Teaching Analysis and Design of Database System Concepts Based on CDIO

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Abstract: The CDIO (Conceive, Design, Implement, Operate) concept is a teaching methodology aimed at cultivating engineering talent, emphasizing the integration of theoretical knowledge and practical skills, and focusing on the comprehensive development of students' abilities. Traditional teaching methods for the Database System Concepts course have issues such as incomplete practical teaching, insufficient integration between courses, and a lack of comprehensive assessment methods. Guided by the CDIO concept, this paper comprehensively analyzes the considerations needed for the conception, design, implementation, and operation of the course. It optimizes the course design ideas, refines teaching objectives, designs a project-driven teaching model, strengthens course integration, and designs a full-process assessment system. This approach comprehensively fosters students' self-learning awareness and ability, enhances the quality of teaching, and lays a foundation for cultivating application-oriented talent.

Keywords: CDIO; Teaching Reform; Course Design; Database System Concepts

1. Introduction

The CDIO engineering education model is the latest achievement in international engineering education reform in recent years[1]. Since 2000, the Massachusetts Institute of Technology and three other universities have jointly founded the CDIO engineering education concept and established an international cooperation organization named after CDIO. In the CDIO education model, C stands for Conceive, D for Design, I for Implement, and O for Operate. It starts from practice, using the product development to product operation lifecycle as a carrier, guiding students to learn related courses in an active, practical, and organically connected manner through practical courses. It measures students' achievement based on whether they meet the predetermined goals across four levels: engineering fundamental knowledge, personal skills, interpersonal team skills, and engineering system skills[2].

The CDIO framework systematically integrates the conception, design, implementation, and operational capability development of experimental projects in the practical courses of Database System Concepts into project-based teaching. It provides operational standards and evaluation systems tailored to the teaching content[3]. The CDIO education concept uses the lifecycle from database system product development to operation as a carrier, organically linking the related knowledge systems through practical course content. It allows students to engage in engineering learning through project-based study, comprehensively developing their practical abilities to cultivate engineering and technical talent that meets actual social needs. Teachers can design high-quality practical teaching content scientifically and reasonably based on this concept, encourage students to participate in practical projects, increase student engagement in teaching activities, and timely grasp students' dynamic learning situations through teaching evaluation and feedback. This ensures that classroom teaching is "efficient," "quality-oriented," and "effective"[4].

2. Analysis of the Current Status of Practical Teaching in the Database System Concepts Course

The Database System Concepts course is an important branch of computer science, forming the core and foundation of information systems. It is also a crucial compulsory course for computer science students, responsible for imparting both theoretical and practical

knowledge of databases. Previously, our university has used traditional teaching methods for this course. Analyzing the course over recent years, we have identified the following main issues.

2.1 Emphasis on Theory over Practice, Insufficiently Engaging Students in Practical Activities

According to the current talent cultivation plan, the Database System Concepts course comprises 64 class hours, of which only 16 hours are practical sessions. As per the course schedule, practical classes are held every other week. In each practical session, students mainly practice specific statements, but their overall system development capabilities need improvement. The initial focus on practicing specific statements does not sufficiently engage students.

2.2 Lack of Integration with Other System Development Courses

Constructing and implementing database systems is crucial in overall system development and often takes up a significant portion of system development-related thesis work. However, due to constraints in class hours and syllabi, system development courses do not usually cover how to use the main programming language to call database programming languages for database application design. This leads to students failing to achieve the synergistic learning effect of "1+1>2" during their coursework.

2.3 Significant Disparities in Student Abilities

Some students show great interest in system development courses, demonstrating strong learning abilities and motivation, while others exhibit resistance to the subject and courses, adopting a "just pass" attitude toward the Database System Concepts course. This disparity in student engagement and ability is detrimental to the overall teaching activities.

2.4 Traditional Assessment Methods Fail to Fully Evaluate Student Abilities

The traditional assessment methods for this course primarily involve theoretical exams, combined with mid-term exams and regular assignments, focusing mainly on evaluating students' theoretical knowledge. This emphasis on theory over practice results in students having poor hands-on skills and low engagement in group activities during practical sessions.

With the acceleration of the new industrial revolution, the construction of new engineering disciplines is imperative. To fulfill the fundamental task of cultivating application-oriented talents that meet social needs, continuous optimization of the practical teaching of the Database System Concepts course is necessary. This includes ongoing refinement of teaching design to cultivate high-quality talents with strong system development capabilities[5].

3. Course Design of Database System Concepts

Practical teaching of the Database System Concepts course should center around students[6]. Combining advanced CDIO teaching concepts, the course syllabus design should be refined, fully exploring teaching elements of the Database System Concepts course and integrating theory with practice. This approach aims to impart scientific knowledge while developing students' logical reasoning, cooperation, and communication skills[7]. The CDIO-based syllabus design content is illustrated in Figure 1.

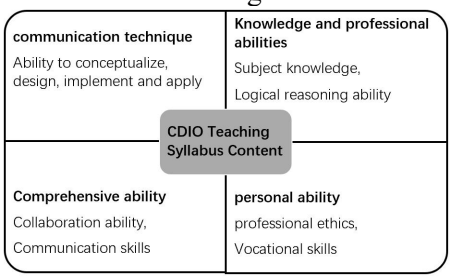

Figure 1. CDIO-based Syllabus Design Content

3.1 Integrating CDIO into Database System Concepts

Theoretically, the CDIO teaching design model is combined with the classroom teaching activities of the Database System Concepts course to form a comprehensive syllabus and teaching activity design framework. This ensures effective linkage between teaching activities from a theoretical framework, allowing students to deepen their understanding of knowledge through various

activities, enhancing their participation and interaction, and promoting their learning enthusiasm[8].

Practically, actual database system development cases are introduced, using the product development to operation lifecycle as a carrier. This approach aims to enhance students' interest and achievements by guiding them to learn related courses actively and practically, with organic links between courses. Students are cultivated in four aspects: foundational course knowledge, personal abilities, interpersonal team skills, and engineering system capabilities, measured by whether they meet the predetermined goals.

This holistic approach increases students' hands-on practice opportunities, enriches learning forms, and cultivates a group of students with strong practical abilities, laying a solid foundation for their future employment.

3.2 Always Putting Students First in Teaching

Throughout the teaching process, it is crucial to always put students at the center, cultivating application-oriented talents that meet social needs[9]. Traditional education models often center around teachers, emphasizing one-way knowledge transmission, which fails to fully engage students. A student-centered education model, however, emphasizes the subjectivity and participation of students, viewing them as explorers and constructors of knowledge. During the teaching of the Database System Concepts course, students are encouraged to engage in self-directed learning, cooperative learning, and other methods to develop their innovation and practical skills, fully leveraging their initiative while fostering their innovative spirit and entrepreneurial awareness.

3.3 Developing Flexible Assessment Schemes

The assessment scheme for this course should fully consider the CDIO teaching process, increasing the weight of practical components and comprehensively evaluating students' learning. During assessment, it is important to consider whether students have developed teamwork and logical reasoning skills and whether they have truly gained the abilities to conceive, design, implement, and operate. This approach ensures that every student feels engaged and valued in group activities.

4. Implementation Process of Teaching

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4.1 Refining Teaching Objectives

The teaching process emphasizes the integration of theory and practice, avoiding the separation of these two aspects[10]. Based on the application-oriented talent cultivation plan, the teaching objectives for students should be refined into knowledge objectives, ability objectives, and quality objectives.

Knowledge Objectives: The design includes key knowledge points of the Database System Concepts course, such as requiring students to "design a small database system according to relational database theory."

Ability Objectives: These are outlined from various perspectives such as mastery, proficiency, and familiarity. For example, "familiarize with the design and development of relational databases, including table design and optimization, and debugging and optimization of complex query statements," and "proficient in SQL statements, able to perform various operations on databases using SQL statements." Additionally, students should develop comprehensive application system abilities, so that upon course completion, they exhibit standardized corporate programming styles and excellent debugging skills.

Quality Objectives: These cover a broad range of content, such as requiring students to develop problem analysis and solving skills, teamwork abilities, and learning and collaboration skills through group work during the course. Students should also improve their documentation writing skills, eventually fostering a strong spirit of innovation, awareness of exploration, and self-regulation abilities.

During the teaching process, according to the teaching objectives and the CDIO concept, the ideas of conceiving, designing, implementing, and operating are implemented to achieve talent cultivation goals.

4.2 Designing a Project-Driven Teaching Model for Database System Concepts

The project-driven teaching model for Database System Concepts, based on the

CDIO concept, divides teaching tasks into six themes, each filled with exploration and interest. It guides students to engage in practice, continuously practicing theoretical knowledge points during project implementation, exploring and mastering the application techniques of knowledge, and internalizing them as their ability to solve real problems. This cultivates students' self-learning and innovative thinking abilities, improving learning outcomes and comprehensive qualities. For instance, in the "Database Design and Operation Comprehensive Experiment," teachers first provide simple examples of database system development processes, helping students visually understand the entire system development process, the development stages, and potential problems at each stage. Classic database design and development case studies are also provided to encourage student reflection. Students then choose their topics for practical work based on the experiment requirements. During the teaching process, teachers guide students to actively participate in project practice, encouraging them to design development system content and topics related to their study life, and guide them to complete system development and testing according to the system development process, cultivating their hands-on and practical skills. The final results are presented in the form of course experiment reports. After the project is completed, students are organized into groups for defense and project results presentation, selecting the most creative and functionally complete projects to summarize and share their learning experiences and achievements, encouraging students to develop innovative and practical skills proactively.

4.3 Strengthening Connections with Other System Development Courses

The Database System Concepts course mainly teaches students how to create new database tables, retrieve, update, and delete data in databases but lacks procedural control structures. Therefore, specific applications need to be combined with other development languages. During the course, teachers integrate the Python programming basics that students are learning in the current semester, explaining various database interfaces provided by Python so that students can easily connect and operate various databases, eventually completing a database system with a front-end interface. Additionally, students are encouraged to self-study and master how to combine database development software with development languages like Java, C#, and PHP, thereby truly building inter-course connections and maintaining long-term learning of Database System Concepts.

4.4 Establishing a Comprehensive Assessment System

In the Database System Concepts course, based on the CDIO teaching concept, assessments are integrated into various teaching segments. Therefore, assessments are not primarily based on traditional end-of-term evaluations such as assignments, final exams, or experiment reports. Instead, the CDIO ideas of conceiving, designing, implementing, and operating are strongly combined with different course stages, focusing on classroom performance, group performance, final assignment outcomes, and system implementation.

Post-reform, students pay more attention to applying theoretical knowledge in practice, comprehensively improving their hands-on skills. The practice process fully cultivates students' abilities to apply knowledge, personal skills, interpersonal team skills, and comprehensive abilities.

5. Conclusion

This paper comprehensively analyzes the teaching process of the Database System Concepts course, integrating the CDIO teaching concept. During the teaching process, the course is centered around students, encouraging hands-on practice and building a case library. Through the stages of conceiving, designing, implementing, and operating, students comprehensively master the course's knowledge system and the entire system development process, fully integrating theory and practice. This approach enhances students' interest in classroom learning and expands learning pathways. By strengthening connections with other system development courses and optimizing the assessment system, a full-process teaching reform is achieved.

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