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The Application of Knowledge Graph in Higher Mathematics Teaching

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Abstract: ***Higher mathematics is characterized by many knowledge points, complex relations and strong logic. In order to help students sort out the internal relations between knowledge points, and visually display the relations between knowledge points, knowledge graph is applied to the teaching of higher mathematics. Based on the analysis of the related knowledge of knowledge graph, by using the tools such as protégé and python, this paper expounds the construction and application of knowledge graph in higher mathematics. Taking the higher mathematics course of Beijing union university as an example, the teaching practice shows that enabling higher mathematics teaching through knowledge graph can effectively improve students' academic performance, and also shows the effectiveness of knowledge graph construction.***

Keywords: Knowledge graph, Higher mathematics, Knowledge graph construction, Teaching effects**.**

1. Introduction

Knowledge Graph is a modern theory that combines the theory and method of applied mathematics, graphics, information visualization technology, information science and metrology citation analysis, co-occurrence analysis and so on, and visualizes the core structure, development history, frontier field and overall knowledge structure of the discipline to achieve the purpose of multi-disciplinary integration. In May 2012, Google released the knowledge map project [1], While proposing knowledge graph, Google applied the knowledge map to search engine services, which through semantic search, return more accurate structured information, and improve the accuracy and completeness of information search, enhance the user's search experience. Tsinghua University proposed an accurate and efficient domain knowledge map construction method- "four-step method", and constructed the knowledge map of nine disciplines of basic education in a relatively short time [2]. Zhang Meng has analyzed the curriculum knowledge ontology and the curriculum knowledge map construction method [3]. Liu and Li introduced the teaching reform scheme of information theory based on knowledge graph [4]. Yuan Ming has studied a learning path recommendation method which is based on the structural expression of junior middle school mathematics knowledge by using knowledge graph and combined with the individual characteristics of learners [5]. Gao Wenliang and his colleagues took the public course of graduate mathematics in Wuhan Institute of Technology as an example to construct a knowledge map, introduce the process of extracting the entities and relationships of the knowledge map, and the method of applying the knowledge map to the teaching of the public course of graduate mathematics [6]. Ge Qiping, Zhong Yanru analyzed ontology and knowledge graph related concepts, partially excavated mathematics knowledge and combined knowledge graph representation technology, to implement construction and visualization of knowledge graph based on mathematics teaching in junior middle school. by recognizing related concepts of graph [7]. Li Yanru, etc. discussed the construction process and application of the subject knowledge map for middle school students, and specifically elaborated the method and steps of constructing of the People's Education Edition high school mathematics subject knowledge map [8]. Taking the mathematics course as the research object, Zhang Chunxia and his colleagues constructed mathematics curriculum ontology, developed a method of constructing mathematics curriculum knowledge graph based on mathematics curriculum ontology, and proposed and implemented a knowledge reasoning method based on mathematics curriculum knowledge graph [9].

At present, the application of knowledge map in the field of higher education is not mature, because there are many knowledge points in university mathematics curriculum, and the relationship between knowledge points is complicated, it is difficult to construct university mathematics knowledge map, which is not as simple as elementary mathematics. The application of knowledge graph in college mathematics curriculum is relatively few. Higher mathematics is a compulsory course for all college students of science and engineering. It is very important to train students' ability of logical thinking, analyzing and solving practical problems. The teaching quality directly affects the college students' subsequent professional learning and quality improvement. According to the survey, higher mathematics is also a course in college with a high failure rate. On the one hand, because of the characteristics of the higher mathematics course itself, students can basically grasp each knowledge point through the study of one academic year, but it is difficult to penetrate the links between knowledge points and build them into a whole, thus forming a complete knowledge system. On the other hand, the difference of educational environment and educational resources that college students receive before entering the university makes the students of the same major or the same class have great difference in cognitive level and learning style, even when they study the same mathematics knowledge, they will have different learning effects. Therefore, it is necessary to study the adaptability of the teaching strategy of higher mathematics under the new background requirements, and better play the role of higher mathematics in the process of cultivating innovative undergraduate talents.

2. Knowledge About Knowledge Maps [10-12]

2.1 Knowledge Extraction

Knowledge extraction refers to the automatic discovery and extraction of relevant information from text, and the merging of information in multiple text fragments to transform unstructured data into structured data, including patterns, entity relationships or PDF triples in a specific field. Knowledge extraction includes text-oriented entity extraction, relation extraction and event extraction.

1) Entity extraction

Entity extraction, also known as named entity recognition, is to extract entity information elements from text, including human name, organizational name, geographical location, time, date, character value and monetary value, etc. To extract entities from text, we first need to identify and locate entities from text, and then classify the identified entities into predefined categories.

2) relation extraction

Relation extraction is to extract semantic relations between two or more entities from text. Relation extraction is closely related to entity extraction. Generally, after recognizing the entities in the text, the possible relations between entities are extracted.

3) Event extraction

Event extraction refers to extracting the event information that the user is interested in from the natural language text and presenting it in a structured form, such as the time, place, cause and participants of the event.

2.2 Knowledge Storage

There are three kinds of knowledge map databases in common knowledge storage: relational database-based storage scheme, RDF-oriented triple database and native map database.

2.3 Knowledge Fusion

Knowledge graph includes ontology layer which describes abstract knowledge and strength layer which describes concrete facts. The ontology layer is used to describe abstract concepts, attributes and axioms in the undetermined domain; the instance layer is used to describe specific entity objects and relationships between entities, including a large number of facts and data. Knowledge fusion, i.e. merging two knowledge maps (ontologies) to fuse descriptive information about the same entity or concept from multiple sources. Knowledge fusion is an effective way to solve the problem of heterogeneous knowledge graph. Knowledge fusion establishes the relationship between heterogeneous ontologies or heterogeneous instances, so that heterogeneous knowledge graphs can communicate with each other and realize their interoperability.

3. Construction of Knowledge map of Higher Mathematics

Firstly, the schema data model is constructed based on the knowledge points of higher mathematics teaching materials by protégé tool. Secondly, higher mathematics textbook content [13] and exercise teaching content are converted into docx format. The documents are parsed by python and python-docx software package, and integrated into knowledge point standard format. And then the knowledge base of teaching materials and exercise books are extracted according to the schema data model and stored in the database by entity extraction, relation extraction and attribute extraction, and finally the knowledge map of higher mathematics is constructed by knowledge fusion (Figure 1).

The map of knowledge in higher mathematics is shown in Figure 2.

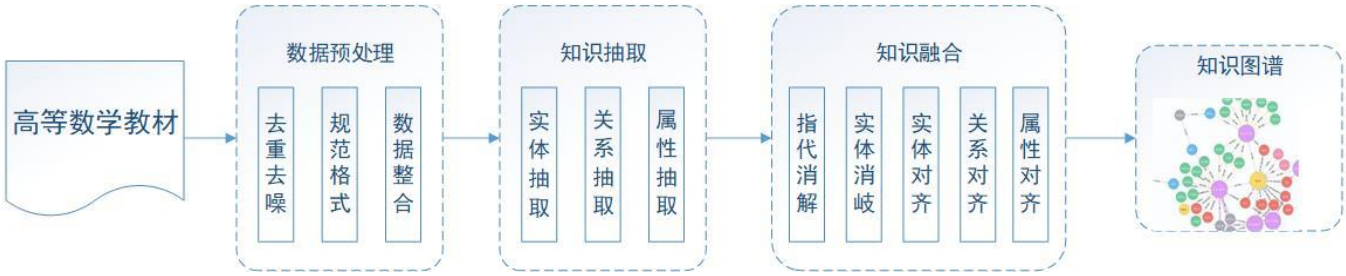

Figure 1: Knowledge Graph Framework of Higher Mathematics

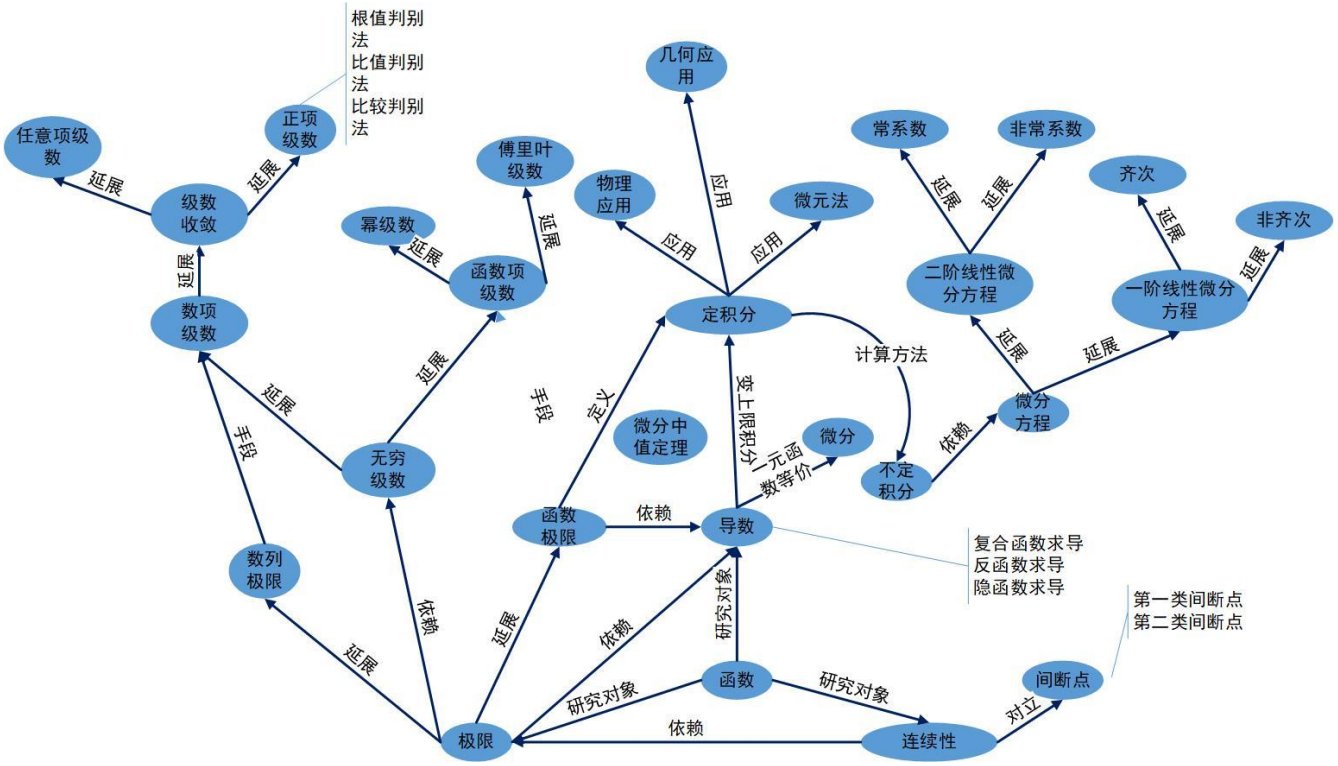

Figure 2: Presentation of knowledge graph of higher mathematics

4. Application and Conclusion of Knowledge Graph of Higher Mathematics

Knowledge graph of higher mathematics is of great significance to improve the teaching effect of higher mathematics. (1) Knowledge graph can provide the internal relations between the knowledge points of the course, and presents the relations between the knowledge points in the form of visualization. Students can clearly understand the relationship between knowledge points by using the knowledge map of higher mathematics, and check the omissions to fill the gaps, and do the corresponding exercises to grasp the knowledge points that they have not mastered, so as to improve students' learning efficiency. (2) Using the knowledge map of higher mathematics, teachers can prepare lessons, teach lessons, optimize curriculum teaching, show the logical relationship between knowledge points to students, make students understand the main problems to be solved in a class and the important knowledge points to be learned, and improve teaching quality and teaching achievements. In addition, teachers can let students build the "mini knowledge framework" of each chapter through the knowledge graph, build the link between each " mini knowledge framework", and targeted preview and review. It is helpful for students to understand the whole frame of higher mathematics and know the context of knowledge points.

In recent years, the teaching and research group of the Department of Mathematics and Science of Beijing United University has carried out teaching activities in the teaching of higher mathematics by using the teaching knowledge map, and improved the higher order and challenge of the course content. Students of Class 22104B (Ordinary Class) of Grade 2022 in our school have obtained the following results in the final examination paper of higher mathematics in the first semester of the 2022-2023 academic year after using the higher mathematics knowledge map.

Table 1: Final Exam Paper Results for Students of Class 22104B, Grade 2022, Beijing Union University

	More than 90 minutes (Excellent)	80-89 minutes (good)	70-79 minutes (medium)	60-69 minutes (Pass)	Under 60 (Failure)	Total pass
59 persons	6 persons	23 persons	23 persons	6 persons	1 person	58 persons
Percentage	10.17%	38.98%	38.98%	10.17%	1.69%	98.31%

From Table 1, we can see that the pass rate is very high, only one student failed; the number of people with more than 80 points accounted for nearly 50%, which shows that the higher mathematics knowledge map is very helpful to improve students' grades.

5. Summary

This paper discusses the application of knowledge map of higher mathematics in improving students' learning achievement and teaching effect. As a hot technology in the context of artificial intelligence, knowledge graph has been gradually applied to the field of education, which has injected new vitality into higher education and will become an important trend in future education. Through the deep integration of disciplinary knowledge map and education system, it is expected to provide important support for students' learning and development, mobilize students' enthusiasm for learning, and contribute to the digital transformation of education.

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