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Research on the Construction of Computational Method Courses Empowered by Knowledge Graphs in the Digital-Intelligent Era

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Abstract: Against the backdrop of intelligent education transformation, knowledge graphs serve as vital tools to boost teaching effectiveness. Nevertheless, Computational Method courses suffer from drawbacks including implicit knowledge structures and unified learning paths. This paper proposes a curriculum reform scheme based on knowledge graphs. Guided by Outcome-Based Education (OBE) philosophy, a four-dimensional curriculum graph integrating knowledge, competence, problems and ideological and political education is constructed. Combined with the three-stage and five-link blended teaching mode, multi-dimensional evaluation system, and three-dimensional teaching scenarios of problem-simulation-practice, teaching contents are reconstructed hierarchically to support students' personalized learning effectively. Teaching practices have fully verified its effectiveness in cultivating students' computational thinking, innovative spirit and practical capabilities, which provides valuable references for the curriculum reform of other science and engineering courses.

Keywords: Knowledge graph; Computational methods; Outcome-based education; Blended teaching; Curriculum construction

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1. Introduction

With the rapid advancement of science and technology and deepening industrial transformation, digital technologies have penetrated the education sector with unprecedented breadth and depth. The 2024 World Digital Education Conference put forward the important assertion that intelligence is a key engine for educational transformation, and systematically proposed to promote the in-depth integration of artificial intelligence (AI) with teaching and learning to empower educational innovation. The 2025 Government Work Report clarified the development orientation of "Artificial Intelligence + Education". In the digital-intelligent era, as a tool capable of organizing knowledge in structured and semantic forms, knowledge graphs have become effective technical support for the construction and reform of AI-related courses.

As a fundamental specialized course, Computational Methods mainly cultivates students' ability to solve practical engineering and scientific problems with numerical analysis tools. Fragmented curriculum resources, implicit knowledge architectures, standardized teaching procedures, unified learning routes and generalized teaching feedback plague traditional teaching approaches. Consequently, students struggle to form complete knowledge systems, and teachers cannot deliver targeted personalized guidance efficiently.

This paper mainly studies how to promote the reform of Computational Method courses with knowledge graphs in the digital-intelligent era. Guided by OBE theory and integrated with AI and knowledge graph technologies, traditional curricula are reconstructed. By building a student-centered and competence-oriented new curriculum ecology, the deficiencies of conventional teaching can be addressed, and feasible curriculum reform solutions for fostering innovative talents needed for new productive forces are ultimately put forward.

2. Background of curriculum construction empowered by knowledge graphs

A Knowledge Graph refers to a semantic network that organizes knowledge in graphical forms. It takes entities as nodes and relationships as edges, connecting scattered knowledge points into semantic networks interpretable by computers. In the education field, knowledge graphs have evolved from simple knowledge visualization tools into important instruments for systematic curriculum system reconstruction and intelligent teaching reform [1]. Guided by OBE philosophy, this paper discusses the multi-dimensional support provided by knowledge graphs for the reform of Computational Method courses, including technical empowerment, knowledge structure reorganization, teaching method innovation and internalization of educational values.

The theoretical research on education empowered by knowledge graphs has shifted from technology-driven modes to educational integration modes. Current studies no longer merely focus on technical implementation such as knowledge extraction and fusion; instead, they deeply integrate pedagogy and cognitive science to systematically explore the application logic of knowledge graphs in real teaching scenarios. Curriculum knowledge graphs convert scattered, linear knowledge systems in traditional courses into structured semantic networks accessible to machines. The networked knowledge structure facilitates the presentation of concepts, attributes and relationships of knowledge points, and lays rigorous mathematical foundations for upper-layer applications including learning path planning, personalized recommendation and intelligent academic diagnosis.

The combination of knowledge graphs and AI technologies opens new avenues for innovating teaching modes and curriculum forms. Systematic design has been carried out for blended Computational Method courses. Knowledge graphs provide well-structured cognitive maps for blended learning, enabling more organized online autonomous learning and facilitating in-depth thinking interaction in offline flipped classrooms [2]. Starting from the significance of Computational Method learning, specific suggestions on teaching reform and curriculum ideological and political construction are offered to deliver tangible Computational Method teaching outcomes [3]. Knowledge modules such as linear equation solving and numerical integration are integrated via knowledge graphs, and linked with competence objectives including algorithm comprehension and engineering modeling. Combined with project-driven virtual simulation and practical problem solving, a new three-dimensional teaching scenario of "problem-simulation-practice" is formed. In mining engineering, knowledge graphs are adopted to construct knowledge threads ranging from geological foundations to intelligent mining technologies, breaking the limitations of segmented traditional teaching and boosting collaborative production, teaching and research [4]. In ideological and political construction for teacher-training majors, the mapping relationship between ideological and political elements and professional knowledge is excavated, and ideological and political cases are organically integrated into teaching resources and case libraries to form operable implementation paths for curriculum ideological and political education [5,6]. A blended teaching mode of “knowledge graph navigation - advanced project-driven - artificial intelligence assistance” is proposed, with elaborate arrangements for pre-class, in-class and post-class sessions, serving as a reference paradigm for personalized learning and intelligent curriculum transformation [7].

3. Design and practical path of computational method curriculum system empowered by knowledge graphs

Knowledge graphs constitute the underlying core of the framework for Computational Method curriculum construction. This paper constructs an interconnected four-dimensional collaborative curriculum graph system [8].

3.1. Construction of four-dimensional graphs

(1) Knowledge Graph

Core modules, including numerical solutions of linear equations, root finding for nonlinear equations, interpolation and fitting, numerical calculus, and numerical solutions of ordinary differential equations, as well as their internal logical relationships, are sorted out [9].

(2) Competence Graph

From the OBE perspective, curriculum objectives are decomposed into algorithm comprehension ability, programming realization ability, numerical analysis ability (error, stability, convergence), and engineering modeling ability. Nodes of the knowledge graph are directly associated with various competencies to design teaching contents.

(3) Problem Graph

A progressive problem sequence ranging from theories to practical applications is designed. It starts with convergence proof of the bisection method, then moves on to solving nonlinear equations via Newton’s method, and finally addresses the solution of nonlinear partial differential equations in weather forecasting. All problems are linked with corresponding knowledge nodes and competence nodes. The problem graph serves both as a learning roadmap and a dynamic network for teachers to track learning progress.

(4) Ideological and Political Graph

The curriculum takes the Banmo culture of Zaozhuang as its spiritual source, extracting concepts such as investigating things to attain knowledge, abiding by rules and standards, and craftsman spirit. Knowledge points including error analysis and algorithm stability are connected with cases of precise assembly of Luban locks, effectively combining the rigor of engineering calculation with craftsman spirit to realize value guidance.

3.2. Blended teaching design

Relying on the four-dimensional curriculum graphs, a three-stage and five-link blended teaching mode covering pre-class, in-class and post-class periods is designed, forming a dual-teacher classroom ecology integrating teachers, machines and students, as shown in **Figure 1**.

Three Stages: Before class, students conduct independent previews assisted by knowledge graphs and AI tools to complete low-order objectives of knowledge memorization, comprehension, and application. During class, teachers organize in-depth interactions and thematic inquiries based on graphs, focusing on high-order thinking training such as analysis and evaluation. After class, AI teaching assistants provide Q&A services, extended graph resources, curriculum design and disciplinary competitions are arranged to realize knowledge consolidation and transfer.

Five Links: Situational introduction to stimulate learning interest; knowledge explanation to consolidate theoretical foundations; classroom practice to strengthen hands-on capabilities; real-time testing to grasp learning effects; summary and reflection to perfect knowledge systems. The whole process adheres to the philosophy of taking practical application as the goal, case teaching as the main line and large models as tools.

Online teaching undertakes asynchronous pre-class guidance and synchronous in-class assistance. Teachers develop learning task lists based on knowledge graphs. Offline classes focus on high-order thinking cultivation through inquiry, presentation and Q&A activities. After-class online assignments, offline practice and AI tutoring form a closed teaching loop to improve teaching effectiveness comprehensively.

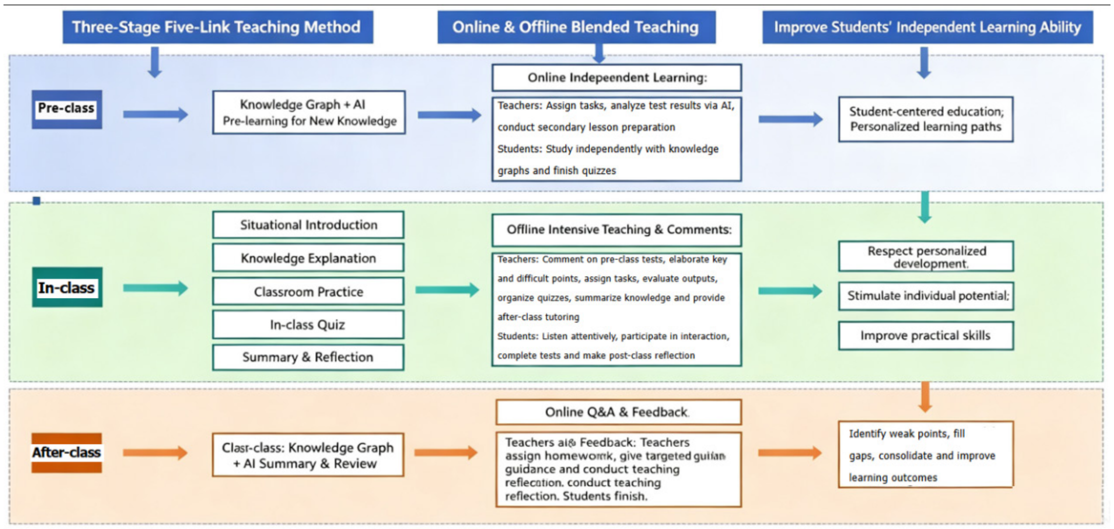

Figure 1. Blended teaching design.

3.3. Reconstruction of curriculum contents

Centering on core knowledge of Computational Methods, teaching contents are reconstructed from four dimensions, including cultural education, research feedback, practical implementation, and innovation empowerment, to enhance the advanced nature, innovativeness, and challenge degree of the curriculum [10].

(1) Educational Integration via Banmo Culture

Based on Zaozhuang's local cultural advantages as the hometown of Luban and Xizhong, the concept of integrating knowledge and practice to consolidate capabilities is adopted to embed craftsman spirit into the whole teaching process. The MOOC *Culture and Ideological & Political Education in Computational Methods* is developed, and a characteristic case library combining Banmo Spirit and mathematics teaching is built. Luban-style classroom activities are carried out to set rigorous academic standards and stimulate students' learning motivation.

(2) Teaching Supported by Scientific Research

Frontier research outcomes of Computational Methods are introduced into classrooms. For instance, the application of Navier-Stokes equations in aerospace aerodynamics is explained when teaching numerical solutions of ordinary differential equations. Regular academic lectures are held to invite experts to share cutting-edge progress, building a communication platform between students and academia and broadening academic horizons.

(3) Integration of Theories and Practices

Virtual simulation experiments are added to raise the proportion of practical teaching. Project training tasks are designed for students to implement numerical algorithms, consolidating programming and problem-solving capabilities independently.

Table 1. Training project list

Project Name	Required Skills
Development of Numerical Weather Forecasting Model	Numerical Analysis, Differential Equations, Python, Meteorology
Implementation of Filtering Algorithms in Image Processing	Image Processing, Linear Algebra, Python
Comparative Research on Optimization Solving Algorithms	Operations Research, Algorithm Design, Data Analysis, Python
Numerical Stability Analysis of Machine Learning Models	Machine Learning, Numerical Analysis, Statistics, Python
Pricing Model Development for Financial Derivatives	Stochastic Processes, Financial Engineering, Python
Large-Scale Data Processing and Parallel Computing	Big Data Processing, Parallel Computing, Python

(4) Innovation Empowered by Mathematical Modeling

Mathematical modeling is taken as a bond to strengthen the practical application of Computational Methods. Professional application cases are designed in combination with curriculum knowledge points, and students are encouraged to participate in mathematical modeling competitions and scientific research projects to cultivate innovative thinking and teamwork capabilities.

Table 2. Modeling cases in computational method courses

Curriculum Content	Professional Application Cases
Numerical Solutions of Linear Equations	Circuit network problems, curve fitting, solving nonlinear equations, solving ordinary/partial differential equations via difference and finite element methods
Root Finding for Nonlinear Equations	Gas equation models, loan interest rate calculation, image processing
Interpolation Methods	Production scheduling planning, aircraft wing profile calculation
Numerical Calculus	Derivative solving, optimization problems, data analysis, elliptic integral calculation, satellite orbit computation, Xiangjiang River flow estimation
Numerical Solutions of Ordinary Differential Equations	Weather forecasting, butterfly effect, population growth models, infectious disease models

3.4. Multi-dimensional intelligent evaluation and feedback system

To comprehensively and accurately assess and improve students' computational thinking and problem-solving abilities, an evaluation and feedback system integrating multi-source data, dynamic diagnosis and intelligent intervention is designed and implemented.

(1) Multi-Dimensional Evaluation and Feedback System

An AI-powered multi-dimensional evaluation mechanism focusing on the depth of comprehension, quality of algorithm application and efficiency of numerical solutions is constructed [10]. Tools including radar charts of theoretical mastery and thermal diagrams of algorithm complexity are adopted to analyze students' command of core knowledge points precisely. Personalized diagnostic reports are automatically generated to deeply analyze strengths and weaknesses in logical construction, error control and algorithm optimization.

(2) Whole-Process Academic Tracking and Adaptive Intervention

Statistical functions of knowledge graphs and AI learning engines are integrated to track the entire learning process dynamically. Knowledge heat maps and fault warning diagrams are adopted to display common weak points of the class and assist teachers in adjusting teaching strategies. Multi-modal data such as students' experiment reports, code quality and virtual simulation operations are correlated to build individual academic portraits, identify knowledge blind spots and ability deficiencies, and deliver adaptive learning interventions.

4. Practical effects and innovative highlights of computational method curriculum

Taking fostering virtue through education as the fundamental task and student development as the core, the curriculum reform has achieved remarkable results with four major innovative highlights:

(1) Model Innovation

The three-stage five-link blended teaching mode based on constructivism and student-centered theories supported by the Xuexitong platform realizes organic connection among pre-class, in-class and post-class sessions with progressive five teaching links. Oriented at practical applications, supported by case teaching and large models, and characterized by ideological and political education, it effectively improves students' class participation, practical skills and problem-solving capabilities, achieving the tripartite training objectives of knowledge, ability and literacy.

(2) Form Innovation

The four-in-one curriculum graph creates a new curriculum form integrating knowledge, competence, problems and ideological and political education. Knowledge graphs build logical knowledge networks; competence graphs link teaching and evaluation; problem graphs adapt to personalized learning progress; ideological and political graphs integrate Banmo culture. It realizes structured knowledge, visualized competence, dynamic problems and integrated ideological and political education, supporting the construction of intelligent teaching platforms.

(3) Educational Innovation

Collaborative education based on Banmo culture forms a joint education mechanism of moral cultivation, intellectual enlightenment and aesthetic edification. Luban's craftsman spirit strengthens the rigor and professional ethics of algorithm design; Mozi's philosophy of mutual benefit cultivates teamwork capabilities; aesthetic concepts of rules and standards infiltrate numerical visualization education. In the past three years, student teams have won more than 10 provincial-level awards in algorithm competitions.

(4) Scenario Innovation

The three-dimensional teaching scenario of problem-simulation-practice innovates teaching modes in the digital-intelligent era. Integrated with virtual simulation and project-based learning as well as cutting-edge research topics, it realizes deep integration of research and teaching. Through group discussions and collaborative learning, students are guided to extract mathematical models from practical problems, enhancing their mathematical application capabilities and broadening academic horizons.

5. Conclusion

This paper introduces a four-graph-empowered AI curriculum system for Computational Methods, proposes the three-stage five-link blended teaching mode, and establishes an integrated dual-teacher classroom ecology combining teachers, machines, and students. The Banmo culture of Zaozhuang and cutting-edge academic achievements are organically integrated. Virtual simulation experiments and mathematical modeling are adopted to strengthen practical training. Meanwhile, an AI-based multi-dimensional intelligent evaluation and feedback system is designed to track students' learning processes and deliver timely feedback accurately. This curriculum reform helps cultivate students' computational thinking, stimulate innovative awareness and boost practical capabilities, serving as a demonstration for curriculum reform of other science and engineering majors.

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The authors declare no conflict of interest.

References

[1] Tian W, Wu Z, Sui P, 2025, Innovative Practice of In-Depth Development of Professional Courses Empowered by Knowledge Graphs. University Teaching in China, 5: 16–25.

[2] Zhang S, Ma Y, Yang X, 2023, Exploration and Practice of Online-Offline First-Class Courses — A Case Study of Numerical Calculation Methods. Innovation and Entrepreneurship Theory Research and Practice, 11: 43–46.

[3] Zhang R, 2012, Discussion on Teaching Reform of Computational Method Courses. Curriculum Education Research, 20: 213.

[4] Lü Y, Wu H, Xiao G, 2025, Digital Curriculum Construction and Innovative Practice of Computational Methods Empowered by Knowledge Graphs. China Machinery, 15: 147–150.

[5] Li J, Wang K, Zhang X, 2025, Exploration and Practice of Digital Mining Curriculum Construction Empowered by AI + Knowledge Graphs. Journal of Education Science, 19–21.

[6] Zhai X, Chen F, 2023, Exploration of Ideological and Political Teaching in Analytic Geometry Under the Background of Professional Certification for Teacher-Training Majors. Journal of Zaozhuang University, 40(5): 120–125.

[7] Zhang Q, Xu J, Liao X, Chen X, Xiao Z, 2026, Knowledge Graph and Teaching Practice of Java Web Courses Empowered by AI. Science & Education Review, 4: 146–149.

[8] Wang G, Sun Y, et al., 2025, Exploration of Teaching Methods for C Language Programming Courses Empowered by Knowledge Graphs. Information and Computer, (1): 197–199.

[9] Lu Z, Guo F, 2025, Research on Teaching Reform of Open Education Empowered by Knowledge Graphs in the Digital-Intelligent Era. Vocational Technology, (7): 7.

[10] Dai W, He J, Wu B, 2025, Research and Practice of Practical Teaching Methods Empowered by Digital Intelligence for Cybersecurity. Software Guide, 24(10): 209–214.