

The Construction of Online Course Knowledge Graphs for Smart Education

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Keywords: Knowledge Graph, Smart Education, Online Courses, Artificial Intelligence

Abstract: This study aims to address issues such as fragmented resources and insufficient personalized teaching. This paper proposes a construction process covering four stages: course resource collection, knowledge system construction, knowledge storage, and knowledge processing. Taking the "Fundamentals of Python Programming" course as an example, the practice was carried out based on the Chaoxing platform. The research shows that the subject knowledge graph can effectively integrate multi-modal teaching resources, support visual knowledge navigation and personalized learning path recommendations, provide technical support and practical paths for smart teaching, and has good teaching applicability.

1. Introduction

Amidst the rapid development of artificial intelligence and the digital transformation of education, smart education has become a key direction leading teaching reform and educational innovation. In 2018, the Ministry of Education issued the "Education Informatization 2.0 Action Plan" notification, which clearly stated the action essentials of "actively carrying out smart education innovation research and demonstration based on emerging technologies such as artificial intelligence, big data, and the Internet of Things, relying on various smart devices and networks, to promote the model change and ecological reconstruction of education supported by new technologies" [1].

As an important carrier of smart education, the construction quality of online courses is crucial. However, the development of online courses in China faces problems such as fragmented teaching resources, singular knowledge structures, passive teaching methods, coarse targeting of learners, and outdated teaching content, making it difficult to meet personalized education needs [2]. As a core technology of smart education, knowledge graphs can integrate educational data and provide strong support for teaching. Knowledge graphs can structure and semanticize teaching resources. They help students build knowledge systems through structured knowledge representation and semantic tags; provide personalized learning paths and resource recommendations based on students' learning situations; and assist teachers in teaching design and optimizing teaching content [3].

Based on this research background, this paper focuses on the construction of online course knowledge graphs for smart education, deeply explores the construction methods and implementation processes of subject knowledge graphs, and takes the "Fundamentals of Python Programming" course as an example to elaborate on the construction process of the course knowledge graph on the Chaoxing platform.

2. Conceptual Analysis

2.1. Smart Education

The concept of smart education was formally proposed by Professor Zhu Zhiting in 2012 [4]. Professor Zhu believes that smart education is technologically supported by smart learning environments, fundamentally based on smart learning, and catalyzed and facilitated by smart teaching methods. Since then, smart education has continuously developed in both theory and practice. Professor Zhu Zhiting [5] found that the future development space of smart education exists in seven aspects: high-awareness learning, skills-based education, human-machine collaborative education, development and application of digital textbooks, construction of the educational metaverse, educational intelligence development, and cultivation of innovative talents. In terms of practical development, Professor Zhong Zhixian [6] believes that China's smart education has gone through the embryonic stage of Education Informatization 1.0 (2012-2017), the development stage of Education Informatization 2.0 (2018-2021), and the comprehensive acceleration stage of digital transformation of education (2022 and beyond).

2.2. Relationship between Subject Knowledge Graph and Smart Education

Subject knowledge graphs provide important support for the development of smart education, and the development of smart education also provides broad space for the application of subject knowledge graphs. They promote each other and jointly drive the innovation and transformation of education. Professor Li Yanyan believes that subject knowledge graphs assist in the construction of a smart education system framework and the reconstruction of the smart education ecosystem [7]. Scholar Zhang Huinan believes that subject knowledge graphs effectively align with the learner-centered educational concept in smart education in three aspects: course content, knowledge graph visualization, learning paths, and data, providing support for smart teaching and smart assessment [8].

In summary, the further development of smart education needs to break through the difficulties in online course resource integration and personalized teaching. This paper will focus on the specific issue of constructing course knowledge graphs within subject knowledge graphs, take the "Fundamentals of Python Programming" course as an empirical case, and systematically elaborate its construction method and implementation process on the Chaoxing smart education platform.

3. Construction Process of Online Course Knowledge Graph for Smart Education

This study proposes a construction process for online course knowledge graphs, following the main line of "Collecting course resources --- Knowledge system construction --- Knowledge storage --- Knowledge processing" to transform raw course teaching resources into a systematic course knowledge network, as shown in Figure 1 below.

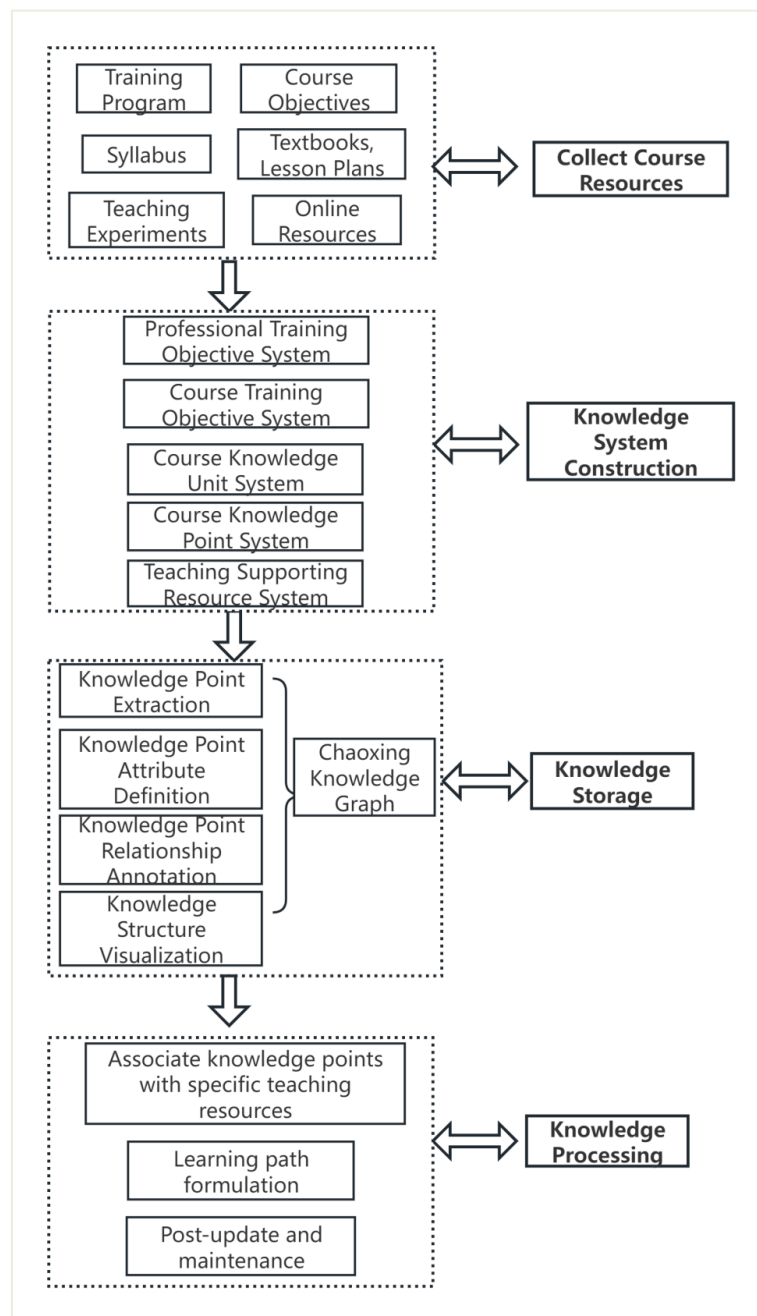


Figure 1: Construction Process Flowchart of Online Course Knowledge Graph for Smart Education

The construction of the course knowledge graph is divided into four steps: 1. Collect course resources: Collect course resources such as training programs and textbooks; 2. Knowledge system construction: Extract a hierarchical system of training objectives, knowledge points, etc. from them; 3. Knowledge storage: Extract knowledge points, define attributes and relationships through the smart education platform, and visually present the knowledge structure; 4. Knowledge processing: Associate knowledge points with teaching resources to empower personalized learning paths.

4. Construction of the Knowledge Graph for the "Fundamentals of Python Programming" Course

This study takes the "Composite Data Types" chapter of the "Fundamentals of Python

Programming" course as an example, based on the Chaoxing smart education platform, and systematically elaborates the specific construction process of the course knowledge graph, including four key links: resource collection, knowledge system construction, graph creation, and knowledge processing.

4.1. Collecting Course Resources

Before constructing the knowledge graph for "Composite Data Types", the teaching resources related to this module were systematically collected and organized. The collected resources mainly include the following three categories: ① Teaching Content Resources: Professional talent training program, syllabus of "Fundamentals of Python Programming", lesson plans, PPT courseware, teaching videos, etc. ② Practice and Assessment Resources: Course experiment assignment sheets, programming exercises, phase test questions, typical student error code examples, etc. ③ Extension Resources: Python official documentation for "Composite Data Types" knowledge points, open-source cases from the internet, course ideological and political resources, etc.

The above resources are uniformly archived in digital form to form a raw resource database, providing a data foundation for subsequent knowledge extraction and structured modeling.

4.2. Constructing the Course Knowledge System

Based on the collection of course teaching resources and the teaching content of textbooks and lesson plans, combined with the teaching experience of subject experts and instructors, the knowledge system for the "Composite Data Types" module was constructed. The content structure diagram of this course module is shown in Figure 2 below.

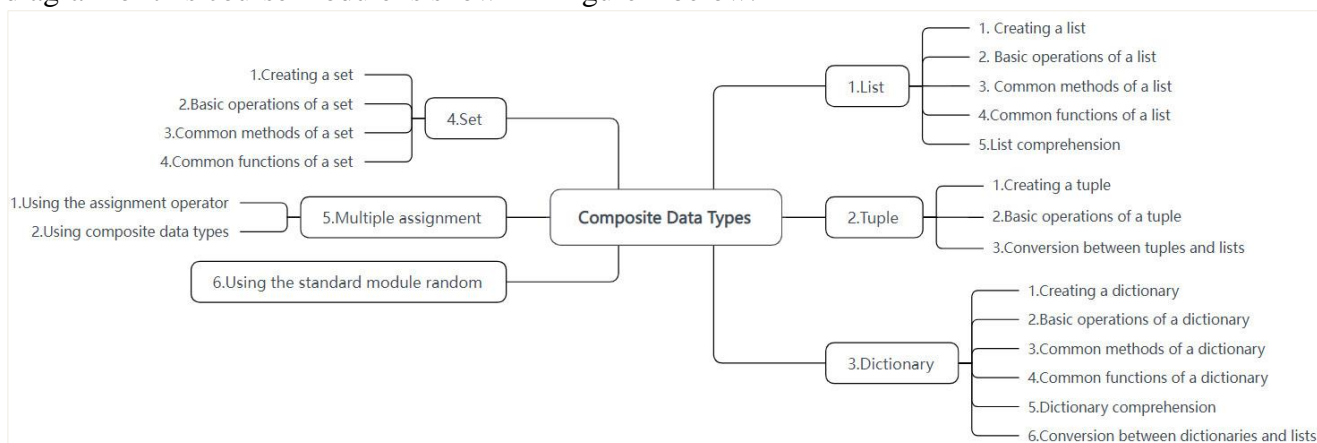


Figure 2: Content Structure Diagram of the "Composite Data Types" Course Unit

4.3. Creating the Chaoxing Knowledge Graph

After completing the knowledge system design, the specific construction work of the knowledge graph for the "Composite Data Types" module was carried out using the knowledge graph construction tools of the Chaoxing smart education platform. The operation process is as follows.

Step 1: Create Outline.

Click on the "Course Graph" navigation in Chaoxing, enter the "Outline Mode" in the "Knowledge Graph" entry. You can manually add module knowledge points, or use the "Batch Import" function provided by the Chaoxing platform. For the hierarchical structure and relationship definition of the "Composite Data Types" module knowledge points, select the Excel template form

in the "Template Import" option.

Step 2: Attribute Editing.

Attribute editing involves adding structured labels to knowledge points: set difficulty (beginner /intermediate /advanced), type (conceptual/methodical/applied), importance (core/extension) and other basic attributes; set teaching objectives (memory/understanding/application, etc.) based on Bloom's cognitive taxonomy.

Step 3: Relationship Setting.

Relationship setting defines the logical associations between knowledge points: the platform supports default prerequisite/postrequisite relationships (learning order), and affiliated relation (content-related); teachers can customize semantic types such as causality, composition, progression, etc.

After attribute and relationship configuration, the knowledge graph is upgraded from static content to a semantic network. Finally, the knowledge graph of this module is shown in Figure 3 below.

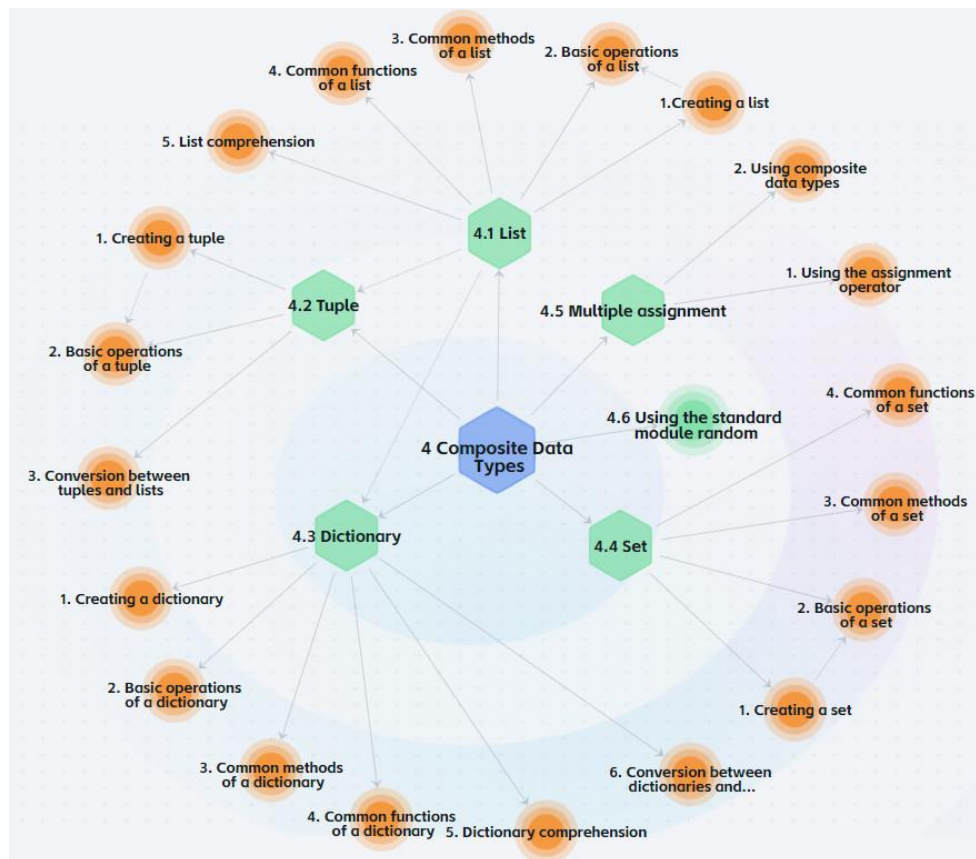


Figure 3: Course Knowledge Graph of the "Composite Data Types" Unit

4.4. Course Knowledge Processing

This stage focuses on the following three aspects:

(1) Resource Association

Resource association involves linking teaching resources to knowledge points, forming an integrated "learning-testing-extension" resource package. The platform's resource attribution is divided into three categories: Learning Resources: link teaching videos, PPTs, PDF handouts, etc., to support knowledge transmission. Assessment Resources: link question bank questions, assignments, tests, typical error cases, to achieve knowledge point-level testing. Extension

Resources: link e-books, academic journals, corporate cases, to meet in-depth learning needs.

(2) Personalized Learning Path Formulation

Based on the relational structure of the knowledge graph and combined with students' mastery status of knowledge points, the system can automatically generate personalized learning paths. Using the knowledge graph function of Chaoxing, the system can break down the course content into several knowledge points and clearly present their logical associations and hierarchical structure. Teachers can intuitively grasp students' completion rate and mastery rate for each knowledge point, promptly identifying weak links in teaching. The Chaoxing platform can identify students' knowledge weaknesses and automatically generate personalized learning paths based on this. Students can quickly locate their own deficiencies and carry out self-directed learning.

(3) Graph Updating and Maintenance

The knowledge graph has dynamic evolutionary characteristics. In this course practice, teachers iteratively update the graph once per semester based on student feedback, teaching effect evaluation, and technological development, including adding new knowledge points, revising relationship strength, and replacing outdated cases, ensuring the timeliness and teaching adaptability of the graph content.

5. Conclusion

This study focuses on the construction of online course knowledge graphs in the context of smart education, taking the "Fundamentals of Python Programming" course as an example and carrying out practical exploration on the Chaoxing platform. The research shows that subject course knowledge graphs can effectively integrate scattered teaching resources, build a clearly structured and semantically rich knowledge network, provide personalized learning paths for students, and offer a reference for further exploration of smart education.

Acknowledgements

Funding Agency:

(1) Teaching Design and Practice of Computer Courses Based on Generative Artificial Intelligence—Taking "Fundamentals of Python Programming" as an Example (2024JXGG41)

(2) 2025 School-level Digital-Intelligence Integration Excellent Course of Guangzhou College of Commerce: Software Modeling and Analysis (XJYXKC202533)

(3) Research on Blended Teaching Model of Computer Public Courses Based on Knowledge Construction (2024-AFCEC-309)

(4) Design and Practical Research on Teaching Cases of Object-Oriented Programming Courses Integrating Ideological and Political Elements Empowered by AIGC (2025-AFCEC-355)

(5) Exploration of Project-Based Learning Model for Computer Basic Courses Supported by AI Technology (2025-AFCEC-356)

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