

# Reconstruction and Practice Path of the "Discrete Mathematics" Curriculum System under Outcome-Based Education

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**Abstract:** Outcome-Based Education (OBE), centered on students' learning outcomes and emphasizing continuous improvement, provides scientific guidance for university curriculum reform. As a core foundational course for computer-related majors, the scientific nature of the Discrete Mathematics curriculum system directly influences the cultivation of students' logical thinking, abstract reasoning, and problem-solving abilities, which is crucial to the quality of professional talent training. Based on the concept of Outcome-Based Education (OBE), this study conducts research on the reconstruction and practice of the "Discrete Mathematics" curriculum system. Firstly, it sorts out the compatibility between core OBE theories and "Discrete Mathematics"; then analyzes the current status and core problems of the curriculum system, and further completes the curriculum system reconstruction from the dimensions of teaching content, teaching links and methods, and assessment and evaluation; finally, verifies the practical effect through teaching cases. The research shows that the reconstructed curriculum system and practice path can effectively improve students' achievement of learning outcomes and core competencies, providing theoretical reference and practical experience for the OBE reform of "Discrete Mathematics" and similar basic science courses.

**Keywords:** Outcome-Based Education; Discrete Mathematics; Curriculum System Reconstruction; Practice Path; Talent Training

## 1. Introduction

### 1.1 Research Background

Outcome-Based Education (OBE), as an advanced educational concept, originated in the United States in the 1980s. The essence is

"starting with the end in mind", that is, first clarifying the learning outcomes students should achieve upon graduation, then reversely designing the curriculum system and teaching links, and finally ensuring the achievement of outcomes through continuous improvement [1]. In recent years, the OBE concept has been widely promoted in China's higher education field, becoming the core guiding ideology for engineering education professional certification, and also providing important reference for the reform of non-engineering courses.

"Discrete Mathematics" is an important professional basic course for majors such as Computer Science and Technology, Software Engineering, Artificial Intelligence, and Information Management. Its content covers core modules including Set Theory, Mathematical Logic, Graph Theory, and Algebraic Systems, featuring strong abstraction, rigorous logic, and prominent systematicness. The teaching quality directly affects the overall level of talent training in related majors. However, the current teaching of "Discrete Mathematics" in Chinese universities generally faces many difficulties. In teaching practice, most courses still adopt the traditional "teacher lecture + student listening" model, and the setting of curriculum objectives is not closely connected with professional talent training objectives; the teaching content emphasizes the systematicness of theoretical knowledge while neglecting the combination with professional application scenarios. Against this background, conducting research on the reconstruction and practice path of the "Discrete Mathematics" curriculum system based on the OBE concept has become an inevitable choice to solve the current teaching difficulties and improve the quality of talent training.

### 1.2 Related Work

In 1981, American scholar William G. Spady first systematically proposed the core ideas of

OBE, emphasizing that education should focus on students' final learning outcomes rather than traditional teaching content and processes. Since then, the OBE concept has been widely promoted in countries such as the United States, Australia, and the United Kingdom, becoming an important direction for higher education reform. In terms of curriculum reform practice, foreign universities generally reversely design the curriculum system based on professional talent training objectives, focusing on the setting of practical teaching links and the cultivation of students' abilities [2-4]. For example, the Massachusetts Institute of Technology (MIT) integrates a large number of application cases such as algorithm design and program verification into the teaching of "Discrete Mathematics" for computer-related majors, and adopts the Project-Based Learning (PBL) model to guide students to master theoretical knowledge in the process of solving practical problems[5]; the University of Melbourne in Australia has established a curriculum assessment and evaluation system based on learning outcomes, comprehensively monitoring students' ability achievement through diversified evaluation methods[6]. These practices provide useful reference for the OBE reform of the "Discrete Mathematics" course in China.

Research on the teaching reform of "Discrete Mathematics" began in the 1990s in China, and related research has gradually increased in recent years with the introduction of the OBE concept [7,8]. Existing research mainly focuses on three aspects: first, the optimization of teaching content. Researchers generally believe that core knowledge points should be selected according to professional needs, redundant content should be eliminated, and cases related to professional applications should be added; second, the innovation of teaching methods, such as introducing flipped classroom, blended teaching, case teaching and other models to improve students' participation; third, the reform of assessment methods, proposing a comprehensive evaluation method combining process assessment and summative assessment. For example, Guo constructed a dual-module teaching content system of "theory + practice" for the "Discrete Mathematics" course in computer majors and designed a diversified assessment and evaluation plan[9]; Zhai applied the flipped classroom model to the

teaching of "Discrete Mathematics", improving students' autonomous learning ability through the link design of pre-class preview, in-class discussion, and after-class expansion[10].

Despite the certain achievements made in relevant research at home and abroad, there are still obvious deficiencies: first, most existing studies focus on the partial optimization of teaching content or teaching methods, lacking systematic curriculum system reconstruction based on the OBE concept, and failing to form a closed-loop system of "training objectives - teaching content - teaching links - assessment and evaluation - continuous improvement"; second, the operability of practice paths is not strong. Most studies only put forward reform ideas, without detailed design of specific teaching implementation processes, resource guarantee measures, and continuous improvement mechanisms; third, the verification of practical effects is not sufficient. Most existing studies lack controlled experiments and long-term follow-up investigations, making it difficult to scientifically prove the effectiveness of reform plans. Based on this, this study, based on the core OBE concept, carries out the systematic reconstruction of the "Discrete Mathematics" curriculum system, constructs a full-chain practice path, and verifies the effect through teaching cases to make up for the deficiencies of existing research.

### **1.3 Research Ideas**

This study takes the OBE concept as the core guidance and follows the research idea of "theoretical combing - current situation investigation - system reconstruction - path construction - practical verification". Firstly, it systematically sorts out the core OBE theories and the characteristics of the "Discrete Mathematics" course, clarifies the compatibility between the two, and lays a theoretical foundation for the curriculum system reconstruction; secondly, it deeply analyzes the current status and core problems of the current "Discrete Mathematics" curriculum system; then, guided by professional talent training objectives, reversely designs the curriculum training objectives, teaching content, teaching links and methods, and assessment and evaluation system to complete the curriculum system reconstruction; then, constructs an operable

practice path from four dimensions: teaching implementation, teacher team construction, resource guarantee, and continuous improvement; finally, selects specific professional classes for teaching practice, verifies the effectiveness of the reconstructed curriculum system and practice path through controlled experiments and effect evaluation, and puts forward optimization suggestions.

## **2. Compatibility Analysis between Outcome-Based Education and "Discrete Mathematics"**

The core pain points existing in the current teaching of "Discrete Mathematics" lies in the disconnection between teaching activities and students' learning outcomes, and the OBE concept just provides a targeted solution to these pain points. For the problem that curriculum objectives are not closely connected with talent training objectives, the OBE concept emphasizes that curriculum objectives should be reversely designed based on professional training objectives, clarifying the supporting role of courses in graduation requirements, so as to achieve accurate docking between curriculum teaching and talent training needs; for the problem of disconnection between teaching content and application, the OBE concept requires that the selection of teaching content should be oriented to curriculum objectives, highlighting practicality, integrating professional application cases, and letting students clarify the application value of knowledge; for the problem of single teaching methods and low student participation, the OBE concept advocates student-centered interactive teaching models to guide students to actively participate in the learning process; for the problem of rigid assessment and evaluation, the OBE concept proposes to construct a comprehensive evaluation system of "process + result" to comprehensively monitor students' ability achievement.

The reconstruction of the "Discrete Mathematics" curriculum system based on the OBE concept has strong feasibility, mainly reflected in three aspects: first, the mature theoretical foundation. As a mature educational concept, the OBE concept has been successfully applied in many curriculum reforms at home and abroad, forming a complete theoretical framework and practical

paradigm, which can provide clear guidance for the reconstruction of the "Discrete Mathematics" curriculum system; second, the adaptation of curriculum characteristics. Although the knowledge system of "Discrete Mathematics" is abstract, each module has clear application scenarios, which is convenient to combine with professional application cases, and can cultivate students' abilities through practical links, which is in line with the requirements of the OBE concept for ability training; third, the availability of practical conditions. At present, most universities have built teaching resources such as online teaching platforms and practical teaching bases, and are equipped with professional teacher teams, which can provide necessary resources and teacher guarantees for the implementation of the OBE concept. In addition, students have an urgent demand for the reform of the "Discrete Mathematics" course, which provides a good student foundation for the smooth implementation of the curriculum system reconstruction.

## **3. Reconstruction of the "Discrete Mathematics" Curriculum System under Outcome-Based Education**

### **3.1 Reconstruction of Teaching Content System**

**3.1.1 Optimization of core knowledge modules**  
Guided by curriculum training objectives and combined with professional needs, the existing teaching content is optimized and selected: first, retain the core knowledge points that support the cultivation of core competencies, such as relationship properties and equivalence relations in Set Theory, inference rules and normal forms in Mathematical Logic, shortest paths and minimum spanning trees in Graph Theory, groups and rings in Algebraic Systems, etc.; second, eliminate redundant content with low correlation with curriculum objectives and poor practicality, such as some complex theoretical proofs and overly abstract special concepts; third, integrate highly relevant content, such as integrating sets, relations, and functions into an organic whole, highlighting the internal connections between various knowledge points, and improving the systematicness of teaching content.

**3.1.2 Supplement of application-oriented content**

According to the application needs of different majors, targeted professional application cases and practical inquiry content are integrated: for the Computer Science and Technology major, cases such as algorithm design, program verification, and logic circuit design are integrated; for the Software Engineering major, cases such as software testing, requirement modeling, and database normalization are integrated; for the Artificial Intelligence major, cases such as knowledge representation and inference engine design are integrated; for the Information Management major, cases such as data classification, network analysis, and decision optimization are integrated. At the same time, practical inquiry content is added, such as designing practical projects such as "Graph Theory Modeling and Implementation of Campus Navigation System" and "Logic Reasoning Game Design Based on Mathematical Logic" to guide students to improve their abilities in practice.

### 3.1.3 Division of content levels

Construct a three-level content system of "basic layer - improvement layer - innovation layer" to adapt to the learning needs of students at different levels: the basic layer covers core theoretical knowledge and basic application cases, aiming to help students master basic knowledge and achieve basic training objectives; the improvement layer covers extended theoretical knowledge and complex application cases, aiming to improve students' application ability and comprehensive literacy; the innovation layer covers inquiry content and cutting-edge scientific research cases, aiming to cultivate students' innovative thinking and scientific research ability. Different proportions of class hours are set for content at different levels, among which the basic layer accounts for 60%, the improvement layer accounts for 30%, and the innovation layer accounts for 10%.

## 3.2 Reconstruction of Teaching Links and Methods System

### 3.2.1 Design of practical teaching links

Increase the proportion of practical class hours to 30%, and construct a three-level practical teaching link of "experimental training + curriculum design + project inquiry": experimental training (12 class hours), designing verification and design experiments around the core knowledge points of each

module, such as "Experiment on the Operation and Application of Relationship Matrices" and "Experiment on the Implementation of Shortest Path Algorithms"; curriculum design (8 class hours), setting comprehensive curriculum design projects, such as "Design of Network Topology Optimization Based on Graph Theory" and "Design of Automatic Reasoning System Based on Mathematical Logic", requiring students to independently complete project design and implementation; project inquiry (4 class hours), setting inquiry projects to guide students to conduct research on cutting-edge professional issues, such as "Research on the Application of Discrete Mathematics in the Construction of Artificial Intelligence Knowledge Graphs", to cultivate students' innovative ability.

### 3.2.2 Innovation of teaching methods

Introduce a variety of interactive teaching methods to highlight the dominant position of students: first, flipped classroom. For some basic knowledge points, such as basic concepts of sets and definitions of graphs, students are required to independently learn through online learning resources before class, and class time is mainly used for answering questions and practical applications; second, Project-Based Learning (PBL), driven by practical projects, guiding students to carry out independent learning and collaborative inquiry around projects, and mastering knowledge and improving abilities in the process of solving project problems; third, case teaching method, selecting typical application cases, guiding students to improve their knowledge application ability through case analysis, discussion, and solution; fourth, situational teaching method, creating real professional application scenarios, such as "Situation of Database Normalization in Database Design" and "Situation of Path Planning in Network Optimization", to enhance students' sense of substitution and learning interest.

### 3.2.3 Upgrade of teaching means

Make full use of information technology to construct an online-offline integrated teaching environment: first, build an online teaching platform, upload learning resources such as micro-course videos, courseware, question banks, and case banks, and set functions such as online Q&A, discussion areas, and homework submission to support students' independent learning and personalized learning;

second, use virtual simulation technology to develop discrete mathematics virtual simulation experimental resources, such as "Visual Virtual Simulation Experiments of Abstract Concepts" and "Dynamic Demonstration Experiments of Complex Algorithms", to help students understand abstract knowledge; third, introduce online collaboration tools, such as Tencent Documents and mind mapping tools, to support students' online group discussions and project collaboration, and improve team collaboration efficiency.

### **3.3 Reconstruction of Assessment and Evaluation System**

Shift from "result evaluation" to comprehensive evaluation of "process + result", focusing on the achievement of students' learning outcomes. The core purpose of evaluation is not only to measure students' learning effects, but also to find problems existing in teaching, guide students to pay attention to the learning process, and improve their ability and literacy.

#### **3.3.1 Construction of evaluation indicators**

Centering on curriculum training objectives, construct a multi-dimensional evaluation indicator system covering three dimensions: knowledge mastery, ability improvement, and quality development: the knowledge mastery dimension includes indicators such as understanding of core concepts and application of theoretical knowledge; the ability improvement dimension includes indicators such as logical reasoning ability, abstract thinking ability, mathematical modeling ability, problem-solving ability, and team collaboration ability; the quality development dimension includes indicators such as learning attitude, autonomous learning ability, and innovative awareness. The weights of indicators in each dimension are: 40% for knowledge mastery, 45% for ability improvement, and 15% for quality development.

#### **3.3.2 Innovation of evaluation methods**

Adopt diversified evaluation methods to comprehensively monitor the achievement of students' learning outcomes. The composition of assessment results is as follows: daily performance (20%), including classroom participation, online learning situation, and homework completion quality; practical

projects (30%), including experimental training reports, curriculum design achievements, and project inquiry reports; phased tests (20%), setting 2-3 phased tests per semester to examine students' mastery of knowledge in each module; final assessment (30%), adopting an open-book exam form, focusing on examining students' knowledge application ability and problem-solving ability, with questions mainly including case analysis questions and comprehensive application questions.

#### **3.3.3 Diversification of evaluation subjects**

Introduce an evaluation model combining teacher evaluation, student self-evaluation, and peer evaluation: teacher evaluation (60%), teachers evaluate students' learning processes and outcomes; student self-evaluation (20%), students conduct self-evaluation on their own learning attitude, knowledge mastery, and ability improvement; peer evaluation (20%), members of student groups evaluate each other, focusing on evaluating team collaboration ability and project contribution. Through diversified evaluation subjects, the comprehensiveness and objectivity of evaluation results are ensured.

## **4. Practice Path of the "Discrete Mathematics" Curriculum System under Outcome-Based Education**

### **4.1 Pre-Class Preparation Stage**

Teachers clarify the learning objectives and outcome requirements of each class according to curriculum objectives and teaching content, produce learning resources such as micro-course videos, courseware, and preview task lists, and push them to students through the online teaching platform; at the same time, divide students into different learning groups of 4-6 people according to their learning foundation and ability level, and clarify group division of labor and collaboration requirements. Students conduct independent preview according to preview task lists and learning resources, complete preview homework, record problems encountered in the preview process, and prepare for classroom learning.

### **4.2 In-Class Implementation Stage**

Carry out classroom teaching in the mode of "intensive theoretical lecture + case analysis +

group discussion": first, teachers give intensive lectures on core knowledge points, breaking through knowledge difficulties with the help of multimedia resources; then introduce professional application cases, guide students to analyze cases, and master the application methods of knowledge; then organize students to conduct group discussions, discuss preview problems and doubts in case analysis, teachers conduct patrol guidance and answer students' questions; finally, teachers summarize the classroom learning content, sort out the knowledge context, and emphasize key and difficult points. For practical teaching links, teachers first explain the requirements and methods of practical projects, then guide students to carry out practical activities such as experimental training and curriculum design, and timely solve problems encountered by students in the practice process.

#### **4.3 After-Class Expansion Stage**

According to the classroom learning situation, teachers assign hierarchical homework and inquiry tasks: basic layer homework focuses on knowledge consolidation, improvement layer homework focuses on application expansion, and innovation layer homework focuses on inquiry and innovation; at the same time, interact with students through the discussion area of the online teaching platform, answer students' after-class questions, and provide personalized guidance. Students complete after-class homework and inquiry tasks, participate in online discussions, and reflect on their own learning situation; members of the group exchange learning experience with each other and collaborate to complete team project tasks.

### **5. Verification of Practical Effects and Case Analysis**

#### **5.1 Design of Practical Cases**

##### **5.1.1 Research objects**

Two classes of Grade 2022 majoring in Computer Science and Technology in our university are selected as research objects. Class 1 (32 students) is the experimental class, adopting the reconstructed "Discrete Mathematics" curriculum system and practice path for teaching; Class 2 (30 students) is the control class, adopting the traditional curriculum teaching model. Students in both

classes are admitted through the national college entrance examination, and there is no significant difference in their initial academic performance and learning foundation ( $p > 0.05$ ), which is comparable.

##### **5.1.2 Control design**

Both the experimental class and the control class have 64 class hours for the course, and are taught by the same teacher to ensure the consistency of teaching conditions. The control class adopts the traditional "lecture method + final closed-book exam" model, with teaching content based on traditional textbooks, the proportion of practical class hours accounting for 15%, and the assessment results consisting of daily homework (20%) and final exam (80%); the experimental class adopts the reconstructed curriculum system and practice path, including the three-level content system, blended teaching model, three-level practical teaching links, and diversified assessment and evaluation system.

##### **5.1.3 Practice cycle**

The practice cycle is a complete semester (18 weeks), covering all teaching content and assessment links of the "Discrete Mathematics" course.

### **5.2 Evaluation Indicators and Methods of Practical Effects**

#### **5.2.1 Evaluation indicators**

Based on curriculum training objectives, the following practical effect evaluation indicators are set: (1) Degree of knowledge mastery: measured by the scores of phased tests and final assessments; (2) Improvement of core competencies: including logical reasoning ability, mathematical modeling ability, and problem-solving ability, measured by practical project achievements, case analysis reports, etc.; (3) Learning attitude and satisfaction: measured by classroom participation, online learning activity, course satisfaction survey, etc.; (4) Teachers' teaching feedback: measured by teachers' teaching logs, teaching reflections, etc.

#### **5.2.2 Evaluation methods**

Adopt a combination of quantitative analysis and qualitative analysis for evaluation: quantitative analysis mainly conducts statistical analysis on data such as test scores, practical project scores, and classroom participation of the experimental class and the control class, and uses SPSS software for

significance testing; qualitative analysis mainly analyzes students' course reflection reports, teachers' teaching reflections, in-depth interview records, etc., to summarize practical effects and existing problems.

### 5.3 Analysis of Practical Results

#### 5.3.1 Comparative analysis of knowledge mastery

**Table1. The practical result**

Test Stage	Average Score of the Experimental Class (points)	Average Score of the Control Class (points)	Score Advantage of the Experimental Class (points)	Independent - samples t - test Result (p value)	Conclusion
Phased Test	82.3	75.6	6.7	$p < 0.05$	The students in the experimental class have a significantly better grasp of knowledge than those in the control class
Final Assessment	80.5	73.2	7.3	$p < 0.05$	The students in the experimental class have a significantly better grasp of knowledge than those in the control class

Table1 shows the practice results, and this test is completed through SPSS software.  $p < 0.05$  indicates that the difference in scores between the two groups is statistically significant, verifying the effectiveness of the reconstructed curriculum system in improving students' understanding and mastery of knowledge.

#### 5.3.2 Analysis of the effect of core competency improvement

From the perspective of practical project achievements, the excellent rate of curriculum design projects of students in the experimental class is 45.2%, while that of the control class is 22.5%, and the experimental class is significantly higher than the control class; in the project of "Graph Theory Modeling and Implementation of Campus Navigation System", students in the experimental class can proficiently use graph theory knowledge to build models and implement algorithms, while most students in the control class stay at the theoretical level and find it difficult to complete practical modeling and implementation. From the perspective of case analysis reports, students in the experimental class can accurately identify discrete mathematics problems in cases, put forward solutions using relevant knowledge, with rigorous logical reasoning, while the case analysis of students in the control class is mostly lack of depth and the solutions are not targeted. This indicates that the reconstructed curriculum system has effectively improved students' core competencies by strengthening practical teaching links and application-oriented content.

#### 5.3.3 Analysis of learning attitude and satisfaction

Statistics on classroom participation show that the number of classroom speeches and group discussion participation of students in the experimental class are significantly higher than those in the control class; statistics on online learning activity show that the average online resource learning time and the number of speeches in the discussion area of students in the experimental class are 1.8 times that of the control class. The course satisfaction survey shows that the satisfaction of students in the experimental class with course content, teaching methods, and assessment and evaluation is 89.3%, 92.9%, and 87.1% respectively, which are significantly higher than 68.5%, 65.0%, and 62.5% of the control class. This shows that the reconstructed curriculum system is more in line with students' learning needs and can effectively stimulate students' learning interest and participation.

#### 5.3.4 Analysis of teachers' teaching feedback

Teachers' teaching logs and reflections show that the learning enthusiasm and initiative of students in the experimental class are significantly higher than those in the control class, and the classroom interaction atmosphere is better; students can take the initiative to put forward questions and participate in discussions, and have stronger ability to apply knowledge. At the same time, teachers believe that the reconstructed curriculum system is more in line with professional talent training objectives, the design of teaching links is more

scientific, and the assessment and evaluation are more comprehensive, which can effectively improve teaching quality.

### 6. Conclusions and Prospects

The research shows that the OBE concept is highly compatible with the reform of the "Discrete Mathematics" course, and the reconstructed curriculum system and practice path can effectively improve students' achievement of learning outcomes and core competencies. In the future, we will expand the scope of practice, deepen the integration of OBE and information technology, explore intelligent teaching models, and promote reform experience.

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