamically adjusts teaching content and difficulty to achieve personalized learning with "thousands of faces for thousands of people".

During the pilot implementation of the integrated curriculum system, students have achieved remarkable improvement in various mathematical model-related competitions. Taking the data of the National College Students' Mathematical Modeling Contest in the past three years as an example, before the reform, the provincial and above-level winning rate of the participating students was about 12%. However, after the implementation of the integrated curriculum system, the winning rate has increased to nearly 30%, among which some students have even won the first prize at the national level. This result indicates that the integrated curriculum system has effectively enhanced students' modeling thinking, algorithm implementation and interdisciplinary application capabilities, promoted the transformation of theoretical knowledge into innovative achievements, and provided a solid support for cultivating new domain and new quality talents with practical scientific research and engineering capabilities.

4 Conclusion

The cross-integration of college mathematics and artificial intelligence is an inevitable choice for higher education to address the challenges of the intelligent era. Mathematics

endows artificial intelligence with theoretical rigor and logical verifiability, while artificial intelligence injects application impetus and innovation space into mathematical research. The deep integration of the two can not only promote the reconstruction of the disciplinary system, but also cultivate new domain and new quality talents with mathematical thinking, algorithmic literacy and intelligent innovation ability. Based on a systematic analysis of the internal logic and integration requirements of the two, this paper proposes the construction principles and architecture design of the integrated curriculum system, emphasizing the construction of a training path that runs through "theory - application - innovation - evaluation" with modeling competitions, project-driven and verification mechanisms as the driving force. Meanwhile, through innovative means such as blended teaching, virtual simulation experiments and intelligent learning platforms, the limitations of traditional teaching are further broken, and the intelligence and personalization of the educational model are achieved. In the future, universities should take this as a foundation to further improve the construction of the curriculum system and evaluation system, deepen the integration of industry and education as well as scientific research collaboration, and build an open, dynamic and sustainable talent cultivation ecosystem. Only by combining the rational light of mathematics with the innovative power of artificial intelligence can we truly cultivate high-end compound innovative talents that support scientific and technological progress and industrial transformation, providing a solid talent support and intellectual guarantee for the development of new quality productive forces.

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