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Research on the Construction of Knowledge Graph of "DSP Principle and Application" Course from the Perspective of Smart Education

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Abstract: *With the rapid advancement of smart education and the gradual deepening of digital teaching reform, the structured organization of curriculum knowledge has become the key to the implementation of smart teaching. The course of electrical engineering and automation focuses on the organic combination of theory and engineering practice. However, most of the existing teaching resources are fragmented, and the internal relationship between knowledge is difficult to present intuitively. Therefore, this paper takes the core course of electrical engineering and automation "DSP Principle and Application" as an example, and proposes a systematic curriculum knowledge graph construction scheme. The research focuses on the four key steps of curriculum data collection, curriculum ontology design, knowledge element identification and knowledge fusion processing, combs the curriculum concept association and hierarchical relationship, and forms a complete and landing knowledge graph construction process. The practical application results show that this method effectively enhances the logic and intuitive display effect of the course knowledge system, enriches the digital teaching resources, provides strong support for personalized learning, and has a good demonstration effect on promoting the transformation of electrical engineering teaching to intelligent direction.*

Keywords: *Smart Education; Electrical Engineering; Knowledge Graph; Teaching Innovation; the Principle and Application of DSP*

1. Introduction

With the in-depth advancement of educational informatization, smart education has become an important strategic direction for the transformation of education modernization. As one of the core technologies in the intelligent education system, the knowledge graph can integrate the scattered and fragmented teaching resources into a clear and structured knowledge network, and present the logical relationship between knowledge points in a visual way, provide personalized learning paths for learners, and provide intelligent teaching support for teachers. It is the key support for the digital transformation of education [1-4]. Applying knowledge graphs to the modernization of professional courses in universities can further connect the data link between teaching and learning, and has practical value in improving classroom teaching effectiveness and implementing individualized teaching.

2. The Significance of Constructing a Curriculum Knowledge Graph

The core courses of the electrical engineering and automation major are characterized by abstract and abstruse theories, strong logical connections, and obvious interdisciplinary intersections. The content of professional courses includes a large number of difficult to understand theoretical formulas, as well as key knowledge points in multiple fields such as signal processing, circuit analysis, and control algorithms. Each knowledge point is nested and interlocked, and the knowledge content of the chapters before and after the course is closely connected. Students often find it difficult to clarify the internal connections between knowledge points during the learning process, which can lead to one-sided understanding of concepts and scattered knowledge systems, making it difficult to establish a complete and systematic understanding of the subject.

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The comparison between traditional teaching and knowledge graph teaching models is shown in Table 1.

Table 1 Comparison of Traditional Teaching and Knowledge Graph Teaching Mode

Comparison Dimension	Traditional Teaching	Knowledge Graph Teaching
Knowledge Presentation	Chapter-based teaching with relatively isolation	Network-structured correlations with clear logic
Learning Path	Unified teaching with consistent progress	Self-customization, and dynamic recommendation
Resource Acquisition	Distributed by teachers while students search for resources on their own	Resource binding and platform pushing
Learning Feedback	Depending on assessment and leading to delayed response	Full recording and real-time tracking
Teaching Decision-Making	Relying on teachers' experience and subjective judgment	Data analysis and precise adjustment
Autonomous Learning	Over-reliance on classroom teaching and weak student autonomy	Knowledge-graph-based navigation and independent inquiry
Knowledge Association	Limited knowledge scope and weak association	Strong association and achieving mastery through a comprehensive study

Compared with traditional teaching, the knowledge graph teaching mode has significant advantages in knowledge presentation, personalized learning path, real-time feedback of learning situation, and accuracy of teaching decision-making. It transforms the knowledge points of the course from "linear narrative" to "network association", enables students to build a knowledge system more systematically and actively and also provides teachers with more advanced teaching support. It is an effective way to promote the intelligent transformation of teaching in electrical engineering courses.

3. The Construction Plan of the Knowledge Graph for the "Principles and Applications of DSP" Course

"DSP Principles and Applications" is a core professional course in Electrical Engineering and Automation, and its teaching pain points are particularly prominent. The course integrates microcontroller hardware architecture, assembly language programming, peripheral configuration, and engineering debugging, with a deep coupling of theory and practice. Many students are able to independently master various scattered knowledge points, but lack a comprehensive understanding of the logical links between knowledge. The network structure of knowledge graph can precisely make up for this shortcoming, helping students break out of the perspective of isolated chapters and establish a holistic knowledge cognition for engineering applications. Therefore, introducing the curriculum into the knowledge graph teaching mode is of great significance.

The construction of the knowledge graph of the "DSP Principle and Application" course relies on the "Chaoxing Smart Online Teaching Platform". The course textbook "DSP Controller Principle and Application Tutorial" published by Professor Li Quanli of Higher Education Press is selected. The whole construction process is divided into four links: curriculum data acquisition, curriculum ontology construction, knowledge element identification and knowledge fusion processing, as shown in Figure 1.

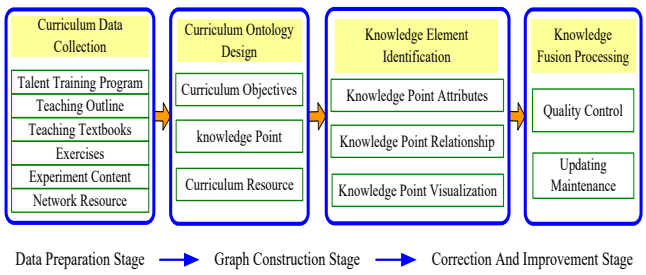


Figure 1 Construction Framework of Curriculum Knowledge Graph

1) Curriculum data collection: it is the preparation stage of the construction of curriculum knowledge graph, which can obtain teaching resources in many ways and lay a data foundation for the construction of curriculum knowledge system; 2) Curriculum ontology construction: including the

ISSN 2663-8169 Vol. 8, Issue 9: 67-73, DOI: 10.25236/IJNDE.2026.080911

confirmation of curriculum objectives, the extraction of knowledge points and the effective connection of curriculum resources, which is the macro framework of curriculum map construction; 3) Identification of knowledge elements: it is necessary to further complete the identification of attributes, relationships, and presentation of system knowledge points, which is the refinement process of knowledge graph construction; 4) Knowledge fusion processing: It is the correction and improvement stage of the construction of curriculum knowledge graph. Through continuous quality evaluation and update maintenance, the quality of knowledge graph is improved to the greatest extent [5-7].

3.1. Curriculum Data Collection

The data sources of the curriculum knowledge graph mainly fall into the following two categories:

On-campus teaching resources: Including the talent training program of electrical engineering major, the teaching outline of “DSP Principle and Application” course, teaching plan, experimental instruction manual, teaching calendar, exercise set, etc., are the basic and normative resource content of knowledge graph construction [8-10].

Online teaching resources: Including various public teaching videos, course-related technical documents and professional exchange forums of the “DSP Principle and Application” course, which are supplementary and expanding resource content of knowledge graph construction [11].

3.2. Curriculum Ontology Design

The main process of curriculum ontology design is as follows:

Objective: According to the talent training objectives and requirements of electrical engineering major, the teaching objectives of "DSP Principle and Application" course are sorted out, which provides a clear guidance direction for the construction of knowledge system and resource matching of the following courses.

The knowledge point system: Mainly completes the five-level content classification of “course →knowledge system →knowledge unit →knowledge set → knowledge point”. Among them, the “course” of this study corresponds to “DSP principle and application”; the “knowledge system” is the content of the textbook chapter (such as the structural principle, interrupt system and timer of F28335); “Knowledge unit “ is the content of the course section (such as F28335 CPU, CPU timer, etc.); “Knowledge set” is a set of related knowledge points (such as register group, timer structure principle, etc.); “Knowledge point” is the smallest knowledge unit (such as accumulator ACC, periodic register, etc.).

Curriculum resources: Establish the corresponding relationship and organic connection between knowledge points and experimental projects, exercises and cases, and form a complete and unified teaching resource system.

3.3. Knowledge Element Identification

The identification of knowledge elements mainly includes three core steps:

Define the attributes of knowledge points: from the cognitive dimension, it is divided into factual, conceptual, procedural, metacognitive and other types, which are used to distinguish the learning focus of different knowledge points; from the perspective of teaching application, it distinguishes the labels of key points, difficulties, test points, expansion, ideological and political education and so on, which are used to clarify the teaching weight of each knowledge point and provide support for hierarchical teaching and personalized learning.

Arrange the relationship of knowledge points: the knowledge points in the platform are divided into pre-relationship (essential basis), post-relationship (advanced extension), correlation relationship (complementary assistance), and cross-chapter, cross-course and interdisciplinary knowledge links can be achieved. When sorting out the interrelationships between knowledge points, special attention should be paid to distinguishing the strength level of the relationships. The prerequisite relationship is a necessary foundation that must be mastered and a hard prerequisite for subsequent learning; Post relationship represents the expansion and extension of knowledge; The association relationship only represents complementary reference to the content and is not a necessary condition for learning. Distinguishing the strength of relationships can avoid the graph displaying all links with equal weights,

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and prevent students from being disrupted by a large number of network connections that interfere with the core learning mainline.

Visualization of knowledge points: “Chaoxing Teaching Platform” provides five view modes of knowledge graph: graph, ring graph, tree graph, map and 3D graph. Users can flexibly choose to switch according to teaching needs and preferences, intuitively view knowledge levels and logical relationships, thereby improving learning and teaching efficiency.

Based on the three steps of Section 2.1, Section 2.2, and Section 2.3, the knowledge points of each chapter of the "DSP Principle and Application" course can be determined and entered in the knowledge graph editing interface of the "Chaoxing Platform". The screenshots of some chapters are shown in Figure 2.

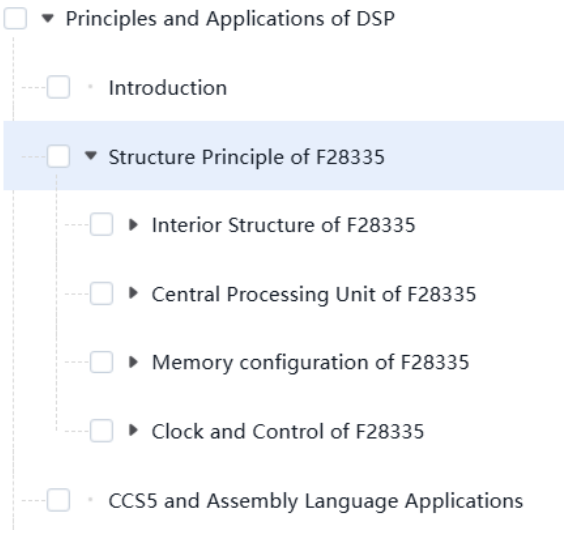


Figure 2 Editing Interface of Curriculum Knowledge Graph

After editing the knowledge points and associations of all chapters, the system can “automatically” generate a hierarchical image of the curriculum knowledge graph, some sections are shown in Figure 3. The intelligent color matching scheme is selected in the process of graph generation, and each knowledge point is distinguished by different colors. It is selected to be distributed in a ring topology, which can realize the flexible scaling of the image.

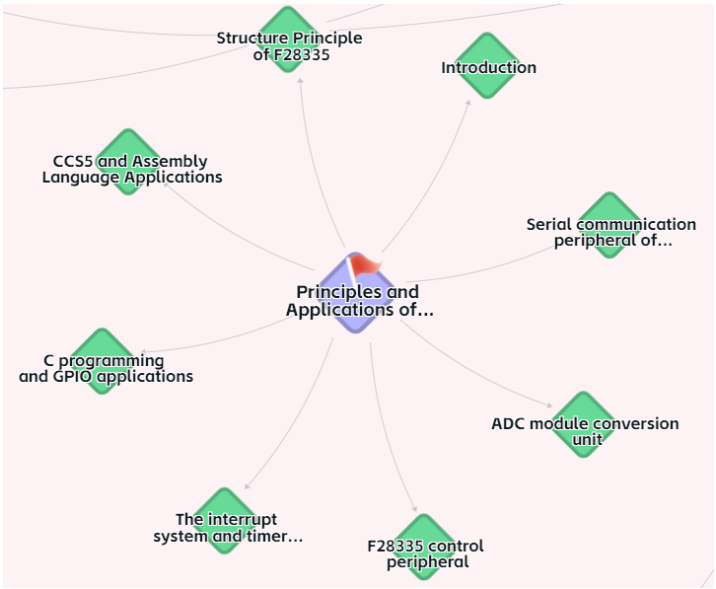


Figure 3 Knowledge Graph of “DSP Principle and Application”

The knowledge graph construction of “Chaoxing Smart Online Teaching Platform” can associate each knowledge point with various digital resources, and students can view the relevant teaching

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materials related to the platform by “clicking on the link”. The platform can also realize automatic tracking and recording of students' learning data, which is convenient for teachers to count and flexibly adjust teaching strategies. In addition, the “Chaoxing platform” also has the function of “intelligent marking” of video knowledge points, which can automatically identify the key knowledge points in the teaching video, and make corresponding time marks in the prompt bar, so that users can jump to learn according to their own weak links.

3.4. Knowledge Fusion Processing

Knowledge fusion processing mainly includes two parts: quality control and updating maintenance:

Quality control: It requires a team of teachers from the Electrical Engineering major (3 or more people) to conduct regular quality review of the knowledge graph according to the three evaluation criteria of “accuracy, integrity and timeliness”. Among them, “accuracy” requires that the expression error rate of knowledge content is not higher than 3%; "Integrity" requires that the coverage of knowledge points should reach more than 95% of the teaching content; “Timeliness” requires the frequency of updating the new technology and new theoretical content of the course once a year [12-14].

Updating maintenance: Calculate the learning behaviors of students in a teaching round, such as the duration of video learning, the number of clicks on extended resources, and the duration of knowledge point stays, and summarize and analyze the quality of knowledge graph construction. At the same time, a satisfaction survey questionnaire was released to identify and fill in the gaps, and continuously optimize the construction effect of the course knowledge graph [15].

4. The Teaching Application of Knowledge Graph

The teaching application of knowledge graph is mainly as follows:

The application of teachers in teaching: The clear knowledge network of the knowledge graph is convenient for teachers to grasp the main structure of the course teaching, with prominent focus and clear hierarchical structure. The system can intelligently push lesson preparation resources related to curriculum teaching to teachers and improve teachers' teaching efficiency. Teachers can combine the actual learning behavior data of students to quickly and accurately identify the common difficulties and individual weaknesses of the course, provide support for dynamic adjustment of teaching strategies, and truly teach students in accordance with their aptitude [16-17].

The application of students in learning: Knowledge graph integrates scattered knowledge points into a complete knowledge network, so that the logical relationship between knowledge points becomes clear at a glance. According to the students' personal knowledge mastery, the system intelligently recommends personalized learning programs, supports independent planning and accurate review, and is more conducive to the integration of knowledge in various disciplines.

The application in teaching management: The knowledge graph provides intuitive course learning data statistics for managers, which ensures the authenticity and objectivity of the evaluation system. At the same time, the resource allocation can be continuously optimized according to the learning feedback of students and teachers to form a continuously improved closed-loop teaching management model.

After a round of teaching trials, it was found that knowledge graphs belong to teaching aids and have their own application boundaries. Knowledge graphs excel at organizing and navigating theoretical knowledge, but practical knowledge such as practical experience and troubleshooting in hardware debugging is difficult to fully translate into standardized node relationships. At the same time, the platform can only collect learning behavior data and cannot directly equate to students' knowledge mastery level. Therefore, in the process of teaching implementation, it is necessary to adhere to the combination of knowledge graph navigation, classroom teaching, and practical assessment. Knowledge graphs cannot completely replace traditional teaching processes. Only by coordinating multiple teaching methods can the value of knowledge graphs in smart teaching be maximized.

5. Conclusion

This study takes the course of "DSP Principle and Application" as a practical case, and systematically explores the application path and practical value of knowledge graph technology in

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professional course teaching. During the research process, it is necessary to first organize various course materials such as textbook texts, courseware PPTs, and post class exercises, and complete the collection of basic data; Secondly, sort out the subordination, derivation, and correlation relationships between course concepts, theorems, and algorithms, and do a good job in constructing the ontology framework; Then classify and label teaching elements such as knowledge points, key and difficult points, and exercises; Finally, complete the fusion processing of multi-source teaching content. The research shows that the curriculum knowledge graph constructed based on the “Chaoxing Smart Online Teaching Platform” successfully realizes the structured reorganization and intelligent presentation of the curriculum knowledge system through the closed-loop process of “data acquisition-ontology construction- element identification -fusion processing”. It effectively improves the problems of scattered and isolated knowledge in traditional teaching, enriches teaching resources, improves the quality of course learning, and has positive demonstration and promotion significance for the teaching reform of electrical engineering courses.

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