Research on Teaching Reform of Data Structure Course for the Cultivation of Application-oriented Talents

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Abstract. The data structures course, as a fundamental course in applied undergraduate computer-related majors, bears the responsibility of imparting algorithm knowledge, cultivating logical thinking, and conducting programming practices based on the disciplinary background. It also expands innovation and establishes a solid learning foundation for the cultivation of applied talents. In order to address the issues in current data structures teaching, such as traditional teaching methods, a vast knowledge system, numerous concepts and algorithms, strong theoretical nature, low student participation, and single assessment methods, this study proposes a reform approach in course teaching called "Three Real + Six Micro," which involves the use of real classic algorithms, real typical enterprises, real typical cases, as well as micro-videos, micro-courseware, micro-exercises, micro-case studies, micro-experiments, and micro-scenarios. This approach aims to reconstruct the teaching content, integrate ideological and political education into the curriculum, implement a blended online and offline teaching mode, establish a process evaluation mechanism, and provide online and offline dual-channel learning support, to comprehensively enhance students' autonomy and exploration abilities. Through the exploration and practice of the practical courses in some classes of a university in Jiangsu Province, the effect was significant and can be further promoted and applied in similar courses.

keywords: Applied Talent Cultivation; Data Structure; Teaching Reform

1 Introduction

With the continuous development of computer technology, the learning of data structures and algorithms in computer-related fields has become increasingly important. Teaching models should also be adjusted according to practical applications[1]. However, there are common problems in course teaching in universities, including slow updates of theoretical knowledge, disconnection from actual work, disconnection between theoretical and practical teaching, vague course learning objectives, and monotonous and rigid teaching models[2]. Taking the "Data Structures" course as an example, the pain points of the course can be summarized in the following three aspects:

(1) The course has a vast knowledge system, rich content, complex concepts, and confusing knowledge points. The root cause of this pain point is that the course learning

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objectives only list the knowledge points to be taught and mastered by students without providing a clear knowledge system. This leads to a lack of overall understanding of the course for students. Additionally, some students have a weak foundation in programming languages, which results in a situation of forgetting what they have learned[3-4].

(2) The theoretical aspects of the course are complex and difficult to understand, involving numerous algorithms and complex programming processes. The root cause of this pain point is that although information technology has been introduced in the teaching process, it has only transformed from "teaching from the textbook" to "teaching from the PowerPoint slides." The teaching methods of "reading concepts and explaining code" are monotonous, and the knowledge is obscure and difficult to comprehend[5]. Furthermore, students have different levels of learning ability, which leads to poor internalization of knowledge points and difficulties in self-study[6-8].

(3) The practical effect of the course content is not ideal, and students have low interest and participation. The lack of practical application of the course and the lack of substantive ideological and political education content become pain points[4,9]. The root cause of this is the inability of the teaching system and design to promote effective teacher-student interaction, stimulate students' enthusiasm for professional learning and practical innovation, and enable students to appreciate the practical value of the course.

This article takes the innovation and reform process of the "Data Structures" course as an example. In the process of cultivating applied talents, it integrates value shaping, knowledge imparting, and ability development. With a focus on "student-centered" approach, it follows the value orientation of "student learning interest" and "student ability," emphasizing the design of high-level teaching objectives, reconstructing the curriculum and teaching content, and creating learning experiences. It employs problem-oriented and project-based teaching methods, combines formative and summative assessments, and employs questionnaire evaluations to assess teaching effectiveness, constructing a blended online and offline teaching approach throughout the whole process [10-11].

2 Course Teaching Reform Plan

2.1 Implementing the "Three Truths + Six Micros" Teaching Philosophy

By incorporating real classic algorithms, real typical companies, and real typical cases, along with micro-videos, micro-courseware, micro-exercises, micro-case studies, micro-experiments, and micro-scenarios, namely the "Three Truths + Six Micros" in Figure 1.

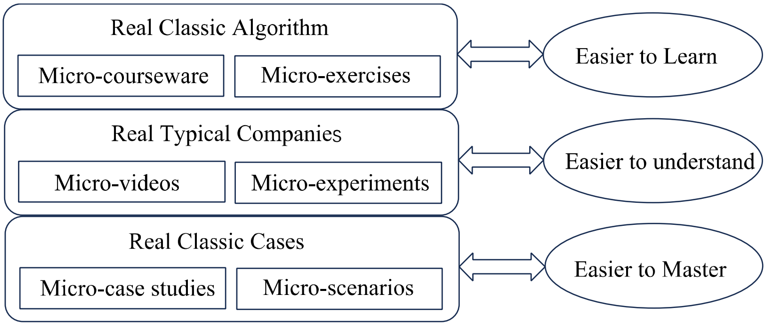

Fig. 1. "Three Truths + Six Micros" Teaching Philosophy

(1) Addressing the first pain point, the knowledge points of the data structure course can be organized around "real classic algorithms" such as sorting, searching, recursion, Kruskal's algorithm, etc. By using "micro-courseware" and "micro-exercises," complex and abstract concepts can be explained, illustrating how they solve problems or improve existing solutions. This approach makes the difficult and important content of the course more engaging and easier to learn. Additionally, an online learning platform can be utilized with appropriate learning tasks, allowing students to consolidate their understanding of the course content through completing tasks.

(2) To tackle the second pain point, introduce real-world problem scenarios from relevant industries and companies. Identify the key course content that addresses real problems encountered by these companies. Create "micro-videos" and "micro-experiments" to provide detailed explanations of the algorithm-solving process. Guide students to understand how the knowledge taught in the course can be applied to solve real problems. By providing online resources such as micro-videos and micro-experiments, students can engage in self-directed learning, accessing algorithm-related materials at their own convenience.

(3) For the third pain point, adopt a problem-oriented approach and create scenarios using "real typical cases." Design the teaching process with "micro-case studies" and "micro-scenarios" in the following flow: "example of application problems (by the teacher) - discussion of solutions (by students) - summarizing principles/learning theories (by the teacher/students) - exploring other applications (by students)." This approach allows students to learn theoretical knowledge in the context of practical application, making the course content more easily understood. Additionally, incorporate scenarios such as "city planning" and stories of famous individuals to immerse students in real-life situations and cultivate their problem-solving abilities.

2.2 Constructing the "Five-in-One" Approach to Teaching Reform

Building upon the implementation of the "Three Truths + Six Micros" strategies, the "Five-in-One" approach to teaching innovation has been developed (refer to Figure 2).

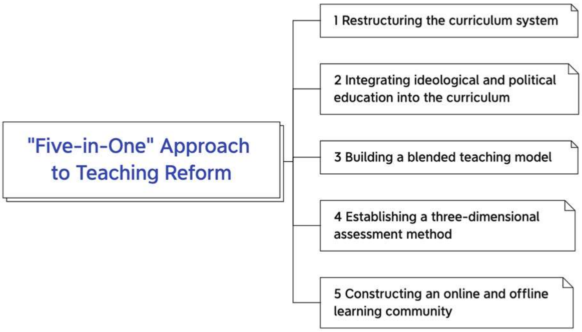

Fig. 2. "Five-in-One" Approach to Teaching Reform

Reconstructing the curriculum system, optimizing course content, and highlighting key points.

Based on the main theme of "Global Overview - Three Major Data Structures - Two Major Algorithms," and considering the characteristics of blended online and offline classrooms, the curriculum is reconstructed with the three guiding principles of "Easier to Learning, Easier to Understanding, Easier to Mastery." The design adheres to the cognitive laws and capacity development rules of learners, integrating knowledge, skills, and qualities into the project development process. Through problem-solving and project completion, it aims to drive the learning of knowledge and skills as well as the cultivation of professional qualities. The reconstructed curriculum content, in Fig3.

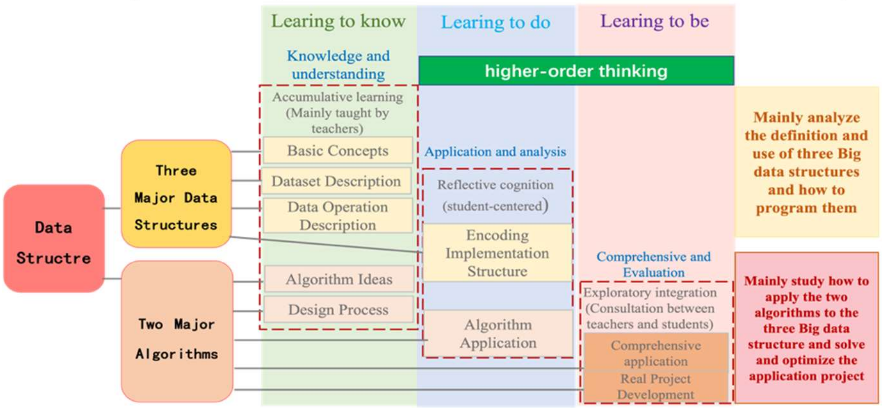

Fig. 3. Curriculum Content Reconstruction

Integrating ideological and political education into the curriculum, combining science with ideological and political education, and achieving comprehensive education through a dual approach.

During the ideological and political education process, various teaching methods such as group discussions, interactive questioning, and multimedia presentations are employed. Using personal stories, current events such as the pandemic, and practical engineering cases, students are encouraged to engage in deep thinking. The aim is to cultivate students' ability to not only acquire a solid theoretical foundation but also develop a scientific work style characterized by practicality, rigor, and a connection between theory and practice. Students are inspired to consistently self-reflect and introspect as university students of the new era, remaining true to their original aspirations and unwavering in their beliefs while continuously striving for self-improvement.

By adopting a "problem-oriented, scenario-based" approach, we can establish a blended online and offline teaching mode that focuses on student-centered learning.

This approach breaks away from traditional classroom lectures and fully utilizes the resources available from schools and students. The teaching process is project-oriented, aiming to activate classroom education. The boundaries between pre-class, in-class, and post-class activities are blurred, transforming the learning experience into a three-dimensional classroom. Students engage in learning within an interesting and self-driven environment, the student-centered blended teaching model in Fig.4.

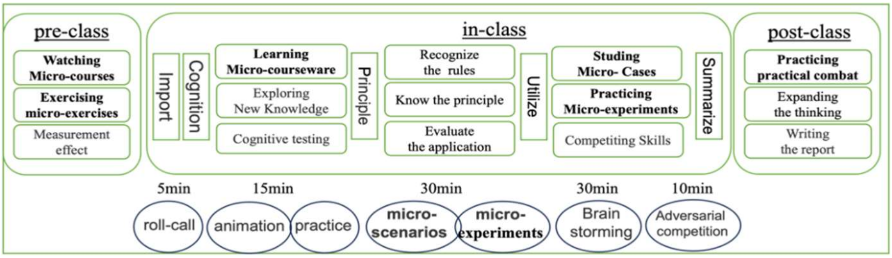

Fig. 4. A student-centered blended teaching model

Establishing a triple evaluation mechanism.

To establish a comprehensive assessment approach, we can implement a triple evaluation mechanism consisting of formative assessment, self-evaluation, and a final examination, as shown in the table 1. The weightage for each component can be allocated as follows: formative assessment (40%), self-evaluation (20%), and written examination (40%). This approach aims to increase the involvement of students in self-assessment and peer assessment.

Table 1. The triple evaluation mechanism

Evaluation Components	Evaluation Indicators	Weight-age
Formative Evaluation	Theme sharing, Classroom discussions, Classroom interactions, etc.	**20%**
	Homework tests: Pre-tests, in-class exercises, post-tests	**10%**
	Attendance and Completion of Knowledge Task Learning.	**10%**

Self-evaluation	Survey Questionnaire and Personal Assessment on Chaoxing Learning Platform.	**20%**
Final Exam	Comprehensive Skills Assessment, including Subjective Skills Test and Objective Skills Test.	**40%**

Building a learning community both online and offline, providing dual-channel learning support services.

Designing the teaching process with a "problem-oriented" approach: "Present application problems (by the teacher) - Discuss solutions (by students) - Summarize principles/learning theories (by the teacher/students) - Explore other applications (by students)." This approach enables students to learn theoretical knowledge under the guidance of practical application value, clarifying the direction for further in-depth learning.

At the same time, utilizing online platforms such as Chaoxing Learning Platform, Tencent Meeting, QQ, WeChat, etc., to create a learning community that fosters better interaction and support for students in the online space. This stimulates their sense of self-efficacy and promotes the generation and transformation of interactive behaviors. Assigning assignments, answering questions, providing feedback in the virtual space, and engaging in real-time communication with students help build a learning community based on "teacher-student discussion" and "student-student discussion."

3 The implementation and effectiveness

Based on the Chaoxing Learning Pass platform, a blended learning approach is implemented, where students independently learn basic knowledge through online resources, and the focus in the classroom shifts towards training students' comprehensive abilities through project completion. The aim is to achieve lower-level learning goals online and higher-level goals through in-person classroom instruction. Simultaneously, attention is given to the development of students' abilities driven by their interests, employing generative teaching strategies such as experiential or project-based learning. These strategies involve problem-solving and project completion to facilitate the acquisition of knowledge, skills, and the cultivation of professional qualities.

The "group learning method" is employed to generate group competition, fostering collaborative teamwork and communication skills. By establishing a learning community and conducting theme-based discussions, a favorable learning atmosphere is created, encouraging interaction between teachers and students as well as among students themselves.

3.1 Implementation Status

1.The course syllabus was revised according to the characteristics of talent cultivation and the process of teaching reform. Teaching materials and resources, including course outlines, lecture notes, and online teaching resources, were developed to guide students in self-directed learning and ensure a balance between theory and practice. Currently, 63 lecture notes and teaching resources, as well as 439 exercise resources, have been completed.

2.Overall student performance has gradually improved. In terms of exam results, compared to the 2018th-grade, 2019th-grade, 2020th-grade, 2021th-grade and 2012th-grade students. Refer to Figure 5 for more details.

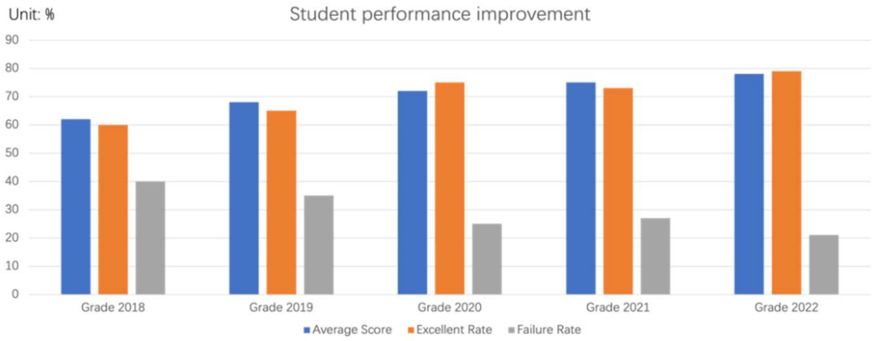

Fig. 5. Student Performance Improvement

3.2 Student and Teacher Achievements

In the past three years, students have shown outstanding performance in subject competitions and scientific innovation. Through participating in engineering projects and innovation competitions, they have enhanced their experimental skills and data analysis abilities. They can apply scientific knowledge to solve practical problems, demonstrating independent thinking, problem-solving, and creative thinking skills. Students have also exhibited strong collaboration skills and teamwork spirit within science and innovation teams.

At the same time, teachers have made significant progress in educational research and scientific innovation. They actively engage in educational research, teaching improvement, and curriculum design activities, providing innovative teaching methods and strategies for schools and the education sector. Their teaching practices and research achievements have been widely applied, playing a positive role in educational reform and teaching development. There is a positive interaction and cooperative relationship between students and teachers. Students are inspired and guided by teachers' scientific innovation, leading to increased participation in scientific research and innovation activities. Teachers, on the other hand, continuously improve their teaching proficiency and scientific innovation capabilities through collaborative exploration and practice with students. The Fig.6 refer to the attached image for relevant information on the achievements.

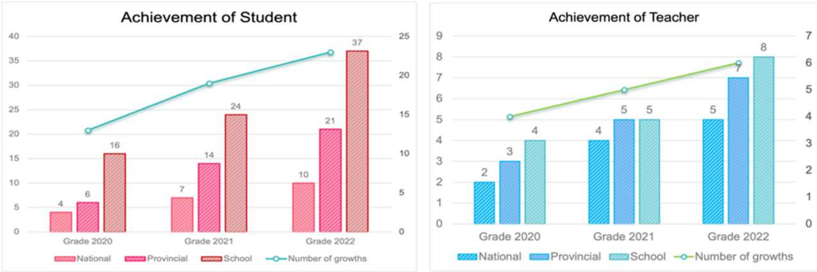

Fig. 6. Achievement of Student and Teacher

4 Conclusions

The implementation of the "Three Real + Six Micro" curriculum reform in data structures, aimed at cultivating applied talents, has successfully transformed the traditional "Data Structures" course. The reform measures include innovative classroom education, curriculum restructuring, and process-oriented assessments. The "Five-in-One" teaching model, which prioritizes students' personalized, comprehensive, and continuous development, has shifted the focus from teacher-centered to student-centered learning. It has effectively transformed passive learning into active participation, receptive learning into research-based learning, and solitary learning into cooperative learning.

After two years of implementation, based on student feedback and teaching quality assessments, this reform has achieved positive results. It has effectively promoted the development of students' practical and applied abilities, providing an effective teaching model for cultivating applied talents.

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