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Original Paper

Exploration of the Reform of Multi subject Co construction Data Structure Experiment Course under the Mixed Teaching Mode

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Abstract

In response to the high complexity of algorithm courses and the difficulty for students to understand, this paper focuses on the data structure experimental course and proposes a multi subject co construction data structure experimental course reform strategy under the blended teaching mode. The article first explores the problems in the content and methods of practical courses, and then proposes reform measures in teaching modes, teaching systems, and teaching methods. At the same time, on the basis of school enterprise cooperation, design differentiated experimental projects, teach students according to their aptitude, and strive for a student-centered teaching model, collaborative assistance to complete the role exchange between teaching and learning.

Keywords

mixed mode teaching, data structure, school enterprise cooperation, collaboration

Introduction

Data Structure is a fundamental course for majors such as Computer Science and Technology, Computer Information Management and Applications, and E-commerce, and is a very important core course. This subject is the foundation of program design, which enables programs to run more efficiently through a reasonable organization of data storage methods. Learning data structures can help students better understand various upper level abstractions, such as operating systems, compilers, databases, etc. (Hang, Ying, Tao, & Hui, 2023).

As a professional course that connects the past and the future, Data Structure mainly examines students' algorithmic logic. Its prerequisite courses include C language programming, discrete mathematics, etc., and subsequent courses include advanced language programming, computer networks, and database related courses (Xu & Zhu, 2021). This course focuses on analyzing the algorithmic logic of data storage and extraction. In order to adapt to the new trend of computer development, Java is often chosen as the implementation language for algorithm validation. Therefore, the process oriented development method in application will have significant differences in structure from C language. Moreover, this course is also a compulsory subject for many universities to take postgraduate entrance exams, so it places more emphasis on theoretical teaching. However, due to factors such as teaching hours, resources, and hardware conditions, the current data structure curriculum has an unreasonable experimental teaching system and content design, which cannot cultivate students' design, development, and implementation abilities from an application perspective, resulting in incomplete knowledge structure and hindering the training and improvement of students' innovative abilities (Wang & Zhu, 2019; Huang, 2021).

1. Problems in the Course

"Data Structure" is a compulsory course offered in the first semester, with a total of 56 class hours, including 8 experimental hours. The course design focuses on theory, with fewer practical sessions, and there is no course design assistance after the end of the course. Students do not have a lot of time to digest theoretical knowledge, resulting in the results of theoretical teaching not being verified in practice, and the teaching effect is greatly reduced.

1.1 Experimental Content

The content of the data structure course generally includes linear tables, stacks, queues, strings, arrays, trees, graphs, searches, sorting, etc. The essence of the course is algorithm analysis, with strong logic. Students need to understand the basic theory of algorithms and complete experimental verification and comprehensive application. Under the premise of less total course hours, experimental hours are also compressed. Due to class time limitations, teachers find it difficult for students to fully grasp theoretical knowledge within an effective classroom time. Teachers can only explain key content, and theory cannot be deeply developed. If the algorithm verification part cannot be carried out, it will make students have a poor understanding of the knowledge points in the learning process, and their application ability will be greatly affected. At the same time, the experimental content is not novel enough. Bundling experimental teaching with classroom teaching content, understanding that experiments are verification, neglecting the scalability of practical ability, is not conducive to exercising students' comprehensive application ability. The current experimental teaching content focuses on theoretical algorithm analysis, which is somewhat disconnected from high-level language, and students cannot apply algorithm analysis to practical development. At the same time, the experimental content is fragmented and the connections between chapters are not coherent (Sun, Song, Shen, & Xu, 2023). The main focus is on confirmatory experiments, which cannot improve students' collaboration and overall abilities.

1.2 Teaching Forms and Methods

This course mainly tests students' programming thinking, focusing on algorithm logic and requiring strong hardware processing ability. Currently, the computing ability of laboratory equipment is slightly weak, and some related software configurations are insufficient. Therefore, the experimental environment also affects the effectiveness of the experiment.

In terms of teaching forms and methods, the data structure teaching design usually adopts a one lesson, one practice model, and the experimental content is customized by the teacher, which is relatively rigid. Due to the limitations of the teacher's ability, the designed content cannot fully reflect its applicability (Huang, Liu, Su, Ju, Zhang, & Wang, 2024). And this course is based on the application of basic language in algorithms. If there are too few experimental hours, or if students do not have a solid grasp of the basic language part and only passively complete the verification in the experiment, it is difficult to demonstrate the ability to solve and analyze problems, which greatly limits students' creativity.

The evaluation of the experimental phase mainly focuses on three parts: attendance rate, experimental performance, and experimental report. This evaluation model adopts a quantitative template approach, which is theoretically very scientific, but in practice, it cannot truly reflect the level of students, that is, it cannot avoid phenomena such as careless experimental attitudes and plagiarism of experimental reports, leading to the inability to achieve experimental results.

2. Exploration of New Teaching Models

2.1 CDIO Teaching Mode

CDIO represents Conception, Design, Implementation, and Operation. It enhances students' practical abilities through engineering thinking, attempting to integrate them into the engineering practice of enterprises, allowing them to practice on their own and complete the construction of the curriculum system. Ultimately, it enhances students' learning ability, technical application ability, team writing ability, and system building product ability. CDIO can be applied to most majors in universities, proposing a total of 12 standards, covering basic environment, learning objectives, integrated teaching plans, engineering introduction, design implementation experience, engineering practice venues, comprehensive learning experience, active learning, teacher ability improvement, teacher teaching ability improvement, student assessment, and professional evaluation.

2.2 Implementing Entity

According to the CDIO ideology, the subject of teaching has shifted from teachers to students, and students should seek development in cultural foundations, self-awareness, and social practice, specifically reflected in scientific literacy, self-restraint, and practical innovation. The development of a training plan should include the following contents: (1) improving students' active learning ability, enhancing their ability to analyze and solve problems, and enabling them to gain a sense of gain in learning; (2) Enhance students' confidence, transform teaching methods into multiple modes, that is, adopt multiple blended education models, such as flipped classroom, case driven, online and offline, etc; (3) The concept of practical training mode emphasizes the importance of practice, and guides students into projects through problem posing and project driven approaches, enhancing their application abilities through a combination of industry, academia, and research.

2.3 Improve the Teaching System

A sound teaching system is the guarantee for achieving training goals, and the CDIO engineering education model aims to cultivate innovative and application-oriented talents who can adapt to the needs of industries and enterprises upon graduation. Establish an information exchange platform, build a teaching staff, design innovative experimental projects, and develop reasonable teaching plans. Adopting a school enterprise cooperation model, the practical teaching base integrating industry and education is jointly built by both the school and enterprise. Engineers are introduced to the school, and students are guided according to enterprise rules to complete project construction, master professional skills, accompany students throughout the entire process from demand, design to implementation, and improve practical application abilities.

The reconstruction of the teaching system should be improved on the basis of the original plan, incorporating new ideas into the original plan, developing a student-centered curriculum training plan, turning problem driven into project driven, improving the operability of experimental content, cultivating students' self-learning ability, formulating reasonable learning plans, and selecting experiments that meet their own needs for practice. Develop a scientifically reasonable guidebook for each comprehensive experiment, providing students with basic knowledge guidance and guiding them to solve practical problems.

2.4 Integration of Multiple Teaching Methods

In the context of new engineering, actively integrating new information technology into teaching, exploring new paths, methods, and strategies for teaching development, combining with teaching platforms, leveraging the advantages of information resource sharing, transforming traditional education models, and achieving collaborative teaching goals. Adopting a blended learning mode during class, utilizing flipped classrooms to facilitate role exchange between teachers and students, and utilizing online platforms to upload key content before class to enhance students' self-directed learning abilities.

The specific implementation method is to publish the experimental content and related requirements on the online teaching platform before class, so that students can fully preview the content. Teaching should always pay attention to the interaction between the platform and students, and answer difficult questions. In the experimental class, the teacher will list and explain the key problems that have been calculated one by one, and require students to learn through the internet outside of class to further improve their practical abilities. Make full use of online resources in class, adopt a flipped classroom teaching method to exchange roles with students, and subtly infiltrate knowledge into books.

The school and the enterprise jointly send personnel to participate in the formulation and implementation of the graduate training plan. Both parties refer to the teaching outline and combine industry characteristics to develop innovative and research oriented plans, organize graduate students to combine their research direction with the actual situation of the enterprise, and use actual projects to complete scientific research work. The reform of the curriculum should be adapted to the integration of industry, education, competition, and research. The overall or partial construction projects in enterprises should be introduced into the school enterprise cooperation plan, and project guidance should be used to guide graduate students in scientific research training, so that scientific research projects have a certain focus, thesis research does not deviate from reality, and thus achieve technological innovation. This type of scientific research training not only promotes production and research, but also helps to reorganize the direction of disciplinary construction, thereby achieving a deep integration of industry, academia, and research.

2.5 School Enterprise Cooperation

This study aims to establish a bridge between schools and enterprises, establish a win-win platform for school enterprise cooperation, and cooperate around teaching objectives with the strong support of enterprises. Regular project seminars will be held to analyze the problems between enterprises and schools, continuously improve and perfect cooperation models, and achieve win-win goals.

Actively exploring the activities of industrial models entering the classroom, developing new teaching systems, forming project-based curriculum models, and setting the cultivation of innovative talents as the goal of talent cultivation. Establishing a dual mentor system with enterprises, that is, parallel mentors on campus and off campus, clearing the barriers between theory and practice, and teachers and students tackling practical problems in the industry and enterprises. School enterprise cooperation is not only limited to the student side, but teachers can also go deep into the enterprise, reside in the enterprise as observers or technical guidance, participate in enterprise projects, jointly apply for projects, and apply some results to teaching research, forming a positive interaction between school enterprise cooperation and completing innovative plans for project co construction.

3. Reform of Experimental Projects

3.1 Differentiated Experimental Projects

In the context of new engineering disciplines, the cultivation mode of innovative talents is the main mode, and the design of experimental content should be closer to the industry and more practical. Basic experiments should be carried out using classic case studies, dividing the difficulty into different levels and progressively advancing the key points of knowledge. Through continuous advancement, the process of knowledge accumulation can be completed, allowing students to gain a sense of achievement in learning and enhance their interest in learning.

(1) Basic experiments

This experimental project tests students' basic operational abilities, including basic knowledge points and some basic algorithms. The algorithms involved include linear table construction (sequential table, chain), element search, expansion, element truncation, chain stack construction, infix expression to suffix expression, etc. These belong to the basic algorithms in data structures, which are easy to understand and involve basic knowledge points, making them suitable for students with weaker foundations to practice. In teaching, the experimental content is constantly adjusted according to the actual situation of students, professional skill requirements are updated, and basic experimental projects are extended.

(2) Advanced experiment

The projects involved in this experiment have improved in difficulty, extending the knowledge from the basic level to the advanced level, increasing the complexity and comprehensiveness of the operation. The algorithms involved include iterator construction, suffix expression calculation, string concatenation, string insertion, string deletion, string replacement, binary search, insertion sorting, fast sorting, selection sorting, etc. Before conducting experiments, students need to consult relevant materials to understand the correlation between knowledge points in different chapters, and design comprehensive experimental methods. The experimental project should cover the vast majority of knowledge in the outline, while also considering practicality, and integrate these algorithms into specific practical projects to achieve advanced projects and meet the practical ability cultivation of most students.

(3) Extended experiment

The difficulty of the experimental content continues to increase on the basis of advancement, with the aim of cultivating students' innovation ability. This type of experimental project requires pre class publication of task content, requiring students to consult relevant materials. Teachers should actively participate, and online meetings can be held to invite enterprise engineers to participate. Student discussion groups can be established to play the main role of students, forming a multi role interactive project group. Through this way, students can deepen their grasp of theoretical knowledge. Expansion project: Analyze the award-winning works of various A-class computer competitions in recent years in class, study the technologies applied in the works, and cross compare them with the research topic to find the technical relevance, and ultimately complete the experimental project.

3.2 Reconstruction of Teaching Content

(1) Improvement of teaching and experimental content

This course is offered in the first semester, and programming courses during the same period include Java programming Web system development technology, this course uses Java language as the foundation. Due to the fact that most students come from other majors and have poor foundations, while teaching algorithm logic, they also need to consider the language part. Therefore, in order to cope with the situation of limited experimental hours, the course teaching plans to break down the algorithm part of the teacher's self-developed projects or innovation and entrepreneurship projects and infiltrate them in class. A large number of algorithms will be arranged to be interspersed in various knowledge points and improved in the experiment, emphasizing the idea of algorithms serving practice, effectively connecting theory with practice, to make up for the experimental hours.

(2) Multi subject collaborative training

There is a certain correlation between the three programming courses offered this semester, Java programming is the foundation of language, data structure is the middle layer algorithm logic, and web system development technology is the front-end and back-end application. Therefore, the three are interdependent and mutually reinforcing. In data structure experiments, do not simply separate it from other courses. Instead, guide students to conduct project analysis, engage in discussions within the team, and encourage them to actively think about applying knowledge to different subjects. This strengthens knowledge through mutual verification, in order to achieve the ultimate goal of the experiment.

(3) Flexible assessment system

The newly established assessment system is no longer based solely on the report after the experiment. The evaluation of student experimental results takes into account the experimental results of the entire group, student attitudes, their role and performance within the group, and adds group collective defense and peer evaluation. Each group must participate in the defense for each experiment, and teachers and students from other groups should ask questions about the experimental content and related knowledge. Each defense group should assign task related personnel to participate in the defense, ensuring that each student in each group has at least one defense. At the same time, a one-on-one Q&A approach is adopted for each student and teacher, achieving sufficient fairness and impartiality. This assessment method not only cultivates students' teamwork ability, but also enhances their own adaptability and innovation ability.

4. Analysis of the Effectiveness of Teaching Reform

4.1 Evaluation Item

The teaching reform project is based on "Data Structure". By studying this course, students can understand the basic principles of algorithms and further expand their application software. Organize many knowledge points in the data structure course into knowledge nodes, and connect these nodes with some algorithms in actual projects to design a flexible algorithm training system suitable for students. The system modules should include tables, stacks, queues, strings, groups, trees, graphs, search, and sorting related algorithms. These algorithms are the middle layer of the entire system, namely the logical operation layer. By mastering the algorithm core implementation, students can not only greatly improve their programming ability, but also complete the level advancement as developers. The project assessment is divided into two parts, corresponding to relevant knowledge points. The detailed rules are shown in the Table below:

Table 1. Curriculum Evaluation Standards

evaluation project	Proportion (%)
the Order of Linear Tables and Chain Storage	10
queue initialization	10
stack initialization	20
infix and suffix operations on the stack	10
adding, modifying, and deleting strings	10
traversing binary trees	20
classic search algorithm	10
classic sorting algorithm	10

4.2 Collaborative Mutual Assistance

At present, the total duration of this course is 56 hours, aiming to explore the transformation of abstract knowledge into practical algorithms, solve the algorithmization of theoretical knowledge, and intersperse validation and design experiments in the design experiment process. Students can selectively operate based on their personal abilities and interests.

In the article, differentiated experimental projects are used to divide student abilities, and students choose moderately difficult questions based on different experimental projects. Basic experiment: Students are selected to form groups of 6 people, with each group having a team leader. The team leader is responsible for checking the algorithm of the group members and submitting it to the teacher uniformly; Advanced experiment: Students select 4 people in groups, with a team leader set for each group. Members of the group check the algorithm with each other, and the team leader is responsible for it, and the algorithm needs to be optimized; Expansion experiment: Set up a group of 2 people without a team leader. Members of the group should collaborate with each other to complete the algorithm writing, and the algorithm should have innovation and multi subject collaboration.

5. Conclusion

The key issues of this reform project include four aspects: design of experimental content, reform of experimental methods, control of collaborative training, and design of assessment system. The ultimate goal of the project is to stimulate students' interest in learning, complete interdisciplinary training, improve their independent thinking ability, and enhance their collaborative abilities. Based on teacher self-developed or college student innovation and entrepreneurship projects, design a complete set of effective experimental teaching reform models according to the requirements of the teaching syllabus. In the progress of the project, emphasis is placed on the coherence and scientificity of experimental teaching content, building a multi subject co construction platform, and integrating resources within disciplines. Explore experimental teaching methods through online and offline modes, propose flexible assessment systems, and develop high-quality and efficient experimental teaching reform plans.

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