Discrete Mathematics Teaching Reform and Practice for Engineering Certification in Computer Science

Minghui Zhang[1] and Mingchao Zhang[2,*]

[1] School of Information Science and Technology, Sanda University, Shanghai, China
[2] Changchun Humanities and Sciences college, Changchun, China
Email: minghuizhang@sandau.edu.cn (M.Z.)
*Corresponding author

***Abstract*—Engineering education professional certification is the certification of engineering majors in higher education institutions in accordance with the standards and processes of the Washington Agreement. It is an effective means to improve the quality of engineering education, promote continuous improvement of the profession, and enhance the international competitiveness of professional talents. Discrete mathematics is the core backbone course of computer science and technology and related majors. Under the guidance of the certification concept of engineering education, the curriculum outline of discrete mathematics, the core basic course of computer science and technology, has been revised to focus on cultivating students' graduation abilities, refine teaching objectives, closely adhere to graduation requirements, support graduation indicators, and continuously reform teaching methods, teaching modes, and assessment forms. Teaching practice has shown that students' mastery of computer mathematics theoretical knowledge is more solid, their ability to solve complex engineering problems is improved, and good teaching results are achieved.**

***Keywords*—engineering certification, discrete mathematics, course objectives, graduation requirements**

I. Introduction

Accreditation of engineering education majors is based on the standards and processes of the International Mutual Recognition of Undergraduate Engineering Degrees, the standards and processes of the Washington Agreement. In June 2016, China became the 18th full member of the Washington Accord, realizing the internationalization of engineering education.

Professional certification of engineering education is an effective means to improve the quality of engineering professional education, effectively promote the continuous improvement of the profession, and enhance the international competitiveness of professional talents [1]. Engineering Education Professional Certification has 3 core elements: student centered, output-oriented, and continuous improvement.

The core of computer science engineering certification is to confirm that undergraduate students who graduated from computer science meet the established quality standards recognized by the industry, and it is a qualification evaluation oriented to training goals and graduation requirements. Computer engineering certification requires that the professional curriculum system be set around students' graduation ability, emphasizing the establishment of continuous improvement mechanism and feedback mechanism of computer major, and ensuring the educational quality and vitality of computer major [2].

Discrete mathematics is one of the important branches of modern mathematics, and has been recognized by IEEE as the core backbone course of computer science and technology and related majors since 1977 [3], which plays an important role in the basic theoretical support of computer science and technology professional course system, and is closely related to data structure, algorithm design and analysis, database principles, digital logic circuits, compilation principles, information security, operating systems, artificial intelligence, and other courses. Discrete mathematics is also a course closely related to the practice of engineering and has a wide background in engineering applications. Through the study of discrete mathematics courses, students can cultivate mathematical modeling ability, system thinking ability, and logical reasoning ability of practical problems. The comprehensiveness of discrete mathematics courses is incomparable with other courses, and it is a good carrier and platform for engineering quality education [4].

In the context of professional certification of engineering education, focusing on the cultivation of students' graduation ability, the teaching objectives of discrete mathematics courses are refined, graduation requirements are closely followed, course content is decomposed, graduation indicators are supported, teaching methods are reformed [5], and diversified assessment methods are explored [6–9].

Manuscript received February 26, 2023; revised April 7, 2023; accepted September 18, 2023; published February 29, 2024.

II. Course Teaching Objectives and Graduation Requirements

Sanda College is an application-oriented undergraduate college, discrete mathematics is a professional basic course for sophomores majoring in computer science, 48 hours to complete mathematical logic, set theory, graph theory three parts, using Geng Suyun, Qu Wanling, Zhang Liang edited "Discrete Mathematics" (fifth edition).

In order to better cultivate students' ability to achieve, promote the transformation from ability to literacy, continuously improve the talent training plan, and achieve the refined support of teaching goals and graduation requirements.

A. Course Teaching Objectives

TABLE I. Course Objectives

Course objectives	Description
Course objective 1	Understand and master some basic concepts, basic ideas, and basic methods commonly used in discrete mathematics in computer science; From the proposal and application of many algorithms, we can understand the deeds, ideas and innovative spirit of mathematicians and computer scientists, especially the application of discrete mathematical methods in many fields in China.
Course objective 2	Can solve discrete mathematical problems with knowledge of propositional logic, relations and sets, and graph theory, can build mathematical models for discrete systems, and describe complex engineering problems mathematically.
Course objective 3	Can use common proof methods such as direct proof, counter-proof, mathematical induction, construction method, etc., can express problems symbolically, use logical reasoning ability to deduce problems, and research and analyze complex engineering problems through literature research, scheme reasoning and other methods, and determine suitable solutions, cultivate students' inquiry ability and sense of innovation.

Set teaching goals for graduation requirements and specific subdivision indicators for computer science and technical engineering certification. Through this course, students can achieve the teaching objectives shown in Table I and lay a solid theoretical foundation for subsequent computer science courses.

B. Graduation Requirements Supported by the Course

The graduation requirements supported by discrete mathematics courses are shown in Table II.

TABLE II. Graduation Requirements

Graduation requirements	Description
1. Engineering knowledge	Ability to apply mathematics, natural sciences, engineering fundamentals, and computer expertise to solve complex engineering problems in computer applications
2. Problem analysis	Be able to apply the basic principles of mathematics, natural sciences and engineering sciences to identify, express, and analyze computer hardware and software system development and applied technology research and development problems through literature research to obtain effective conclusions.
3. research	Be able to conduct research, analyze and interpret data on complex engineering problems in computer-related fields based on scientific principles and adopt scientific methods, and obtain reasonable and effective conclusions.
4. Professional norms	Have humanities and social science literacy, sense of social responsibility, be able to understand and abide by engineering professional ethics and norms in computer engineering practice, and fulfill social responsibility.

C. The Correspondence between Course Objectives and Graduation Requirement Indicator Points

The relationship between discrete mathematics teaching content and teaching objectives and supporting graduation requirements indicators is shown in Table III.

TABLE III. Correspondence between Curriculum Objectives and Graduation Requirements

Course objectives	Graduation requirements indicator points	Teaching session		
		Class	Home work	Class interaction
Course objective 1	1. Engineering knowledge 1.1 Ability to use language tools in mathematics, natural sciences, and engineering sciences for appropriate formulation of engineering problems in the field of computer science and technology. 1.2 Be able to select or establish appropriate models for complex computer technology and software systems and processes to describe and solve. 1.3 Be able to use basic knowledge of mathematics, natural sciences, engineering and professional basic theoretical knowledge to deduce, analyze and solve complex software engineering problems.	√	√	√
	4. Professional norms 4.1 Have good literacy in humanities and social sciences, establish a correct concept of the legal system, correctly understand the relationship between individuals and society, and have a sense of responsibility to promote national rejuvenation and social progress.	√		
Course objective 2	2. Problem analysis 2.1 Be able to use mathematical and engineering methods to develop and analyze system requirements models. 2.2 Be able to design software engineering models based on computer systems and network system organization and structure, and correctly express complex engineering problems in computer and related technical fields.	√	√	√
Course objective 3	3. research 3.2 Ability to choose the right research route, perform protocol analysis, design and interpretation of data, including conducting experiments, and comparing experiments with predicted or expected results.	√	√	√

III. Teaching Reform and Practice

According to the professional certification concept of engineering education, the teaching of discrete mathematics courses should not only cultivate students' ability to master professional knowledge, but also cultivate students' communication and expression skills, teamwork skills, and ability to solve complex engineering problems.

A. Reform the Teaching Content and Benchmark the Index Points of Graduation Requirements

According to the hours offered by the discrete mathematics courses of the School of Information, a reasonable choice of teaching content should be made to pay attention to the basics, highlight the key points, and meet the needs of subsequent professional courses in teaching. Closely follow the graduation requirements and specific subdivision of the index points of computer major engineering certification, organize teaching content, carefully design teaching links, reduce the teaching difficulty of some chapters, weaken the explanation of difficult certification topics during teaching, focus on introducing the basic concepts and basic principles in the basic theory with engineering application background, complete the course objectives, and implement the graduation requirements indicator points.

The specific teaching content, teaching hours allocation, and the correspondence between the supporting curriculum objectives and graduation requirements index points are detailed in Table IV.

TABLE IV. Allocation of Teaching Hours

Teaching Content	Total hours of lectures	Lectures	Discussion lesson	Supported course objectives	Support indicator points
Propositional logic	12	11	1	Course objective 1 Course objective 2	4.1 1.1, 1.2
Predicate logic	4	4	0	Course objective 1 Course objective 2	1.1, 1.2 2.1, 2.2
Relationship	12	11	1	Course objective 2	2.1, 2.2
Function	2	2	0	Course objective 2	2.1, 2.2
Figure	12	11	1	Course objective 1 Course objective 2	1.1, 1.2, 1.3 2.1, 2.2
Tree	6	6	0	Course objective 2 Course objective 3	2.1, 2.2 3.2

B. Reform Teaching Methods and Build Online Resources

In the context of professional certification in engineering education, teaching activities focus on the learning effect of all students, ensure that students achieve specific learning outcomes, and encourage students to engage in self-reflection to cultivate the ability of inquiry and innovation. Teaching adopts a blended teaching model to creatively flip the classroom. Build online resources and establish a multi-objective teaching case database. According to the learning goals that students need to achieve, establish a multi-perspective and multi-objective teaching case database, including conceptual, professional, life-oriented, classic story case database etc. [10].

IV. Assessment Form and Result Analysis

According to the professional certification concept of engineering education, reform the discrete mathematics assessment program, pay attention to ability training, test students' mastery of basic discrete mathematics concepts and principles, test students' ability to analyze and solve problems, and test students' knowledge expansion ability and self-learning ability. Overall scores include formative and conclusive assessments. Formative assessment (usual grades) 40%, including: class attendance and in-class tests, class performance and class discussions, homework submission and completion, etc. Outcome assessment (final grade) 60%, including closed-book final exam results. The assessment of grades is shown in Table V, the evaluation method for achieving course objectives is shown in Table VI, and the evaluation criteria for achieving course objectives are shown in Table VII.

TABLE V. Methodology for Classification

No.	Form of assessment	Assessment methodology	Assessment weights	Assessment corresponds Course objectives	Remark
1	Attendance and in-class tests	Scores are submitted on a case-by-case basis, and the level of knowledge is tested in class	12%	Course objective 1	4.1 1.1 1.2 1.3
2	Classroom performance and class discussions	Points are awarded for the number of assignments submitted as required	15%	Course objective 2 Course objective 3	2.1 2.2 3.2
3	Job submission and completion	Acceptance or time-limited programming, process assessment	13%	Course objective 1 Course objective 3	4.1 2.1 2.2
4	final	Final closed-book exam	60%	Course objective 1 Course objective 2 Course objective 3	1.1 1.2 1.3 2.1 2.2 3.2

TABLE VI. ACHIEVEMENT OF EVALUATION CRITERIA FOR CURRICULUM OBJECTIVES

Course Objective	< 0.6	0.6–0.69	0.7–0.79	0.7–0.89	0.9–1.0	Score
1	0.05	0.17	0.32	0.26	0.2	1
2	0.03	0.19	0.31	0.24	0.23	1
3	0.04	0.18	0.3	0.25	0.23	1
Average value	0.04	0.18	0.31	0.25	0.22	1

In Table VII, the calculation method of course goal achievement is: the average score of the sample/the score of the sample should be the degree of achievement of the course goal, expressed in decimals.

Taking the 500 students of the 2018, 2019, and 2020 grades of the School of Information Science and Technology who offer discrete mathematics courses as the data and statistics, the achievement of the course goals of the three grades is shown in Fig. 1, the final examination results of the three years of discrete mathematics courses are shown in Table VIII, and the overall evaluation results of the three-year courses are shown in Table IX. It can be seen that according to the concept of professional certification of engineering education, the teaching reform and practice effect are obvious year by year, the achievement of course goals is improved year by year, and the quality of teaching and talent training is steadily improved.

TABLE VII. EVALUATION METHODS FOR ACHIEVING CURRICULUM OBJECTIVES

Course Objective	The usual score is 40 points			The final score is 60 points	Course goal attainment
	Class Attendance and Classroom Test (12 points)	Classroom Performance and Seminar (15 points)	Assignment submission and completion (10 points)	Final (60 mins)	
1	5	4	4	25	Objective1 = 38
2	4	5	5	20	Objective2 = 34
3	3	6	4	15	Objective3 = 28
score	12	15	13	60	100

TABLE VIII. COMPARISON OF FINAL EXAM RESULTS IN 3 YEARS

Grade	60 or less	60–69	70–79	80–89	90–100	Average score
2018	72.13%	14.75%	4.92%	4.92%	0.82%	45.991
2019	66.67%	18.75%	9.38%	2.08%	3.13%	52.224
2020	17.76%	18.69%	19.63%	31.78%	12.15%	72.261

TABLE IX. COMPARISON OF OVERALL EVALUATION RESULTS OF 3 YEARS

Grade	60 or less	60–69	70–79	80–89	90–100	Average score
2018	43.44%	31.97%	13.11%	10.66%	0.82%	58.663
2019	26.04%	33.33%	28.13%	9.38%	3.13%	64.531
2020	8.41%	7.48%	23.36%	37.38%	23.36%	79.401

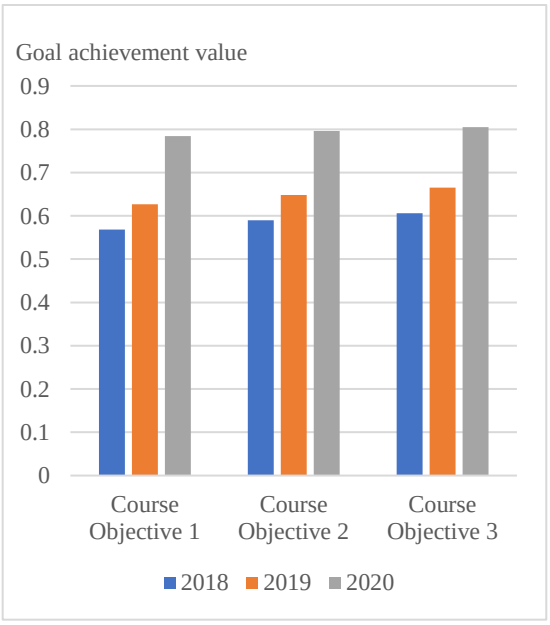

Fig. 1. Comparison of course goal achievement.

V. CONCLUSION

With the continuous development of engineering certification, higher requirements are put forward for the courses of computer science and technology and information majors. Under the guidance of the professional certification concept of engineering education, the course outline of discrete mathematics, the basic course of computer science and technology, is revised, focusing on the cultivation of students' graduation ability, refining teaching objectives, closely following graduation requirements, supporting graduation indicators, and constantly reforming teaching methods. Guide students to solve problems through independent learning, give full play to students' main position, promote students' independent learning, and cultivate students' ability to ask questions and solve complex engineering problems. By introducing a diversified assessment mechanism, it focuses on assessing the learning status of students throughout the process, and can also continuously improve teaching methods and methods according to the assessment results and student evaluations to improve teaching effectiveness.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Minghui Zhang completed the research and paper framework writing; Mingchao Zhang analyzed the data and completed the production of charts and tables, and revised the paper. All authors have approved the final version.

FUNDING

This research was funded by the 2022 Sanda University School-level Course Construction, grant number PZ-

522117, and the 2023 Sanda University Teaching Reform, grant number JW-2222450.

REFERENCES

[1] Y. Ge, L. Leng, and X. Wang, "Research on discrete mathematics hybrid teaching model for engineering education professional certification," *Journal of Higher Education*, vol. 22, pp. 121–124, July 2022.

[2] C. He, W. Zhou, and M. Li, "Discussion on curriculum teaching reform of "Artificial Intelligence" in the environment of professional certification of engineering education," *Education and Teaching Forum*, vol. 32, pp. 88–89, Jan. 2017.

[3] M. Guo and H. Wen, "Teaching reform of "discrete mathematics" curriculum based on the cultivation of independent innovation learning ability," *Research Education*, vol. 11, pp. 33–35, July 2018.

[4] D. Hu, "Discussion on the teaching reform of "Discrete Mathematics" course based on engineering quality training," *Industrial and Information Education*, vol. 4, pp. 24–28, May 2020.

[5] L. Wei, L. Zhang, and K. Zhang, "Exploration on the construction of discrete mathematics curriculum for computer engineering certification and curriculum ideological and political needs," *Education Informatization Forum*, vol. 11, pp. 11–12, May 2019.

[6] S. Sun, "Practice of reforming the discrete mathematics curriculum for engineering education professional certification," *Computer Knowledge and Technology*, vol. 15, no. 36, pp. 24–28, Dec. 2019.

[7] X. Deng, Y. Zhang, and S. Qiao, "Exploration of teaching reform of "Discrete Mathematics" course based on OBE concept," *Education and Teaching Forum*, vol. 38, pp. 186–187, Sept. 2019.

[8] Y. Zhang, "Research on the teaching of "Discrete Mathematics" course based on OBE concept," *Journal of Dali University*, vol. 7, no. 6, pp. 37–41, Jun. 2022.

[9] A. Ding, L. Xu, and J. Cui, "Research on teaching reform of Discrete Mathematics based on OBE concept," *Research and Practice of Innovation and Entrepreneurship Theory*, vol. 22, pp. 28–31, Nov. 2020.

[10] J. Lin, "Exploration of the construction of first-class undergraduate courses in application-oriented universities-taking discrete mathematics teaching reform as an example," *University*, vol. 39, pp. 55–57, Nov. 2021.