

Research on Backward Design and Multi-dimensional Evaluation Teaching of Discrete Mathematics Based on OBE

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Abstract: Based on the OBE philosophy for engineering education accreditation, a three-in-one teaching model of Discrete Mathematics featuring "backward design, module restructuring and diversified evaluation" is constructed. With mapping analysis between curriculum objectives and graduation requirements, the corresponding relationship between knowledge units and competency cultivation is established. A case-driven modular teaching approach is adopted, and formative plus summative assessments are integrated to build a closed-loop feedback system. This study aims to improve the teaching quality of Discrete Mathematics and realize preset teaching outcomes via the implementation of the OBE philosophy.

Keywords: OBE Philosophy; Discrete Mathematics; Backward Design; Diversified Evaluation.

1. Introduction

Discrete Mathematics, as a core fundamental course in computer science and technology, holds an irreplaceable position in the professional curriculum system. This course cultivates students' ability to abstract mathematical models from specific problems through systematic logical thinking and abstract ability training, and employs rigorous logical reasoning methods for problem analysis and solution. Simultaneously, Discrete Mathematics provides solid theoretical support for subsequent courses (such as data structures, algorithm analysis, artificial intelligence, database principles, etc.), helping students deeply understand the essence of computer science and master theoretical methods and practical skills for handling discrete structures, laying a foundation for their future career development and academic research in computer-related fields

2. Limitations of Traditional Discrete Mathematics Teaching and Necessity of OBE Education

Traditional Direct Math education has clear disadvantages. Traditional teaching takes teachers as the center, and such a model includes academic training based on set outlines and books, with little regard for students' needs. Lacking opportunities for active thinking and inquiry, students usually engage in passive listening and repetition, which reduces both interest and motivation, ultimately leading to poor learning outcomes[3]. Many students study merely for exams without mastering logical concepts and practical uses, failing to apply concepts to real-world problems.

Compared with traditional teaching modes, Outcome-Based Education (OBE) offers novel ideas and approaches to Discrete Mathematics lessons. Centered on students, OBE adopts a student-centered focus. It focuses on the success of learning outcomes, rather than the mere delivery of information. It defines focused knowledge, skills, and literacy pupils ought to gain upon course completion, using these targets to guide learning design. Various methods, such as case-based and project-driven teaching are used to help

learners meet learning goals and improve overall competitiveness[4]. In addition, with continuous improvement, OBE improves teaching iteratively through evaluation and input to meet students' learning needs and social skills demands.

2.1. Curriculum system

From a learning view, the typical Discrete Mathematics textbook focuses on systematic and solid information with strict topics, failing to consider students' practical needs and professional growth. However, an OBE-aligned syllabus centers around set learning outcomes. Specifically, it reviews the specific demands of computer science and technology areas, integrating market developments and job-specific competencies to simplify and modify course content. Thus, the syllabus allows for a perfect balance between academic knowledge and practical use, thus improving both value and relevance.

2.2. Teaching methods

In terms of teaching methods, conventional teaching is heavily dependent on lecture, providing students with few chances of involvement and practical practice. By contrast, OBE-aligned teaching utilizes a broad range of methods, such as such as group which include learning and online learning tools. Specifically, case studies involve students in real-life problems, prompting them to use discrete mathematics rules for problem analysis and resolution, thus developing practical competencies and creativity. Group learning supports communication and teamwork to improve students' communication and teamwork skills. Online platforms supply numerous tools for personalized self-paced learning in keeping with individual study needs.

2.3. Teaching evaluation

In terms of teaching methods, conventional teaching is highly dependent on lecture, leaving students with few chances of involvement and hands-on learning. By contrast, OBE-aligned teaching utilizes a broad range of methods, such as group based learning and online learning tools. Specifically, case studies involve students in real-life problems, allowing

them to use discrete mathematics rules for problem analysis and resolution, thus developing practical skills and creativity. Group learning supports communication and teamwork to improve students' collaboration and communication skills. Online platforms have numerous tools for personalized self-paced learning in line with specific study needs[5].

Against the backdrop of deepening educational reforms, conventional discrete mathematics instruction can hardly meet the needs of students' diversified development, and the society's demand for high-quality professional talents. The OBE philosophy provides innovative ideas and methods for Discrete Mathematics teaching, making it urgent to construct a scientific, systematic and effective teaching mode for the course.

3. Overall Framework of Discrete Mathematics Teaching Mode Based on OBE Philosophy

3.1. Backward Design Teaching

Backward design teaching embodies the practical

implementation of the OBE philosophy. It abandons the conventional teaching sequence from curriculum content to teaching objectives, and starts instead from the expected final learning outcomes. On this basis, it reversely plans and optimizes the curriculum system, teaching content and teaching methods. The schematic diagram of the forward implementation process is shown in Figure 1.

3.1.1. Curriculum Positioning Analysis

As a basic foundational course for majors including Computer Science and Technology, Software Engineering and other related fields, Discrete Mathematics includes many abstract and logically challenging modules—such as set theory, propositional logic, base logic, binary relations and graph theory. By defining the specific skills that students ought to develop after finishing the lesson, including logic, abstract thinking, and the ability to deal with practical problems with mathematical knowledge, educators may develop focused course and use appropriate teaching strategies. Teaching methods are next selected to align with these goals, making sure that teaching methods are both focused and purposeful.

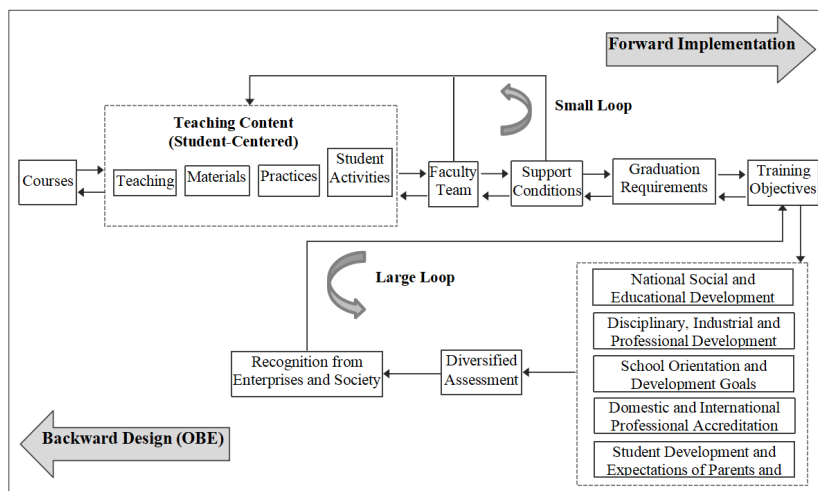


Figure 1. Forward Implementation Schematic

3.1.2. Knowledge Unit Analysis

Table 1. Module Restructuring

Traditional Chapters	Module Restructuring	Applied Competence Development	Knowledge
Chapter 1 Set Theory	Basic Theory Module	Data Deduplication, Set Operation Competence	Set Definition, Power Set, Cartesian Product, Cardinality Comparison of Infinite Sets
Chapter 2 Propositional Logic	Logical Reasoning Module	Logic Circuit Design, Rule-based Reasoning Competence	Propositional Connectives, Truth Table, Principal Disjunctive/Conjunctive Normal Form, Natural Deduction
Chapter 3 Predicate Logic	Logical Reasoning Module	Natural Language Processing, Knowledge Representation Competence	Predicate Symbolization, Quantifier Scope, Prenex Normal Form, Inference Rules of Predicate Logic
Chapter 4 Binary Relations	Relationship Modeling Module	Database Design, Social Network Analysis Competence	Relation Matrix Representation, Reflexive/Symmetric/Transitive Closure, Equivalence Relation and Partition
Chapter 5 Special Relations	Relationship Modeling Module	Algorithm Complexity Analysis, System Optimization Competence	Compatible Relation Covering, Hasse Diagram of Partial Order Relation, Well-ordered Set, Injective/Surjective/Bijective Function
Chapter 6 Graphs	Graph Theory Analysis Module	Path Optimization, Network Topology Analysis Competence	Adjacency Matrix of Graph, Handshaking Theorem, Connected Component, Shortest Path Algorithm (Dijkstra)
Chapter 7 Special Graphs	Graph Theory Analysis Module	Engineering Planning, Data Structure Design Competence	Spanning Tree Construction, Euler Graph Judgment, Kuratowski's Theorem for Planar Graphs, Bipartite Graph Matching Algorithm
Chapter 8 Algebraic Systems	Algebraic System Module	Cryptography Fundamentals, Symbolic Operation Competence	Homomorphism and Isomorphism of Algebraic Systems, Properties of Semigroups and Monoids
Chapter 9 Groups, Rings and Fields	Advanced Algebraic Structure Module	Encryption Algorithm Design, Abstract Algebra Modeling Competence	Definition and Properties of Groups, Generators of Cyclic Groups, Normal Subgroup Judgment, Structure of Finite Field $GF(p)$
Chapter 10 Lattices and Boolean Algebras	Advanced Algebraic Structure Module	Logic Circuit Design, Formal Verification Competence	Duality Law of Lattices, Distributive Lattice Judgment, Boolean Expression Simplification, Algebraic Model of Logic Gate Circuits

Based on guidance by OBE norms, the course topics is divided into many closely related and clearly focused knowledge sections, including the basic concepts of set theory, proposition and logical calculus, relations and functions, and elementary combinatorics. Each knowledge module is designed according to certain graduation standard index points. Through systematic lessons, it allows students to learn basic ideas, basic principles, and traditional solution methods typical of discrete mathematics.

Taking the "Set Logic" module as an illustrative example:

(1) Teaching Content: It includes the basic ideas of sets, operations, infinite sets, and applied contexts.

(2) Learning aims: Students ought to understand core terms, grasp functional rules, understand the properties of infinite sets, and prove the ability to use set-theoretic rules to practical problem-solving.

(3) Academic Role: Known as the bedrock of discrete mathematics, set theory provides the basic formal theory based on which later modules—such as propositional logic, base logic, and binary relations—are carefully built.

3.2. Module Restructuring Based on the OBE Concept

Under the principles of the OBE educational theory, the

modular reform of Discrete Mathematics teaching provides a key strategy to improve the quality of teaching and improve students' learning outcomes. Traditional Discrete Mathematics curricula are usually organized in independent chapter units. Although such arrangement ensures the systematicness of teaching content, it fails to carry out targeted design for students' core competency cultivation. To solve this problem, a comprehensive modular restructuring strategy is adopted based on OBE concepts.

The entire course is divided into several logically connected teaching modules with clear training objectives, mainly covering the Logical Reasoning Module, Set and Relation Module, and Applied Graph Theory Module[6]. Each module inherits the core theoretical knowledge of the original textbook chapters and centers on predefined competency training goals. The implementation of modular teaching allows students to accumulate professional theoretical knowledge while effectively strengthening their core abilities, including logical reasoning, abstract analysis and practical problem-solving skills. Relevant details are shown in Table 1.

Table 2. Teaching Strategies

Restructured Module	Teaching Method	Teaching Mode	Teaching Media	Learning Organization	Design Logic
Logical Reasoning Module (Propositional / Predicate Logic)	Comparison Method: Comparison between propositional logic and programming conditional statements Visualization Method: Dynamic generation tool for truth tables	Five-Star Teaching Mode (Focus on the construction of logical reasoning chains)	Online logic simulator Natural language to predicate formula conversion plugin	Large-class intensive Individualized	Lower the threshold of formal expression through programming analogy, and assist the concretization of abstract concepts with media tools
Relationship Modeling Module (Binary / Special Relations)	Case Method: Analysis of social network relationship matrix Problem Chain Method: Exploration of the engineering significance of closure operation	346 Teaching Mode (3 stages, 4 links, 6 tasks)	Relational database design software Hasse diagram drawing tool	Group discussion (3-4 people per group)	Drive relationship modeling with real data, and support the migration from mathematical theory to engineering practice with tool chains
Graph Theory Analysis Module (Graphs / Special Graphs)	Project-Driven Method: Subway network planning simulation Analogy Method: Comparison between tree structure and file system	Online-offline hybrid mode	Graph-viz visualization tool Graph theory algorithm experiment platform	lecture + project group defense	Decompose complex problems in stages, provide immediate feedback through the algorithm platform, and strengthen graph theory modeling ability
Algebraic Structure Module (Algebraic Systems / Groups, Rings and Fields)	Situational Method: Application of group theory in encryption algorithms Scaffolding Method: From integer modular groups to polynomial rings	Five-Star Teaching Mode	Cryptography simulation system Interactive courseware for abstract algebra	learning + expert lectures	Establish learning significance through cryptography cases, and reduce the cognitive load of abstract algebra with interactive tools

On the solid foundation of curriculum module restructuring, this paper conducts an in-depth analysis of the knowledge characteristics and competency cultivation objectives of each module. Based on the analysis, differentiated and targeted teaching strategies are elaborately formulated to realize high matching between teaching approaches and module contents. Eventually, a virtuous closed-loop of "Module Content-Teaching Strategy-Competency Achievement" is constructed. The detailed teaching strategies are presented in Table 2.

3.3. Diversified Evaluation System

As a crucial link for the implementation of the OBE

philosophy, teaching evaluation needs to break away from the shackles of the traditional single-score assessment and establish a full-cycle, multi-dimensional evaluation mechanism[7-9].

Furthermore, the multi-faceted evaluation system combines both formative and summative tests. Formative testing fluidly improves learning through performance in the classroom, frequent tests, and group work. It supports regular teaching change and helps students achieve confidence above mere scores. Students develop a feeling of success by solving individual math problems, build trust through algorithm optimization and find collective value in team work. These

incalculable advantages develop students' basic skills subtly.

Summative evaluation in the end evaluates learning results. It measures academic achievement to verify graduation standards, and uses competency matrix analysis to establish focused improvement plans for course changes and student

development[10]. This results in an "Evaluation-Feedback-Optimization" closed cycle, which allows regular teaching quality growth and regular consistency with talent development aims.

Table 3. Quantitative Reform Effectiveness

Evaluation Dimension	Before Reform (Grade 2023)	After Reform (Grade 2024)	Growth Margin	Measurement Method
Curriculum Objective Achievement Rate	0.68	0.82	+20.6%	Weighted Method Based on Curriculum Objective-Graduation Requirement Mapping Matrix
Student Satisfaction	72%	91.6%	+19.6%	Likert 5-Point Scale (Teaching Effectiveness Dimension)
Compliance Rate of Algorithm Design Ability	54%	74%	+37%	Project Defense Score (Threshold \geq 80 Points)

Verified after two rounds of teaching practice, the broad evaluation system built under the OBE theory has achieved outstanding practical effects. Taking 217 students majoring in CS from the classes of 2023 and 2024 as study samples, teachers made focused changes to teaching topics based on input collected from formative testing. The success rate of curriculum goals went up from the initial 68% to 82%. In the after-course poll survey, over 90% of students expressed satisfaction with the course teaching mode. In addition, the success rate of students' algorithm design ability rose greatly. The measured reform effects are shown in Table 3. This table logically shows a statistical data of every metric before (Grade 2023) and after (Grade 2024) the teaching change, computes associated growth margins, and defines the measurement method used for each indicator, so as to visually demonstrate the progress and changes achieved by the teaching reform in the different axes.

4. Summary

Building on the curriculum in Outcome-Based Education (OBE), this study develops a discrete mathematics teaching model based on "reverse design, modular restructuring, and multidimensional testing." Focusing on a student-centered approach, it connects teaching topics and resource allocation with set learning goals, making sure every academic activity focuses on the development of broad skills. In particular, reverse planning extends teaching goals down from graduation requirements, while adaptive restructuring modify the curriculum design to meet students' cognitive styles and learning needs.

Studies show that this approach successfully transforms students from passive receivers to active learners, greatly improving learning independence and involvement. By meeting engineering school accreditation standards and market demands for high-caliber experts, the model sets a solid foundation for continuous learning refinement. The next study will focus on improving the model's generalizability in various learning environments to better develop novel and practice-based ability.

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