

Research on the Practical Application of the Tiered Teaching Model Based on the CDIO Concept in CMF Design Courses

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Abstract:

This study addresses the issues existing in the current CMF design course teaching mode, such as the complexity of knowledge content, singular teaching objectives, and assessment methods. It proposes a hierarchical teaching model based on the CDIO concept. This model emphasizes a project-oriented approach and customizes more rational teaching objectives and course assessment mechanisms, aiming to cultivate comprehensive talents in industrial design with professional knowledge, innovative thinking, and practical abilities. Through teaching practices, it has been proven that this model can effectively cultivate the practical and innovative abilities of students at different levels, thereby enhancing the teaching level and quality of instructors.

Keywords:

CMF Design, CDIO, Hierarchical Teaching

1. Introduction

CMF design is a core professional course required for industrial design majors, involving aspects such as product appearance design, color matching, material selection, and processing technology. Through in-depth study of this course, students will be able to proficiently understand and master the basic characteristics of materials and manufacturing processes. They will gain a comprehensive understanding of which materials and processes to use in product design to achieve a harmonious balance of functionality, aesthetics, and economy. The teaching content of the CMF design course features “interdisciplinary integration, emphasis on material exploration, and strong comprehensiveness and practicality.” The current traditional teaching mode often fails to achieve the teaching objectives and improve the overall teaching quality. In order to break through traditional teaching methods, innovative teaching models have become a key solution strategy.

The CDIO teaching model is a new achievement in engineering education reform obtained through years of exploration by universities such as MIT and has been widely used in teaching reforms in various countries. The so-called CDIO teaching

model refers to the integration of engineering practice projects into course teaching, the establishment of a curriculum system based on engineering practice needs, and the implementation of theoretical and practical teaching throughout the lifecycle of project development. Through the processes of conceptualization, design, implementation, and operation, students are provided with comprehensive training in theoretical foundations, practical skills, teamwork, and professional ethics, thereby enhancing their overall capabilities and professionalism [1].

Based on students' existing knowledge levels and professional abilities, grouping students with similar comprehensive abilities and conducting specialized and hierarchical teaching is the main purpose of hierarchical teaching [2]. Academic circles in various countries have discussed hierarchical teaching since the early 20th century according to their own national conditions. Although there are some differences, the basic approach to hierarchical teaching is consistent, that is, students are divided into different levels based on factors such as their learning levels, types of abilities, cognitive styles, and physiological characteristics, providing different types and levels of teaching content for students at each level. In recent years, hierarchical teaching in China has shown a flourishing trend, with various disciplines actively exploring hierarchical teaching models that fit their own academic situations.

Based on the analysis above, the author believes that integrating the CDIO concept with hierarchical teaching can meet the educational and developmental needs of modern vocational college students. This research, based on the CDIO concept, explores hierarchical teaching methods aimed at targeted cultivation of students' innovation and practical abilities.

2. Analysis of Teaching Issues

2.1. Course Analysis

2.1.1. *The knowledge content is extensive and difficult to accumulate rapidly.*

The CMF design course belongs to interdisciplinary studies, with a complex knowledge structure covering a substantial amount of material and engineering-related expertise. Consequently, students have relatively limited knowledge reserves in this field, making it difficult to accumulate rapidly in a short period of time [3]. Students' understanding of materials and processes mainly comes from two aspects: first, knowledge accumulated during high school, where preliminary understanding of materials and processes is partially reflected in high school physics and chemistry subjects. Given that this major is mostly comprised of students from humanities backgrounds, there are significant deficiencies in related knowledge and uneven levels of cognition. Second, knowledge is acquired from daily life experiences, but the accumulation of common knowledge is fragmented and incidental, making it difficult to form a complete system. These two situations result in the occurrence of the problem "difficult teaching for teachers, difficult learning for students" in the teaching process of this course.

2.1.2. *The setting of teaching objectives is singular, making it difficult to meet the needs of students at different levels.*

In CMF design courses, typically uniform learning objectives are employed in teaching. However, these objectives may lead proficient students to find the course content too simplistic and lacking in challenge, thereby losing enthusiasm for learning.

Conversely, students with weaker foundations often struggle to meet the set learning standards, resulting in feelings of frustration and a loss of confidence in their learning abilities. In light of this situation, CMF design courses should be based on the theory of the Zone of Proximal Development (ZPD), tailoring personalized learning objectives for students of different levels. The aim is to enable each individual to unleash their potential, ultimately achieving the educational goal of facilitating growth and showcasing talents for every student.

2.1.3. The assessment methods of the course are singular, making it difficult to comprehensively evaluate students.

In the assessment of the CMF design course, a combination of regular grades and final exams is typically used for comprehensive evaluation. Teachers grade students based on attendance, classroom performance, quality of assignments, and overall project outcomes. Process grades account for 60%, while final assessments make up 40%. However, a problem arises in the final assessment where all students take the same exam with identical evaluation criteria, making it challenging to achieve personalized development for industrial design talents. Therefore, both process-based and final assessments in the CMF design course should adopt a layered assessment approach, tailoring evaluation methods and exam questions to different levels of student proficiency, ensuring stratified evaluation and assessment.

2.2. Analysis of Student Situations

2.2.1. Students' career positioning is not clear.

Employment is an important goal for students in vocational colleges. However, some students are not clear about their future career paths and the nature of their work. Therefore, when designing courses, teachers need to analyze not only the students' current theoretical foundation, professional interests, and personality traits but also analyze the relevant job positions related to the course and the skills they need to possess. This helps students clearly identify their career paths and enhance the professional skills required for their positions.

2.2.2. Students lack the ability to comprehensively apply various skills.

The CMF design course is broad in scope and comprehensive [4]. In the process of teaching implementation, students are usually better at mastering individual skills, but they often lack comprehensive skills. This indicates that students lack a true understanding and integration when learning individual skills. Therefore, to enable students to have a more comprehensive understanding of the knowledge points in the CMF design course, a project-based teaching method should be adopted. This method helps students understand the logical relationships between different skills and acquire the ability to use various skills to comprehensively solve engineering problems.

2.2.3. Students lack the full process experience from product design to mass production.

Currently, most students' product engineering capabilities remain at the theoretical level, lacking experience in the full process of product design projects. Nowadays, the scope of product design is very broad, and the pace of innovation and iteration is fast. To proficiently master the engineering capabilities of various products or the CMF design capabilities of a certain type of product, one needs long-term learning and

accumulation within the industry [5]. Therefore, the teaching design of CMF design courses needs to be scientifically conceived and targeted, emphasizing the basic logic of CMF design. It should highlight the approach and process of solving problems in specific environments, allowing students to evaluate their design proposals from multiple dimensions of the course.

3. Construction of Hierarchical Teaching Model Under CDIO Concept

3.1. Implementation of teaching

The core of the CDIO philosophy is the integration of knowledge, qualities, and abilities. Under the CDIO philosophy, a distinctive system is constructed focusing on teaching objectives, content, and assessment. Based on the CDIO philosophy, a tiered teaching model is implemented, where various teaching practices are designed in reverse from multiple dimensions. Through project design units, specific design competitions, and design workshops, students' practical skills are gradually cultivated. Moreover, with learning outcomes as the guide, a multidimensional, multilevel, and participatory assessment system is established. Innovative assessment methods are introduced, continuously optimizing the practical teaching system, aiming to cultivate comprehensive qualities and practical abilities in innovative industrial design talents.

3.1.1. Customize the rationalization of teaching objectives and the four-element course content

(1) Course Overall Objectives: Under the framework of CDIO projects, the teaching philosophy of the CMF design course shifts from "teaching what" to "learning what." Through the implementation of "project-driven" and "learning by doing" teaching methods, the course aims to achieve the integrated development of theoretical knowledge and practical skills. CMF design is a practical course with strong application characteristics and is a fundamental skill required in industrial design [6]. Based on the demands of industrial design enterprises and the market, the course's teaching objectives are determined to clarify the knowledge and skills that students should master in the course. These objectives can be divided into three categories: knowledge, abilities, and qualities.

(2) Course Decomposition and Determination of Teaching Sub-Objectives: After determining the overall objectives of the course, the course outline and schedule are researched and developed. Due to the rapid development of CMF design, it is necessary to conduct research on the needs of the market and enterprises to adjust the course content. Within the limited course period, scientific teaching content is formulated and delivered. Course content is allocated based on class hours, and teaching objectives are determined for each session. Accordingly, rationalized courses are developed to realize the construction of the CDIO philosophy's four-element course system.

3.1.2. Guided by project output objectives and relying on CDIO project-based hierarchical teaching, cultivate students' practical abilities at different levels

The key component of practical teaching in the CMF design course is CDIO project-based teaching. Under the guidance of CDIO principles, combined with design competition projects as the main focus, students are placed at the forefront. Through the complete process of competition-based practical teaching, students'

innovative design abilities and comprehensive qualities are gradually enhanced, transforming fragmented course content into a cohesive whole, expanding into a broader landscape. The practical teaching content of the course is divided into three categories to meet the abilities of students at different levels [7]. The first category comprises fundamental practical content, centered around design units, utilizing diverse teaching methods and approaches to stimulate student interest and cultivate their practical skills. The second category involves comprehensive practical modules within the course, leveraging enterprise projects and competition projects for design after the completion of basic practical content. This allows students to master the comprehensive application of various design knowledge, familiarize themselves with the complete design process, and enhance their overall ability in CMF product design. The third category involves comprehensive practical modules outside of the course, focusing on the teacher's research projects, emphasizing the integration of science and education, and enhancing students' abilities for independent exploration and breakthrough innovation in design. Each design unit, specialized design, and research project must undergo the entire process of conception, design, implementation, and operation, allowing students to experience the complete journey from conceptualizing design proposals to implementing them, truly realizing the transition from design theory to practical application [8].

3.1.3. Taking “layered tasks, personalized guidance, and triple internalization” as the main thread to implement precision teaching, coordinating the integration of stage courses, and creating distinctive classrooms

In curriculum design, adhering to the CDIO engineering education philosophy, adopting “project-driven” and “learning through practice” teaching methods to promote the unified development of design theory knowledge and practical skills [9]. According to the layered teaching model, grouping students scientifically based on their learning levels and abilities, forming learning groups of the same level, implementing targeted and hierarchical teaching, creating unique classroom environments, and comprehensively enhancing students' innovative design abilities and practical application skills.

Before class, emphasis is placed on cultivating students' abilities for independent inquiry and critical thinking, igniting their interest in learning course content. Through the use of teaching platforms and online resources, tasks are assigned, discussion topics are set, and students are inspired and guided regarding upcoming instructional content.

During class, a project-based teaching approach is adopted, with knowledge and skill objectives scientifically designed based on the instructional content. Typical cases and materials are collected to design the implementation approach of the course content, subtly integrating values into the teaching process. During practical teaching sessions, guided by work tasks, instructors provide on-site guidance while students work in groups to practice, focusing on cultivating students' professional qualities [10]. Group cooperative tasks are established to foster students' communication and teamwork skills. The technical requirements of practical operations are elevated to cultivate students' rigorous attitude and pursuit of excellence in their professional demeanor. Throughout the completion of practical tasks, students' ability for practical innovation and problem-solving is cultivated through task-driven approaches, enhancing their sense of professional pride and social responsibility.

After class, instructors utilize teaching platforms to assign homework and provide additional learning resources for students to explore independently, expanding and enhancing their knowledge.

3.1.4 Constructing the “1245” curriculum ideological and political education construction model and methods.

The “One Mainline” refers to the job capabilities in CMF design positions; the “Two Course Resource Libraries” consist of the course resource library and the ideological and political education resource library; the “Four Teacher Teaching Modules” include pre-class, in-class, post-class, and extracurricular activities; the “Five Student Learning Steps” include pre-class introduction, in-class teaching, practical exercises, presentations, and evaluation feedback.

Utilizing online course platforms for pre-class introductions, employing in-class sessions as the main implementation platform for ideological and political education, adopting task-driven project-based teaching methods, using the “Introduction - Lecture - Practice - Presentation - Evaluation” framework to structure classroom activities, integrating ideological and political education elements into theoretical teaching, practical exercises, problem feedback, as well as extracurricular activities.

3.2. Course Assessment

The assessment of the course introduces value-added evaluation methods, establishing a diversified assessment system in collaboration with enterprises to measure the implementation effectiveness of course content from multiple dimensions. School teachers and industry mentors jointly formulate assessment schemes encompassing knowledge, skills, and qualities, including evaluation content, weight, and methods. During course instruction, students engage in self-assessment, peer evaluation, teacher assessment, and industry mentor evaluation, ultimately determining the course grades. For the comprehensive evaluation of students’ overall qualities, practical design projects serve as carriers, combined with the course’s teaching objectives, employing a combination of online and offline methods where students, teachers, and industry mentors jointly conduct comprehensive and full-process evaluations.

4. The Effectiveness of Teaching Reform

Based on the CDIO concept, the construction of the CMF design course’s tiered teaching model and the integration of the industry-course-competition certification system have set core course teaching objectives focused on developing the abilities of students at different levels. The author, guided by these objectives, reverse-designed the practical aspects of the course, integrating real industry projects and discipline design competitions throughout the course via project-based teaching. In course design, the “four-element concept” teaching steps, compatible with the CMF design process, were introduced, along with effective teaching tools and methods, alongside phased practical teaching segments. In terms of assessment, a combined approach of process-stage evaluation and final evaluation was proposed, utilizing multi-entity, multi-dimensional evaluation, and establishing value-added assessment criteria.

Currently, this reform in teaching mode has achieved preliminary results in the practical teaching of CMF design courses. Students have shown increased enthusiasm for course learning, demonstrating higher levels of enthusiasm and autonomy in

practical projects. Their sense of autonomous innovation, teamwork, and practical application abilities have also been enhanced.

5. Conclusions

The combination of the CDIO engineering education concept with the tiered teaching model has transformed the existing CMF design course, which previously suffered from poor class teaching effectiveness and limited teaching methods. Through practice, this teaching model has been proven to cater to individual differences among students, thereby enhancing their interest in learning course content and uncovering their potential. It also helps students understand job requirements, acquire necessary job skills, and adapt well to work positions. Additionally, this teaching model facilitates teachers in improving classroom management skills and enhancing their professional abilities. During classroom teaching, teachers need to focus on students with different levels of abilities, develop tiered teaching objectives, content, and assessment plans, and stay updated on the trends in science and new materials to timely update teaching content, thereby achieving the true purpose of teaching and learning.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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