

A Knowledge-Graph-Based Digital Teaching Model: Taking the Course "Principles of Automatic Control" as an Example

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Abstract: As digital transformation in education deepens, traditional teaching models often struggle with conceptually abstract and knowledge-intensive courses like "Principles of Automatic Control," resulting in high cognitive load, weak knowledge connectivity, and limited personalized learning. Taking this course as a case, we explore the construction and practice of a knowledge-graph-based digital teaching model. By building a knowledge graph with granular knowledge points and attaching rich, systematic learning resources, we integrate digital teaching resources, content, processes, and assessment into a personalized, intelligent approach that boosts student efficiency and teaching quality. Practice shows the model structures knowledge visually, helps students build systematic frameworks, markedly improves learning focus and instructional efficiency, and offers a reference and case for digital reform in core STEM courses.

Keywords: Principles of Automatic Control; Knowledge graph; Digital teaching model.

1. Introduction

As the new wave of technological and industrial revolution deepens, digital transformation in education has become a global consensus. Educational digitalization is a key breakthrough for China to open new tracks and create new advantages in education development. Further advancing digital education provides effective support for personalized learning, lifelong learning, broader access to quality educational resources, and educational modernization. Keeping pace with digital trends and seizing the moment to advance educational reform and innovation is vital for modernizing education and building a strong educational nation.

2. Course Pain-Point Analysis and the Significance of Knowledge-Graph-Based Digital Teaching Reform

"Principles of Automatic Control" is a core professional course for automation and related majors. The course is both highly theoretical and technical. Teaching it therefore balances mastery of theory, handling of real problems, and independent research, laying the theoretical groundwork for later practical training aimed at solving complex automation and electrical-engineering problems in high-end equipment manufacturing and AI.

2.1 Course Pain-Point Analysis

As a platform course for automation and electrical majors, "Principles of Automatic Control" serves a large audience. Yet its heavy load of mathematics and control theory and its abstract concepts intimidate students; its strong systematic nature means topics are tightly linked, and learners often stumble because they cannot build a complete knowledge framework. Digitizing the course via knowledge-graph-based reform is both timely and inevitable.

2.2 Significance of Knowledge-Graph-Based Digital Reform

The theoretical value of a knowledge-graph-based overhaul of "Principles of Automatic Control" has three facets. First, a knowledge graph integrates scattered topics into a systematic network, supporting diverse digital educational resources. As digital tech evolves, resource design shifts from "for teachers" to "for the whole student learning journey." Second, visualizing knowledge offers students a novel learning experience and creates a blended teaching space where physical and digital classrooms merge seamlessly. Finally, building the graph draws on AI, applied math, graphics, etc., fostering cross-disciplinary fusion, breaking boundaries, and advancing the field.

3. Constructing the Course Knowledge Graph for "Principles of Automatic Control"

The graph clarifies structural relations within the course. Coupled with a problem graph, it lets students and instructors approach content from knowledge and problem angles, grasping logical structure and pedagogical semantics among topics, chapters, and levels. This promotes overall framework understanding, cultivates synthesis, analysis, and application skills, and boosts teaching effectiveness. The concrete steps are as follows:

- (1) Clarify objectives and analyze needs. Define the teaching requirements of the course "Principles of Automatic Control," set the goals and scope of the knowledge graph. Gather needs and pain points through user surveys (subject heads, instructors, students, multiple angles).
- (2) Resource collation. Start from the course's core concepts; collect and supplement materials following the top-level ontology. Bring in lab simulations, real cases, and project practice so students learn and apply control principles in context, boosting problem-solving skills. As the course is interdisciplinary, link it with electrical engineering, computer science, etc., to show control across domains and foster cross-disciplinary thinking.
- (3) Build and integrate the knowledge graph. First, map the course knowledge system: identify key points and concepts, divide content into tiers—basic ideas, theoretical models, application cases—so students see the whole framework and how points relate. Next, use IT to model these relations. Then integrate and reason over existing resources for fast retrieval and recommendation.
- (4) Build a question graph. Cultivate abilities from multiple angles: basic questions tie to single knowledge points, requiring recall and understanding; composite questions target analysis, demanding structural insight and concept linkage; complex problems ask students to find deep connections, reorder concepts/rules, and make choices, comparisons, value judgments. The three levels chain together and link to knowledge points to boost integrated application.

(5) Continuous improvement via iterative optimization. Design new teaching modes from the graph—personalized paths, smart Q&A—and deploy them. Refine the graph through teacher feedback and tech updates; collect student data, analyze outcomes, and keep optimizing the reform. Periodically update the graph with latest research and tech to keep content cutting-edge and scientific.

4. Digital Construction Plan and Implementation for "Principles of Automatic Control" Based on Knowledge Graph

4.1 Digital Teaching Resource Development

In implementing knowledge-graph-based digital teaching, the graph alone is insufficient; digital teaching resources must also be built, fundamentally replacing the traditional isolated, piecemeal “resource bank” with an organic “knowledge system” framed by the knowledge graph. The core is to decompose and tag fragmented videos, documents, exercises, simulation cases, etc., so each becomes an entity precisely anchored to the corresponding node (concept, principle, application) and interlinked. This deep integration turns resources from information silos into a structured, networked knowledge system. The system can then, based on each learner’s real-time position in the graph, intelligently aggregate and push highly personalized resource packages (e.g., a “targeted consolidation pack” for weak spots or an “inquiry learning path” for extension), shifting the model from “human seeks resources” to “resources seek human,” providing precise, efficient, and evolvable support for digital teaching.

4.2 Knowledge-Graph-Based Teaching Model Reform

Build a digital teaching model that is “student-centered, data-driven, and graph-navigated.” It re-engineers the “pre-class, in-class, post-class” flow into a dynamic, closed-loop, personalized pattern. Key moves:

(1) Pre-class warm-up. Instead of one-size-fits-all prep, the graph enables personalized preview: the system auto-pushes the core node plus its directly linked prerequisite cluster.

(2) In-class discussion. Teaching shifts from sequential lecturing to joint graph exploration. With a visual graph interface, the teacher is no longer bound to textbook order; paths are generated and jumped in real time. The goal: break classroom knowledge silos and help students build a systematic framework, not memorize scattered facts.

(3) Post-class practice. Drills move from “sea of questions” to “precision strikes,” learning from passive reception to active inquiry. Based on homework/test data, the system pushes targeted videos and materials; for advanced learners, it recommends extension paths along graph links. After mastering PID control, for instance, it may ask whether to explore PID tuning or fuzzy PID.

In summary, the knowledge graph plays a vital role in students’ learning, offering personalized support from pre-class warm-up, in-class discussion to post-class practice, helping shift from “teacher teaches” to “student learns.”

4.3 Teaching-effect analysis Based on the Knowledge Graph

Building on earlier online-course development on the Chaoxing platform, this course revamped the site with a knowledge graph; statistics are shown in Figure 1.



Figure 1: Course knowledge-graph statistics on the Chaoxing platform



Figure 2: Word cloud of student acceptance of the knowledge graph in teaching

Using this digital platform, we conducted teaching practice. Figure 2 shows student evaluation of the knowledge graph's impact, indicating strong acceptance.

5. Conclusion

Targeting the complex, difficult knowledge system of Principles of Automatic Control, we built a course-wide knowledge graph and designed a digital model covering pre-, in-, and post-class stages. Practice shows the model turns linear delivery into student-centered networked exploration, helps students build systematic frameworks, enables precise resource push and personalized paths, and lifts efficiency and depth. While dynamic updates and richer adaptive learning remain to be refined, the study proves the huge potential of deep integration of knowledge graphs and education, offering a reference for digital reform in engineering courses.

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