

Exploration of Discrete Mathematics Teaching Reform for Professional Accreditation of Higher Engineering Education

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Abstract: Discrete mathematics is one of the professional core courses in the major category of computer science, to meet the teaching objectives of discrete mathematics in the engineering education certification of computer science and technology, we carry out reforms in terms of sorting out the teaching objectives and the teaching methods, teaching methods and assessment methods to meet the characteristics of discrete mathematics as well as the problems existing in traditional teaching. The results of the teaching practice show that the students' learning initiative and learning synthesis skills have improved.

Keywords: Engineering Education Professional Accreditation; Discrete Mathematics; Teaching Reform; Assessment Methods.

1. Introduction

The professional certification of higher engineering education (referred to as professional certification) clarifies the requirements for implementing the fundamental task of cultivating people with moral integrity. At the same time, in accordance with the conceptual requirements of the "Washington Accord, WA", it states that it is "student-centered" and "student-centered". "Output Oriented (OBE)", takes the "output target evaluation mechanism as the bottom line" certification requirements, and adheres to "continuous improvement" to cultivate students' ability to solve "complex engineering problems" and "logical thinking ability" in the future [1], ensuring that the training requirements for undergraduate-level engineering talents with engineers as the training goal are met. Carrying out professional accreditation can further promote China's reform in engineering education, improve the adaptability of engineering education talents to industrial development, and at the same time enhance international competitiveness [2].

The National Standard for Teaching Quality of Undergraduate Professional Classes in General Colleges and Universities prepared by the Teaching Guidance Committee of Higher Education Schools of the Ministry of Education, as well as the computer textbook CC2013 jointly developed by the American Computer Society, ACM, and the Institute of Electrical and Electronics Engineers in the Computer Section, IEEE-CS, the course of Discrete Mathematics is listed as one of the core courses for the computer science majors [3]. Discrete mathematics is the core foundation course for computer science and technology majors, which aims to study the structure of discrete quantities and the relationship between them, fully embodies the characteristics of discrete computer science and technology, and is an important foundation for the subsequent specialized courses in computer such as data structure and algorithm analysis, computer network, operating system, compilation principle, software engineering, database system principle, artificial intelligence, circuit and logic design, etc. It plays an important basic theoretical supporting role in the computer science and technology professional curriculum system [4]. Therefore,

oriented to the requirements of professional accreditation, this paper describes the reform methods of the discrete mathematics course in terms of teaching objectives, teaching mode, teaching methods, and assessment methods.

2. Refine Teaching Goals and Closely Follow Graduation Requirements

According to the requirements of professional accreditation, it is necessary to clarify the correspondence between teaching objectives and graduation requirements, in addition to clarifying teaching content and course objectives. According to the basic requirements for graduation stipulated in China Engineering Education Accreditation Standards 2022 Edition, for computer science and technology majors, discrete mathematics is one of the main courses supporting the graduation requirement index points. In professional accreditation, the discrete mathematics course requires students to achieve the following three teaching objectives, to lay a solid theoretical foundation for the subsequent specialized courses in computers [5], and at the same time, to cultivate the students' ability to think logically and to ability to solve complex engineering problems, and to provide a theoretical foundation for the enhancement of lifelong learning ability.

Objective 1: To be able to use the properties and basic principles of sets and relations, to establish the mathematical idea of combining numbers and shapes, and to develop students' ability to analyze and describe problems from the viewpoint of sets and relations.

Objective 2: To be able to memorize and understand the basic concepts of graphs and trees, and to be able to apply the fundamentals of graph theory, oriented to computational systems and computational processes, to select or build descriptive models, and design algorithms in practical problems.

Objective 3: To be able to understand the basic principles of propositional and predicate logic, to be able to understand the use of formal logical reasoning and mathematical proofs to identify and determine complex computer problems, and to be able to effectively decompose complex engineering problems.

Corresponding to these three pedagogical objectives are the supporting professional certification graduation requirement indicator points respectively:

Supporting Indicator Points for Teaching Objective 1 Corresponding to Graduation Requirements 1: To be able to correctly understand the professional formulation of computational problems, and to use mathematics, natural sciences, engineering fundamentals, and specialized knowledge in the formulation of computational problems.

Teaching Objective 2 corresponds to Graduation Requirements Supporting Indicator Point 2: To be able to select or build appropriate descriptive models and solve them for computational systems and their computational processes.

Instructional Objective 3 corresponds to Graduation Requirements Supporting Indicator Point 3: Be able to correctly identify and determine computerized complex engineering problems and effectively decompose complex engineering problems.

In the course of the lectures, the textbook used is Discrete Mathematics (Second Edition) edited by Geng Suyun and Qu Wanling, and the specific contents of the lectures are related to the teaching objectives and the supporting graduation requirement index points as follows: first, mathematical logic, corresponding to the teaching objective 3; second, set theory, corresponding to the teaching objective 1; and third, graph theory, corresponding to the teaching objective 2.

3. Teaching Reform for Professional Accreditation

After clarifying the correspondence between the teaching objectives of the discrete mathematics course and the indicator points of the graduation requirements, it is necessary to implement the graduation requirements of the computer science and technology program throughout the teaching process, in addition to completing the teaching content. Discrete mathematics is characterized by a high degree of

abstraction and unity of modern mathematics, and the teaching contents are both independent of each other and organically combined. Therefore, to complete the teaching content with high quality in limited class time, the whole teaching process needs to be reformed in the teaching mode, teaching method, and teaching assessment [2].

3.1. Adoption of “Online + Offline” Blended Teaching Mode

Discrete mathematics courses are characterized by many abstract contents, many concepts and strong theory. It plays a very important role in the training of abstract and logical thinking, and the subsequent study of specialized courses. However, due to the limited teaching hours, the main contents of discrete mathematics cannot be fully covered. The teaching content is divided into three parts, namely, mathematical logic, set theory, and graph theory, totaling 48 hours. To accomplish a large amount of teaching content with high quality in a small amount of class time, a hybrid teaching mode of “online + offline” is adopted. The teachers in the group have recorded 100 hours of micro-lesson videos, which contain the basics of the content, as well as key and difficult content. To achieve the three teaching objectives in the professional certification, the teaching content of each part is split, and the concepts and knowledge points that are easy for students to grasp are allowed to be self-study by watching videos under the classroom. Classes explain the theorems and related derivation proofs of the corresponding contents, the correlation relationship between the knowledge points, the relationship between the knowledge points and other specialized courses, and the application of the knowledge points in the field of artificial intelligence and other fields, in order to develop the students' ability to think abstractly and logically, as well as the ability to link theory to practice. The content of each chapter is broken down as shown in Table 1.

Table 1. Discrete math content decomposition

Chapter	Self-study content	Lecture content
Propositional logic	Propositions and connectives, truth tables	Propositions and propositional symbolization, propositional formulas and assignments, equivalence calculus, disjunctive and conjunctive normal forms, reasoning theory of propositional logic
First-order logic	Predicate formulas, substitution rules	Basic concepts and symbolization of first-order logic, first-order logic formulas and interpretations, first-order logic equivalences, and prenex normal form
Basic concepts and operations of sets	Basic concepts of sets, relationships between sets, and intersection, union, and complement operations	Power sets of sets, set identities, counting finite sets
Binary relations and functions	Basic operations on relations, definition and properties of functions, inverse functions	Cartesian product of sets, properties of relations, closure of relations, equivalence relations and partial order relations, composition of functions
Basic concepts of graphs	Definition of undirected graphs and directed graphs	Handshake theorem, pathways, loops, connectivity of graphs, matrix representation of graphs
Tree	Concepts of undirected trees, rooted trees	Spanning tree, Huffman algorithm, optimal prefix code, rooted tree and its applications

Through practice, the “online + offline” hybrid teaching mode has played a very good teaching effect. Online resources through the “Blue Ink Cloud Class” as a supplementary teaching platform, the teacher arranges teaching activities to enhance the teaching effect, such as homework/group tasks, chapter tests, brainstorming, live broadcast/discussion, etc. If students need to study online, teachers need to design the online learning content in advance,

upload the videos that require students to learn the knowledge points on their own through the cloud class APP, and then randomly check the students' self-study knowledge points in the offline class, and at the same time, they can also check the students' mastery of the online learning knowledge points through homework.

3.2. Reform of Teaching Methods

3.2.1. Typical Case-driven to Achieve Teaching Goals

The core idea of professional certification is to cultivate students' lifelong learning ability and make students realize that discrete mathematics is not a pure mathematics theoretical course, but to transform abstract theoretical knowledge into a way of thinking that can solve practical problems through calculation through teaching, thereby cultivating Students' ability to analyze and solve problems. Fully mobilize students' learning initiative in teaching and improve students' interest in learning. Corresponding to the teaching objectives of professional certification of discrete mathematics, a case-driven teaching method is adopted in teaching [3]. First, the problem to be solved and the research background of the case are explained, and then students are inspired to abstract the problem and use the knowledge of discrete mathematics to apply the problem. Expressed in formal language, students are then guided to reason or solve problems.

For example, an application of graph theory: the site selection problem. A city wants to establish an emergency center to serve the seven districts belonging to the city. Ask in which district it should be located so that it has the shortest path to the farthest district.

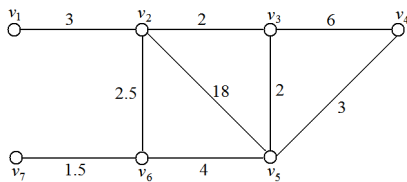


Figure 1. Site selection problem represented by an undirected graph

(1) First abstract the problem into graph form (as shown in Fig. 1). Use Floyd's algorithm to find the distance matrix $D = (d_{ij})_{v \times v}$:

$$D = \begin{pmatrix} 0 & 3 & 5 & 10 & 7 & 5.5 & 7 \\ 3 & 0 & 2 & 7 & 4 & 2.5 & 4 \\ 5 & 2 & 0 & 5 & 2 & 4.5 & 6 \\ 10 & 7 & 5 & 0 & 3 & 7 & 8.5 \\ 7 & 4 & 2 & 3 & 0 & 4 & 5.5 \\ 5.5 & 2.5 & 4.5 & 7 & 4 & 0 & 1.5 \\ 7 & 4 & 6 & 8.5 & 5.5 & 1.5 & 0 \end{pmatrix}$$

(2) Calculate the maximum service distance $S(v_i)$ for setting up a service facility at each point.

$$S(v_i) = \max_{1 \leq j \leq v} (d_{ij}), i = 1, 2, \dots, v$$

$$\text{There is: } S(v_1) = 10, S(v_2) = 7, S(v_3) = 6, S(v_4) = 8.5$$

$$S(v_5) = 7, S(v_6) = 7, S(v_7) = 8.5$$

(3) Find the vertex v_k such that $S(v_k) = \min_{1 \leq i \leq v} \{S(v_i)\}$, then v_k is the required location for the emergency center. Since $S(v_3) = 6$ is minimal, the first aid center should be located at v_3 . This point is called the center of the graph.

3.2.2. Sorting out Teaching Content and Closely Linking it to Specialized Courses

In the teaching process, not only the content of the discrete mathematics textbook is taught, but also the connection

between the discrete mathematics knowledge points and the subsequent courses of the computer major. If it cannot be completed in class due to limited class time, discrete mathematics and professional courses (such as databases), data structure, computer network, software engineering, artificial intelligence) are assigned to students in an online form [6], and students are required to complete it in the form of a report in the cloud class.

An example is the relationship between discrete mathematics and database principles [7]. Relational theory can be used to make the database from the network type, and hierarchical type into relational type, so that the data in the database is easy to represent, and easy to store and process, so that the logical structure is simple, data independence, data sharing, data redundancy can be controlled and simple to operate. The Cartesian product in a collection facilitates the querying, insertion, deletion, and modification of records when there are more records in the database. The relationship between discrete mathematics and database principles is shown in Table 2.

Table 2. Correspondence between discrete mathematics and operations related to database principles

In Discrete Mathematics	In Principles of Databases
Negation: denoted by \neg	Logical not: denoted by NOT
Conjunction: denoted by \wedge	Logical and: denoted by AND
Disjunction: denoted by \vee	Logical or: denoted by OR
Intersection: denoted by \cap	Intersection operation: denoted by intersect
Union: denoted by \cup	Union operation: denoted by union
Set difference: denoted by $-$	Set difference operation: denoted by except
Cartesian product: denoted by \times	Cartesian product
Composite function	Transitive functional dependency

3.2.3. Structured Knowledge Points to Enhance Lifelong Learning Capabilities

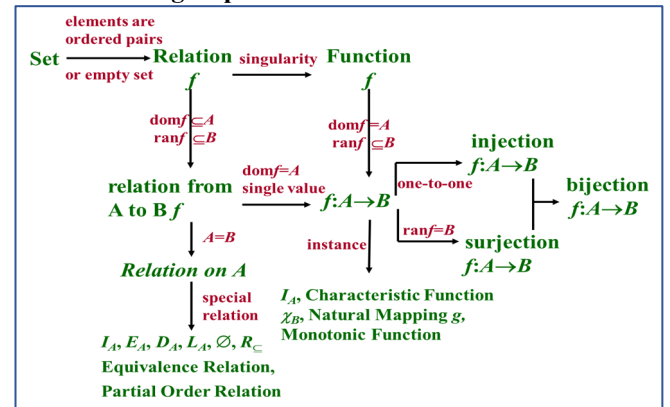


Figure 2. Structure diagram of binary relations and function knowledge points

To overcome the problem of discrete mathematics courses with many concepts and scattered content, the content of each lesson should be done to have a main line, through the main line will be related to the knowledge points in the series, and can do a good job of summarizing each knowledge unit after the lecture, the structure of the link between the knowledge points, so that the "scattered" for "whole", and to show the form of diagrams [8]. In this way, it helps students to clarify the knowledge system and promotes their overall grasp of knowledge, while guiding them to learn the learning methods

of sorting, summarizing, and concluding knowledge, and enhancing their ability to learn for life. The unit on binary relations and functions in set theory contains many concepts, which will be summarized by organizing the knowledge points as shown in Figure 2.

3.3. Reform of Assessment Methods

Previously, the assessment was composed of usual grades (including attendance, usual assignments, and 50% of the midterm exam) and the final exam (50%) [9]. Regular assignments and midterm and final exams mainly test students' understanding of conceptual and theoretical knowledge and seldom test students' analytical and creative ability to apply their knowledge of discrete mathematics to solve complex engineering problems. To achieve the teaching objectives corresponding to the professional certification, the assessment of engineering applications was added to the usual assignments, for example, in the explanation of the application of rooted trees in graph theory, the students were asked to implement Huffman coding in the Python language and compare it with other coding methods. At the end of each chapter have the students research and summarize how each chapter relates to the relevant subsequent computer science courses list specific knowledge points, and upload the summary report to the cloud classroom so that the students can appreciate the importance of the discrete mathematics course. Students who are academically inclined are also encouraged to participate in research projects and are given extra credit on their grades to encourage this. Through the reform of the assessment method, it makes students pay more attention to their usual learning, and pay more attention to the understanding and application of knowledge and innovation.

4. Conclusion

To achieve the three teaching objectives of the professional certification of discrete mathematics courses, the teaching process of discrete mathematics is reformed by first sorting out the teaching content and corresponding to the corresponding graduation requirement support points. The teaching methodology is reformed by adopting online and offline teaching modes, as well as guiding with cases, sorting out the relationship with specialized courses, and structuring the knowledge points. At the same time, the assessment method also increases the strength of the assessment of the usual grades and improves the student's learning ability and creativity. Through these measures, some results have been achieved, but there is still a need for continuous improvement,

focusing on the core concept of student-centered OBE for professional accreditation, and continuing to explore the teaching mode and teaching methods to further enhance the teaching effect.

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