Research and Practice on Project-Based Teaching Reform of the Course Fundamentals of Database Systems under the Background of Emerging Engineering

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Abstract: The construction of Emerging Engineering has put forward higher requirements for the practical ability and comprehensive quality of professionals in computer-related majors. As a core course, Fundamentals of Database Systems is faced with prominent problems in traditional teaching, such as rigid teaching content, disconnection from engineering applications, and rigid integration of ideological and political education, which need to be solved urgently. Based on the CDIO engineering education concept, this paper constructs a project-based teaching system, organically integrates curriculum ideological and political education into the entire life cycle of course projects, and introduces domestic information innovation databases to respond to the strategic needs of independence and controllability. Teaching practice shows that this reform mode effectively improves students' engineering practical ability, teamwork awareness and national sentiment, and provides a reference path for the teaching reform of similar courses.

Keywords: Emerging Engineering Education; Principles of Database Systems; Ideological and Political Theories teaching; CDIO; Information Innovation Database

1. Introduction

Since the launch of Emerging Engineering construction by the Ministry of Education in 2017, it has adhered to the development philosophy of *Responding to Changes and Shaping the Future*. It emphasizes interdisciplinary integration and the cultivation of innovative practical capabilities, putting forward systematic requirements for the reform of engineering education in colleges and universities. Against this backdrop, the teaching reform of computer-related professional courses has become a key measure to fulfill the talent training objectives of Emerging Engineering [1].

As a core course for computer majors, *Fundamentals of Database Systems* undertakes the important mission of laying a solid theoretical foundation of databases for students and cultivating their ability to solve practical problems [2]. Nevertheless, the traditional teaching mode of "theoretical lecture + demo system" has obvious drawbacks. First, the teaching content is course-centered with an intricate knowledge system constrained by limited class hours, making in-depth teaching difficult. Moreover, the course mainly adopts foreign database products and fails to timely meet the talent demand for domestic databases under the information innovation strategy. Second, teaching objectives are disconnected from engineering applications, leaving students unable to experience real engineering scenarios. Third, the separation of ideological and political education from professional teaching still persists, resulting in unsatisfactory educational outcomes [3].

In view of the above problems, based on the teaching reform practice of *Fundamentals of Database Systems* in the School of Information Science and Technology, Baotou Teachers' College, this study explores and constructs a project-based teaching model. The model takes medical data projects as the carrier, adopts the CDIO engineering education concept as the framework, features the organic integration of

curriculum ideological and political education, and takes the introduction of domestic information innovation databases as a highlight. It strives to realize the organic unification of knowledge imparting, ability cultivation and value guidance under the background of Emerging Engineering.

2. Problems Existing in the Traditional Teaching Mode

2.1 Rigid Teaching Content and Inability to Adapt to the Needs of the New Era

The teaching content of the traditional *Fundamentals of Database Systems* course has long revolved around the theoretical system of relational databases, covering data models, relational algebra, SQL language, database design, transaction processing, concurrency control and other contents. Although the curriculum system is complete, it tends to "cover everything without in-depth exploration", making it difficult to elaborate each knowledge point thoroughly within limited class hours [4].

Meanwhile, with the development of big data, the Internet of Things, artificial intelligence and other technologies, emerging database systems such as NoSQL and NewSQL have become increasingly important, while traditional courses obviously lack coverage of these cutting-edge contents [5]. More importantly, as the Information Technology Application Innovation (ITAI) industry has become a key national strategic direction, domestic databases including Huawei GaussDB, Alibaba OceanBase and Kingbase have been widely applied in key fields such as finance, government affairs and medical care. Nevertheless, most universities still adopt foreign products such as MySQL and Oracle in teaching, leading to a clear disconnection between teaching content and industrial demands.

2.2 Disconnection between Teaching and Engineering Application and Insufficient Cultivation of Practical Competence

Traditional database courses generally adopt the teaching mode of "theoretical explanation + demonstration system", with a simplified version of the *Student Course Selection System* or *Library Management System* running through the whole teaching process [6]. Although such examples facilitate students' understanding of knowledge points, they differ greatly from real engineering applications. Students lack cognition of complex business scenarios and can hardly experience the engineering decision-making process in database design, including requirement trade-off, performance optimization, and security strategy formulation.

Some scholars have pointed out that the conventional teacher-dominated teaching of the course *Fundamentals and Application of Databases* suffers from inadequate training of practical skills and an imperfect teaching evaluation system. After completing the course, students are usually only able to perform basic CRUD (Create, Read, Update, Delete) operations and feel helpless when facing slightly complex business requirements [7].

2.3 Forcible Integration of Curriculum Ideology and Politics and Unimproved Educational Effect

Curriculum ideological and political education is an important approach for colleges and universities to fulfill the fundamental task of fostering virtue and cultivating people [8]. Nevertheless, in computer-related professional courses, the integration of ideological and political elements is often superficial and stereotyped, such as making occasional remarks on current politics at the start of the course or inserting several red-themed pictures into courseware [1]. Such practices lack organic connection with professional teaching content.

Effective curriculum ideological and political education ought to be naturally integrated into teaching just as "salt dissolves in water", instead of being rigidly attached mechanically [5]. The course Fundamentals of Database Systems contains abundant ideological and political educational resources, including data security and national information security, research on independent and controllable technologies, self-reliance in science and technology, as well as data ethics and social responsibility. However, these in-depth inherent connections have not been fully explored in actual teaching practice.

3 Design of Project-Based Teaching Reform Based on CDIO

3.1 Reform Philosophy and Framework

The CDIO engineering education model is an important achievement of international engineering education reform. It advocates organizing the teaching process based on the

product life cycle, namely Conceive, Design, Implement and Operate, enabling students to construct knowledge and enhance competencies through complete engineering practice [9].

Drawing on the core philosophy of CDIO, this study constructs a project-based teaching framework of Three Stages and Four Levels. The "Three Stages" refer to the blended teaching organization form consisting of online self-study before class, project practice in class, and reflection and expansion after class. The "Four Levels" correspond to the four phases of CDIO, which closely couple the teaching process with the life cycle of engineering projects.

In terms of the teaching platform, an online teaching resource library is established based on the Chaoxing Learning Platform, realizing the chapter-based release and dynamic update of learning materials such as project cases, lecture videos, experimental manuals and phased quizzes. Relevant studies have shown that adopting teaching platforms such as SPOC to assist classroom teaching can effectively improve students' learning efficiency and form a three-dimensional teaching resource system.

3.2 Restructuring of Teaching Content: Goal-Oriented Project-Based Design

In terms of teaching content restructuring, guided by talent training objectives, this study constructs a three-tier content system: core foundation, frontier expansion, and information innovation practice. The core foundation layer includes basic database theories, data manipulation skills, database security mechanisms and design methods, which ensures students consolidate the fundamental knowledge of the discipline. The frontier expansion layer introduces the basic concepts of emerging databases such as NoSQL and NewSQL, helping students acquire a full picture of technological development. The information innovation practice layer takes the community edition of the domestic database Ocean Base as the teaching platform, guiding students to experience independent and controllable database technologies.

In the selection of project cases, this study abandons conventional classic topics such as the Library Management System and Student Course Selection System, and focuses on medical informatization — a field featuring both professional depth and social value. Specifically, the *Database System for Community Smart Medical Service Platform* is designed as a comprehensive project throughout the whole course. Its data scope covers multiple dimensions, including patients' basic information, medical consultation records, prescription data, drug inventory, examination reports, and doctor scheduling arrangements.

Medical data boasts typical complex relational characteristics: one-to-many relationships between patients and consultation records, many-to-one relationships between doctors and departments, as well as many-to-many relationships between drugs and prescriptions. It is naturally suitable as a comprehensive teaching case for database courses, fully covering core knowledge points such as conceptual model design, logical structure conversion, relational schema normalization, complex SQL queries, transaction concurrency control, and data backup and recovery. Meanwhile, the perceptibility of real medical scenarios enables students to easily comprehend the business logic underlying database design.

3.3 Integration of Curriculum Ideological and Political Education: Data Security and Independence & Controllability

In terms of integrating curriculum ideological and political education, centering on the two main lines of data security and independence and controllability, this study runs ideological and political elements through the four stages of CDIO, achieving a subtle and imperceptible educational effect [10]. Taking the comprehensive project of *Database System for Community Smart Medical Service Platform* designed in this research as an example, this section briefly illustrates the integration approach of ideological and political content within the CDIO framework.

Conceive Phase. Guided by a real case of patient information leakage caused by security vulnerabilities in the core database of a hospital, students are encouraged to discuss the impact of data security on individuals and society, understand the ethical responsibilities in the design of database security mechanisms, and initially establish the awareness that data entails responsibility.

Design Phase. When students design security strategies for medical databases, relevant provisions of the *Data Security Law of the People's Republic of China* and the *Personal Information Protection Law of the People's Republic of China* are

introduced [5]. Students are required to translate legal and regulatory requirements into technical constraints in terms of permission management, data encryption, audit logs and other aspects, so that they can naturally understand the connotation of the spirit of the rule of law and professional ethics in the design of technical schemes.

Implement Phase. The teaching practice of domestic information innovation databases is introduced in this phase. When explaining the development history of domestic databases, students are guided to understand the independent innovation journey of China's database industry, evolving from the predicament of chip and core technology shortage to the international leading status of products such as Huawei Gauss DB and Alibaba Ocean Base. This inspires students' dedication to serving the country through science and technology and their sense of mission. By comparing the technical routes of foreign commercial databases and domestic open-source databases, students are cultivated to form dialectical thinking to view technological independence and controllability rationally.

Operate Phase. In the operation and maintenance link of the project, situational tasks such as *emergency response to data anomalies* are arranged. Students are required to simulate data recovery and traceability analysis after the database is attacked, so as to cultivate their crisis handling capabilities and sense of responsibility.

The classroom presentation arrangements and political arrangements at each phase are illustrated in Figure 1.

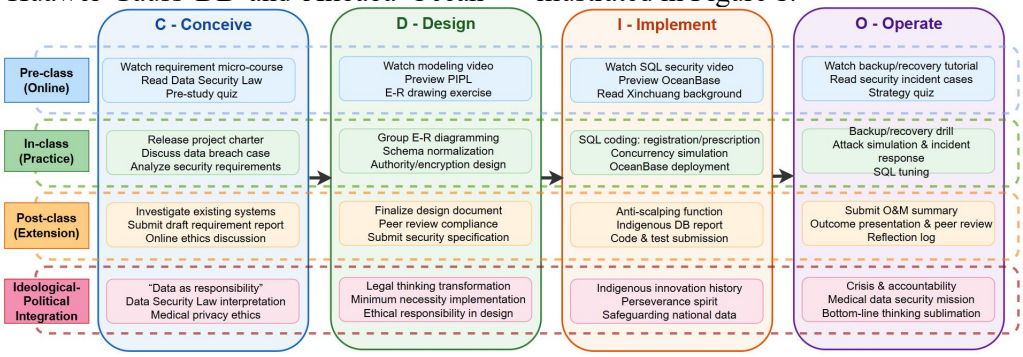

Figure 1.The Classroom Presentation Arrangements and Political Arrangements at Each Phase

3.4 Optimization of Teaching Evaluation System

The assessment of traditional courses mainly relies on final written examinations, which can hardly fully reflect students' practical capabilities and comprehensive literacy. This study establishes a diversified three-in-one evaluation system consisting of process assessment, project achievement evaluation, and ideological and political literacy evaluation.

Process assessment accounts for 30% of the overall grade. Relying on the Chaoxing Learning Platform, it records students' online learning tracks, classroom participation, scores of phased tests and other learning data. Project achievement evaluation takes up 50% of the total grade, which is comprehensively scored according to the process documents of the four CDIO stages (including requirement analysis reports, conceptual model design, database scripts, project summary reports, etc.) as well as the performance in the final defense. Ideological and political literacy evaluation accounts for 20% of the overall grade. Through project reflection journals, peer evaluation on team collaboration, special discussions on curriculum ideology and politics and other links, it examines students' growth in terms of data security awareness, team cooperation spirit, professional ethics cognition and other dimensions.

This diversified evaluation system aims to collect teaching and learning process data in a comprehensive and systematic manner, so as to realize real-time analysis of teaching effects and continuous improvement of teaching methods.

4 Teaching Practice and Effectiveness

4.1 Implementation Process

This teaching reform was implemented in the course *Fundamentals of Database Systems* for the Class 2023 Software Engineering major and international class in the School of Information Science and Technology, Baotou Teachers' College, covering approximately 85 students per academic year.

The course adopts a hierarchical blended practical teaching system supported by the

intelligent teaching platform Chaoxing Learning Platform, and is carried out in the three-stage blended teaching mode: online preview before class, project practice in class, and reflection and expansion after class. In the project implementation, students are divided into groups of 4 to 5 members. Centering on the *Community Smart Medical Service Platform* project, they make progressive progress following the four phases of CDIO, with clear task requirements and deliverable submission deadlines set for each stage.

4.2 Reform Achievements

Remarkable results have been achieved after one round of teaching practice. In terms of learning outcomes, students' capabilities in database design and engineering practice have been significantly improved, along with a notable enhancement in the quality of project deliverables. Multiple student groups independently expanded functional modules such as drug inventory early warning and medical visit peak prediction in their projects, demonstrating strong innovative ability.From the perspective of ideological and political education effects, an analysis of project reflection journals shows that more than 85% of students gained a deeper understanding of the importance of data security after completing the course, and showed strong interest and confidence in the development prospects of domestic databases. In terms of student satisfaction, the average score of course teaching evaluation has increased by about 12 percentage points compared with that before the reform. Most students commented that the medical project is close to real life and easy to understand, and project-based learning makes scattered knowledge points logically connected rather than isolated.

5 Conclusions

Against the background of Emerging Engineering construction, the core of the teaching reform of *Fundamentals of Database Systems* lies in breaking down the barriers between knowledge imparting and engineering practice, and realizing the in-depth integration of ability cultivation and value guidance.

The project-based teaching model characterized by medical data driving and ideological-political education integrated into practice constructed in this study adopts the CDIO engineering education concept as the framework. It organically integrates curriculum ideological and political education into the whole life cycle of projects and introduces the teaching of domestic information innovation databases, which has effectively improved students' comprehensive quality.

Follow-up research will be further deepened in continuously enriching the project library, constructing multimodal teaching resources, and conducting empirical evaluation of teaching effectiveness. It aims to provide more valuable practical experience for the curriculum reform of Emerging Engineering-related courses.

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