

Construction and Design of an Intelligent Teaching System Driven by Knowledge Graphs—A Case Study of Electrical and Electronic Technology (B)

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Abstract: *Addressing core challenges in the teaching of traditional engineering foundation course, such as complex knowledge systems, obscure logical relationships, and insufficient personalized teaching support, a knowledge graph-based framework for constructing intelligent teaching systems is proposed. Taking the core non-electrical engineering course "Electrical and Electronic Technology (B)" as the research subject, a course knowledge graph is constructed through a three-dimensional method involving textbook deconstruction, objective alignment, and expert review. Relying on the "Superstar Learning" intelligent teaching platform, four core elements—knowledge modeling, platform application, teaching model reconstruction, and dynamic evaluation—are deeply integrated. A comprehensive pathway is provided, ranging from the three-level deconstruction of the knowledge system and the construction of a multi-collaborative knowledge graph to the design of a "three-stage" teaching model and the establishment of a dynamic evaluation mechanism. This study offers a replicable and promotable model for the systematic and intelligent teaching reform of engineering foundation courses in the context of emerging engineering education.*

Keywords: *electrical and electronic technology, knowledge graph, superstar learning platform, intelligent teaching*

1. Introduction

Driven by the dual trends of educational digital transformation and emerging engineering education development, higher education is undergoing a profound paradigmatic change. As a key bridge connecting general education and professional education, the teaching quality of engineering foundation course directly determines the knowledge foundation and innovative capabilities of engineering talents. However, courses represented by "Electrical and Electronic Technology (B)" face severe challenges in traditional teaching models due to their inherent characteristics: a logically rigorous yet abstract knowledge system, extensive content with limited class hours, and students from diverse professional backgrounds. Teachers often struggle with "inadequate explanation, insufficient practice, and failure to cover all needs," while students generally feel "confused, overwhelmed, and unable to apply the knowledge," resulting in low achievement of course objectives. As an emerging artificial intelligence technology, knowledge graphs, with their powerful semantic expression, relational reasoning, and visualization capabilities, provide a new approach to solving the above problems. They can organize discrete knowledge points into an organic and computable knowledge network, clearly revealing the internal connections between concepts, thereby laying a cognitive foundation for precise teaching and personalized learning [1].

In recent years, top universities such as Stanford and Cambridge have applied knowledge graphs in science and engineering courses [2]. However, due to fundamental differences in educational systems and course structures, their achievements are difficult to directly transplant to the teaching scenarios of undergraduate electrical and electronic courses in China. In contrast, domestic research, closely aligned with local needs, has shown vigorous development. Pan Yanan et al. [3] proposed a multi-dimensional graph system of "knowledge-problem-competence". Dong Xiaowei [4] focused on the connection between knowledge points and the course framework. Zhou Jing et al. [5] constructed a knowledge graph covering four major modules of electrical and electronic engineering. Yao Jianhong et al. [6] and He Chaoxia et al. [7] realized personalized resource recommendation and learning path planning under blended teaching and AI tool assistance, respectively. Tian Li et al. [8] and Rong Hailin et al. [2] emphasized the role of knowledge graphs in goal achievement assessment and comprehensive education

evaluation under the background of engineering education accreditation concept. Qin Fuzhen et al. [9] built a closed loop of "teaching-learning-practice-test-evaluation". Cao Lu et al. [10] confirmed the value of knowledge graphs in mapping curriculum ideological and political elements through CiteSpace analysis. Lu Jianhua [11] explored its application in interdisciplinary competence cultivation. Despite these fruitful achievements, existing domestic research still has three common shortcomings: First, the integration of knowledge graphs with mainstream teaching platforms mostly remains at the level of shallow graph display, failing to deeply utilize the platform's data collection and analysis capabilities to drive teaching decisions. Second, the process of knowledge graph construction often lacks systematic and refined deconstruction of course textbooks, leading to poor adaptability to specific teaching goals, key points, and difficult points. Third, most studies focus on piloting isolated components, lacking a comprehensive and iterative closed-loop system integrating "technology-platform-teaching-evaluation," which constrains large-scale implementation and long-term application.

Targeting the teaching pain points of "Electrical and Electronic Technology (B)" in our university, this paper constructs an intelligent teaching system that deeply integrates knowledge graph with the "Superstar Learning" platform. A rigorous three-dimensional knowledge graph construction method of "textbook deconstruction-goal alignment-expert review" is proposed to ensure its teaching adaptability. A four-dimensional teaching closed loop is established, covering knowledge modeling, platform application, teaching model reconstruction, and dynamic evaluation optimization.

2. Construction Method of Knowledge Graph

The quality of the knowledge graphs directly determines the effectiveness of the entire teaching system. To this end, this paper proposes a three-dimensional construction method of "textbook deconstruction-objective alignment-expert review" to ensure the scientificity, adaptability, and authority of the graph.

2.1. Three-level Knowledge System Deconstruction

Taking the designated textbooks and syllabi of "Electrical and Electronic Technology (B)" as the basis, a systematic deconstruction is carried out using the "three-level decomposition + key annotation" method.

(1) First-Level Decomposition: Defining the Knowledge Scope

According to the natural chapter structure of the textbook, the entire course is divided into several macro knowledge units, such as "Basic Concepts and Laws of Circuits," "Circuit Analysis Methods," "Sinusoidal AC Circuits," "Three-Phase AC Circuits," "Transient Analysis of Circuits," "Magnetic Circuits and Transformers," and "Electric Motors and Control." This step establishes a clear framework for the entire knowledge system.

(2) Second-Level Decomposition: Identifying Knowledge Points

Within each knowledge unit, specific and independently teachable knowledge points are further decomposed. These knowledge points are classified by attributes to clarify their cognitive types. For example, "Kirchhoff's Current Law" is a conceptual knowledge point; "Solving Circuits Using Mesh Current Method" is a procedural knowledge point; and "Applicable Conditions of Ohm's Law" is a factual knowledge point. This classification helps design differentiated teaching strategies in subsequent steps.

(3) Third-Level Decomposition: Weaving the Knowledge Network

This step aims to reveal the complex logical relationships between knowledge points, mainly including:

1) Prerequisite-Successor Relationship: Clarifying the learning sequence, e.g., "Kirchhoff's Laws" must be mastered before learning "Branch Current Method."

2) Hierarchical Relationship: Reflecting the inclusion relationship between concepts, e.g., "RLC Series Circuit" is a sub-concept of "Sinusoidal AC Circuits."

3) Associative Relationship: Indicating horizontal connections between knowledge points, e.g., the connection mode of "three-phase power supply" and "three-phase load" interacts with each other.

4) Application Extension Relationship: Linking theory with practice, e.g., "Thevenin's Theorem" can be applied to simplify complex circuit models.

2.2. Construction of a Multi-collaborative Knowledge Graph System

A single network of knowledge point relationships is insufficient to support comprehensive teaching needs. Therefore, this paper constructs a multi-dimensional collaborative system consisting of three sub-graphs.

(1) Core Knowledge Graph

As the backbone graph, the core knowledge graph fully presents all knowledge points and their internal logical relationships. It provides students with a global and visual knowledge navigation to help them establish a systematic disciplinary cognitive framework.

(2) Objective Graph

Objective graph establishes mappings between knowledge points and specific course teaching objectives. For example, the knowledge point "Thevenin's Theorem" is associated with the competence goal "ability to analyze and simplify active two-terminal networks." This makes learning outcomes measurable and traceable, providing a basis for subsequent precise evaluation.

(3) Course Ideological and Political Graph

To implement the fundamental task of fostering virtue through education, the graph explicitly associates professional knowledge points with the ideological and political elements contained in them. For example, when explaining "electrical safety regulations," it is linked to the values of "prioritizing life and safety". When analyzing rigorous circuit derivation processes, the scientific spirit of "pursuing truth, pragmatism, and excellence" is integrated. This graph ensures that value guidance is like salt dissolved in water, nourishing silently.

2.3. Expert Review to Ensure Graph Quality

To prevent knowledge graphs from becoming a technical pipe dream, a rigorous expert review process is incorporated during construction. Senior teachers with rich teaching experience in "Electrical and Electronic Technology" are invited to conduct a comprehensive review of the first draft against the course requirements. The review assessed three dimensions: logic completeness of knowledge, teaching adaptability, and technical feasibility. Through multiple rounds of feedback and iteration, a high-quality course knowledge graph that is both scientifically rigorous and suitable for front-line teaching practice is finally formed.

3. Intelligent Teaching Design

With a high-quality knowledge graph as the cognitive core, the next step is to integrate it into the entire teaching process to build an intelligent new teaching ecology.

3.1. In-depth Platform Integration

"Superstar Learning" platform is selected as the technical platform mainly due to its large user base, mature functional modules, and good openness. The knowledge graph is deeply integrated into the platform, making it the intelligent core of teaching activities.

(1) Intelligent Resource Association: All existing digital teaching resources of the course (including courseware, micro-videos, exercises, cases studies, etc.) are bound one-to-one with the corresponding nodes in the knowledge graph. When students click on a knowledge point, the system can automatically aggregate all relevant learning materials, realizing "one-stop" precise learning and greatly improving resource utilization efficiency.

(2) Visualization of Learning Paths: Using the topological structure of the knowledge graph, the platform can automatically generate personalized learning path suggestions for students. For students with weak foundations, the system will guide them to review prerequisite knowledge points first. For students with strong learning abilities, it can recommend extended associated content. At the same time, students' entire learning trajectory is visually presented on the graph with different colors or marks, enabling them to clearly see their knowledge mastery landscape.

(3) Intelligent Interaction Function: An interactive function based on problem graphs is developed, with typical engineering problems as nodes to construct a three-dimensional association network of

"problem-knowledge point-skills." Centering on a real or simulated engineering problem scenario, students are driven to actively recall, integrate, and apply multiple knowledge points to solve complex tasks. For example, focusing on the fault phenomenon of "frequent burnout of three-phase asynchronous motors in a workshop," it can be associated with multiple knowledge points such as "unbalanced three-phase load," "excessively large starting current," and "improper setting of thermal relays." The problem graph not only strengthens the transfer and application of knowledge but also supports project-based learning (PBL) and inquiry-based teaching, effectively cultivating students' problem identification, systematic thinking, and engineering practice abilities.

3.2. Reconstruction of the "Three-stage" Teaching Model

Relying on the knowledge graph and intelligent platform, the traditional classroom teaching model is fundamentally reconstructed, and a closed-loop teaching process of "Pre-class Preparation → In-class Exploration → Post-class Consolidation" is designed.

(1) Pre-Class: Precise Guidance. Based on the position of the upcoming teaching content in the knowledge graph, the system automatically pushes micro-videos of relevant prerequisite knowledge points and test questions to students. Using students' answer data, the platform generates personalized preview reports in real time, clearly informing them of their knowledge blind spots, transforming preview from "extensive reading" to "targeted preparation."

(2) In-Class: In-Depth Exploration. Classroom teaching is no longer a simple repetition of knowledge but focuses on the key points, difficult points, and high-order thinking ability training highlighted in the knowledge graph. Teachers use the graph for classroom navigation, guiding students to observe the connections between knowledge points. Through group collaboration and case studies, students collectively solve complex engineering problems designed around the "problem graph".

(3) Post-Class: Personalized Extension. Post-class learning is no longer a unified assignment but highly personalized. The platform uses algorithms to intelligently recommend targeted reinforcement resources based on students' classroom performance and practice data. These may include specialized video explanations for specific concepts, sets of practice exercises, or mind maps for organizing knowledge frameworks, truly achieving "teaching students in accordance with their aptitude."

3.3. Dynamic Evaluation Mechanism

This paper constructs an evaluation system that not only focuses on learning outcomes but also emphasizes the learning process. Not only measures knowledge memory but also emphasizes abilities and literacy, providing comprehensive and objective data support for teaching improvement. This dynamic evaluation mechanism integrating quantitative and qualitative analysis abandons the limitations of a single summative evaluation.

(1) Process Evaluation. This includes, but is not limited to: completion rate and mastery rate of each knowledge point, viewing depth and review times of teaching videos, participation quality in online discussions, accuracy rate and answering time of self-test questions, etc. These data collectively constitute students' process-based learning performance.

(2) Summative Evaluation. The final exam is still retained, but its design is strictly designed based on the "exam point" labels in the knowledge graph and the ability requirements in the objective graph. This ensures assessment content aligns closely with teaching objectives, accurately reflecting students' true proficiency.

(3) Competency and Quality Evaluation. Through the engineering scenario tasks carried by the problem graph, combined with qualitative evidence such as students' problem analysis processes, solution design, team collaboration performance, and reflective statements, an in-depth assessment is conducted on students' practical abilities and innovative thinking in applying multiple knowledge points to solve complex engineering problems. Meanwhile, relying on the implicit guidance of the ideological and political graph, a comprehensive evaluation is made on their comprehensive literacy such as engineering ethics awareness, scientific spirit, and communication and collaboration skills reflected in the task completion process.

4. Conclusion

Centering on the course "Electrical and Electronic Technology (B)," this paper systematically constructs an intelligent teaching system for engineering foundation course driven by knowledge graphs. The construction of this system is not only the teaching optimization of a single course but also a positive exploration of the teaching paradigm for engineering foundation course in the context of emerging engineering education. Starting from the ontology of course knowledge, it empowers the entire teaching process with information technology, aiming to achieve a fundamental transformation from "experience-driven" to "data-driven" and from "standardized supply" to "personalized service." The design concept of this paper can lay a theoretical foundation for subsequent practical exploration. Future research can further explore the synergistic effect of large artificial intelligence models and knowledge graphs under this framework to achieve higher-level intelligent teaching.

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