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Teaching Reform and Exploration of Mechanical Drawing Course Based on OBE-CDIO Concept

Lei Yin[1], Zhongliang Lv[1], Xiaogang Deng [1], Zhifang Liu[1], Jie Meng[1], & Zelun Li[1*]
[1] Chongqing University of Science and Technology, Chongqing, China
[*] Corresponding Author

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Abstract

As a core basic course in mechanical engineering education, "Mechanical Mapping" plays an important role in cultivating students' engineering practice and innovation abilities. However, the traditional teaching model has problems such as focusing on theory over practice and insufficient student participation, which is difficult to meet the requirements of modern engineering education for comprehensive ability cultivation. In order to improve the quality of course teaching, this paper conducts research on curriculum teaching reform based on the concept of integrating OBE (Achievement-oriented Education) and CDIO (Conception-Design-Implementation-Operation). By reconstructing the teaching objectives that are oriented towards ability, designing modular and project-driven teaching content, introducing information technology such as virtual simulation and three-dimensional modeling, and implementing diverse dynamic evaluation methods, the curriculum teaching system is systematically optimized. Practice shows that the reform has significantly improved students' engineering graphic expression skills, spatial thinking skills and teamwork skills, and their academic performance and course satisfaction have been significantly improved. The research has verified the effectiveness and applicability of the OBE-CDIO model in mechanical drawing courses, providing reference for similar curriculum reforms.

Keywords

OBE, CDIO, mechanical drawing, teaching reform, engineering education

1. Introduction

As a core component of cultivating future technical talents, the optimization of curriculum systems and teaching methods in engineering education has always been an important issue in higher education reform. "Mechanical Drawing" serves as a foundational course for mechanical and related engineering disciplines. It not only undertakes the task of imparting knowledge such as projection theory and drawing standards but also is a crucial carrier for cultivating students' spatial thinking ability, engineering design expression ability, and standardization awareness. In the field of engineering practice, drawings are metaphorically referred to as "the language of the engineering world", and the mastery level directly relates to students' learning effectiveness in subsequent professional courses and their ability to engage in design, manufacturing, and other work in the future. The traditional teaching model of "Mechanical Drawing" has long had some limitations, mainly manifested as excessive emphasis on one-way input of theoretical knowledge and repetitive training of manual drawing skills, while neglecting the connection with modern engineering design processes and the cultivation of students' comprehensive innovative abilities. This model tends to lead to a disconnection between theory and practice. Although students can master drawing techniques, they find it difficult to flexibly apply the learned knowledge in complex engineering scenarios to conceive, design, and communicate solutions, thereby failing to meet the increasingly growing demand of current industrial development for the practical abilities and innovative literacy of engineering talents.

To address the above challenges, two influential educational concepts have emerged in the field of international engineering education: OBE (Outcome-Based Education) and CDIO (Conceive-Design-Implement-Operate). The OBE concept emphasizes the reverse nature of teaching design, starting from the final desired learning outcomes for students, and then planning course content, teaching strategies, and evaluation methods in reverse, ensuring that all teaching activities are closely centered around these ultimate outcomes (2023) (Liu, Deng, Luo et al., 2023). It focuses on what students have learned and what they can do, rather than simply what has been taught. The CDIO model provides a comprehensive framework for engineering education, simulating the real product life cycle of engineering, allowing students to experience the entire process of learning from concept conception, system design, prototype implementation to actual operation, aiming to systematically cultivate students' engineering basic knowledge, personal abilities, interpersonal team abilities, and engineering system abilities (2024) (Li, Yue, Zhao et al., 2024). These two concepts are highly complementary and consistent in their value orientations: OBE ensures that talent cultivation goals are clear and focused, while CDIO provides an effective path and contextual carrier to achieve these goals. The organic integration of OBE and CDIO to form an OBE-CDIO integrated education model can provide solid theoretical support and clear directional guidance for the teaching reform of practical courses such as Mechanical Drawing. The necessity of teaching reform based on OBE-CDIO concepts lies in its ability to drive the curriculum from "knowledge transmission" to a fundamental transformation towards "ability cultivation", making curriculum teaching more closely aligned with engineering practice and better supporting the achievement of graduation requirements (2025) (Zhang, 2025).

This study aims to explore the teaching reform path of the "Mechanical Drawing" course based on the OBE-CDIO concept. The main research objectives include: systematically analyzing the main problems existing in current course teaching; redefining the learning outcome goals of the course according to the OBE principle and aligning them with the CDIO competency framework; designing project-based teaching content and practical activities integrated with the CDIO process; and constructing a diversified and sustainable teaching evaluation mechanism to ensure the achievement of learning outcomes. The research methods mainly adopt a combination of theoretical analysis and practical research. By combing educational concepts and reconstructing the curriculum structure, a feasible teaching reform plan is designed, and its potential application value is explored. The structure of this paper is as follows: After the introduction, it will first elaborate on the core connotation and theoretical basis of the OBE-CDIO concept; then analyze the current status and challenges faced by the teaching of the "Mechanical Drawing" course; further focus on discussing the curriculum teaching reform design plan based on the OBE-CDIO concept; then explore the implementation of the plan and effect evaluation methods; finally summarize the full text and look forward to future research directions. It is hoped that through this research, it can provide certain reference for the innovation and reform of engineering graphics courses under the background of new engineering.

2. The theoretical basis and connotation of the OBE-CDIO concept

2.1 The Core Content of the Obe Concept

The Outcome-Based Education (OBE) concept is an education model oriented towards learning outcomes, with its core lying in focusing the design and evaluation of teaching activities on the knowledge, skills, and attitudes that students can ultimately master. This educational concept emphasizes starting from the expected learning outcomes, reverse-designing the curriculum system, teaching methods, and evaluation criteria, ensuring that the educational process always revolves around the achievement of students' abilities. The basic principles of the OBE concept can be summarized into three aspects: clarity, focus, and high-orderness. Clarity requires educational goals to be clear and measurable; focus emphasizes that all teaching activities are directed towards achieving the goals; high-orderness focuses on cultivating students' comprehensive ability to solve complex problems (2022) (Zhang, 2022). In terms of implementation path, OBE usually follows a closed-loop process of "defining learning outcomes-designing teaching segments-implementing teaching activities-evaluating learning effectiveness-continuous improvement", and this systematic approach ensures the continuous improvement of educational quality (2024) (Lin, Hu, Ma et al., 2025).

In the field of engineering education, the OBE concept has special application value. The engineering discipline itself has distinct practical and applied characteristics, which highly align with the ability cultivation orientation emphasized by OBE. Through the introduction of the OBE concept, engineering education can more accurately align with industry needs and cultivate talents with solid professional foundations and engineering practical abilities (2025) (Hu, 2025). Specifically, the guiding role of OBE in cultivating students' abilities in engineering education is reflected in three levels: at the knowledge level, it promotes students to establish a systematic professional knowledge structure; at the skill level, it strengthens students' ability to transform theoretical knowledge into practical applications; at the quality level, it cultivates students' engineering thinking and professional literacy (Zhang, 2022). This all-round cultivation model makes engineering education more in line with the requirements of modern industrial development for talents.

The implementation of the OBE concept has brought profound changes to the traditional engineering education model. Traditional teaching content organization is often centered on knowledge systems, while OBE shifts to being centered on ability achievement; traditional teaching methods focus on one-way transmission, while OBE emphasizes students' active participation and practical experience; traditional evaluation methods focus on summative assessment, while OBE emphasizes process evaluation and ability demonstration (Zhao & Zhou, 2021). This transformation has made engineering education more focused on students' actual gains rather than mere knowledge infusion. In engineering basic courses such as "Mechanical Drawing", the introduction of the OBE concept can effectively solve the problem of disconnection between theory and practice, and through clear ability indicators, help students establish spatial thinking ability and engineering expression ability (Du, 2025).

From the perspective of education quality assurance, the OBE concept provides an operable continuous improvement mechanism for engineering education. By establishing clear learning outcome standards, implementing diversified evaluation methods, and collecting systematic feedback data, educators can accurately identify weak links in the teaching process and take targeted improvement measures (Zhang, 2025). This data-driven quality improvement model enables engineering education to dynamically adapt to changes in technological development and industry needs. It is worth noting that the application of the OBE concept in engineering education is not a simple change in evaluation methods, but a transformation of the entire educational paradigm. It requires teachers to change their role positioning from knowledge imparters to learning guides; requires students to change their learning methods from passive acceptance to active construction; and also requires teaching management to change support methods to provide more flexible institutional guarantees for personalized learning (Li, Ren, Liao et al., 2024).

The combination of the OBE concept and engineering education is also reflected in its emphasis on core ability cultivation. Modern engineering practice pays more and more attention to interdisciplinary integration ability and innovative thinking ability, which are exactly the high-level learning outcomes advocated by the OBE concept. By setting challenging engineering problems and guiding students to use multidisciplinary knowledge for analysis and solution, engineering education under the OBE concept can effectively cultivate students' systematic thinking and innovative ability (Lu & Zhuang, 2015). At the same time, the real situation learning emphasized by OBE also provides students with the opportunity to contact actual engineering problems, enabling them to accumulate valuable engineering experience during school and lay a solid foundation for future career development (He, Wu, & Bian, 2022). This ability cultivation model oriented to real engineering environments enhances the professional adaptability and development potential of engineering talents.

2.2 Educational Connotation of the CDIO Model

The CDIO model, as a systematic engineering education framework, focuses on integrating the entire lifecycle of engineering practice into the teaching process. Originating in the early 21st century, this model was proposed by the international engineering education community to address the disconnect between theory and practice in traditional engineering education. CDIO represents four key phases: Conceive, Design, Implement, and Operate, forming a complete closed loop of engineering practice (Zhang, 2022). The Conceive phase requires students to clarify problem requirements and propose solutions; the Design phase emphasizes detailed planning of technical solutions; the Implement phase highlights hands-on operation and prototype development; and the Operate phase focuses on the practical application and optimization of products. This phased teaching design effectively cultivates students' systematic thinking and engineering practical abilities (Zhang, 2025).

In terms of fostering engineering practical capabilities, the CDIO model has distinct advantages. It uses projects as carriers to integrate scattered knowledge points into an organic whole, helping students establish internal connections between knowledge. By simulating real engineering scenarios, students adapt to workplace environments in advance, shortening the transition period from school to enterprise. More importantly, the model emphasizes the cultivation of teamwork and communication skills, which aligns with the interdisciplinary nature of modern engineering projects (Li, Ren, Liao et al., 2024). Studies have shown that teaching using the CDIO model can improve students’ engineering practical abilities by over 30% (Yu, Wang, Ji et al., 2025), with enhancements primarily reflected in problem-solving skills and innovative thinking.

Integrating the CDIO model with the OBE concept can generate synergistic effects. OBE emphasizes learning outcomes orientation, while CDIO provides specific pathways to achieve these outcomes. Their integration is manifested in: OBE defines “what abilities to cultivate”, and CDIO addresses “how to cultivate them” (Li, Yue, Zhao et al., 2024). At the curriculum design level, the OBE goal matrix can guide the focus of ability cultivation in each stage of CDIO; in the evaluation phase, the continuous improvement mechanism of OBE can optimize the implementation effect of CDIO. This combination maintains the systematicness of engineering education while ensuring the accuracy of training goals (Xie & Li, 2025). Theoretically, their philosophical foundations are consistent—both emphasize student-centeredness and ability orientation, making their integration naturally feasible (Lu & Zhuang, 2015).

Specifically, regarding the integration pathway, it is first necessary to map the four phases of CDIO to the expected learning outcomes of OBE. The conceptualization phase corresponds to the cultivation of requirement analysis ability, and the design phase corresponds to the enhancement of engineering drawing and calculation ability. In curriculum evaluation, both the quality of outputs from each CDIO phase and the achievement of ability indicators set by OBE should be assessed. By establishing feedback mechanisms, evaluation results are used to continuously improve teaching plans, forming a closed-loop management system (Zhang, Lu, Zhao et al., 2022). This integration is not a simple superposition, but requires in-depth reconstruction at three levels: curriculum objectives, content organization, and evaluation system (He, Wu, & Bian, 2022). Practice has proven that curriculum reforms adopting the OBE-CDIO collaborative model can increase students' comprehensive ability achievement by 25%-40%, fully demonstrating the practical value of their integration.

3. Current Situation and Problem Analysis of the "Mechanical Drawing" Course

3.1 Characteristics and Shortcomings of the Traditional Teaching Model

At present, the teaching mode of the course "Mechanical Drawing" in most universities is still mainly traditional. The teaching content usually revolves around core knowledge points such as national drafting standards, projection theory, drawing and reading of part diagrams and assembly diagrams. Although this system has the advantages of systematicness and integrity in theoretical teaching, it often neglects the cultivation of engineering practical abilities. In terms of teaching methods, teachers mostly use classroom lectures combined with blackboard writing or multimedia courseware demonstrations, while students consolidate their knowledge by completing a certain number of exercises. This one-way indoctrination leads students to be in a passive reception state, with less classroom interaction and difficulty in mobilizing learning enthusiasm. The evaluation method generally focuses on the final-term written examination, supplemented by daily homework and attendance. This single evaluation mechanism mainly examines students' memory and understanding of theoretical knowledge, but it is difficult to comprehensively reflect their spatial thinking ability, drawing skills, and comprehensive quality of solving practical engineering problems.

The traditional teaching model has its shortcomings, with the primary issue being "emphasis on theory and neglect of practice". Courses overly stress the explanation of drawing principles and standards, while students lack sufficient practical opportunities to apply their acquired knowledge to real situations. Although students can recite projection rules, they still struggle to accurately construct three-view drawings when faced with complex shapes, reflecting a disconnection between theory and practice. Student participation is generally low. Due to the lack of interest and challenge in the teaching process, many students only aim to pass exams, learning through mechanical memorization without truly developing engineering thinking and innovative abilities. Over time, this tends to lead to a decline in learning interest and limited teaching effectiveness.

Multiple survey data reveal students' true feedback and needs regarding these issues. A questionnaire survey among students majoring in mechanical engineering at a certain university showed that over 65% of the students considered the current course content dull and not closely related to practical applications; nearly 70% of the students hoped to increase the practical class hours for computer-aided design (e.g., CAD software) instead of merely learning theoretical drawing methods (Lin Peng, Hu Dong, Ma Yinhua, et al., 2024). Another study pointed out that about 80% of the students believed that the assessment methods were overly reliant on written exams, which made it difficult to reflect their comprehensive abilities, and they were more inclined to accept diverse evaluation methods such as project assignments and team collaboration. These data indicate that students generally desire a teaching model that places greater emphasis on practice, participation, and innovation, expecting to acquire skills and experience directly applicable to future work through course learning. Therefore, the reform of traditional teaching models is imperative. We must shift to a student-centered and outcome-oriented educational philosophy to truly enhance curriculum quality and educational effectiveness.

3.2 The Demand and Challenges of Teaching Reform

The current engineering education accreditation system has put forward clear requirements for the quality of talent cultivation, emphasizing a student-centered and outcome-oriented teaching model. Engineering education accreditation standards generally focus on students' practical abilities, innovative awareness, and comprehensive qualities to solve complex engineering problems, which has prompted the traditional "Mechanical Drawing" course to undergo reform in order to meet the accreditation requirements (Hu, 2025). From the perspective of industry demands, the trend of modern manufacturing towards digitalization and intelligence is increasingly evident. Enterprises' expectations for talent capabilities are no longer limited to basic skills of reading and drawing diagrams, but rather require them to possess three-dimensional modeling, collaborative design, and interdisciplinary knowledge integration abilities. If the course content and teaching methods fail to keep pace with the times, it will lead to a disconnection between talent cultivation and actual industry needs, weakening the employability competitiveness of graduates.

From the perspective of student development, traditional teaching models often focus on teacher lectures, with students passively receiving knowledge, making it difficult to stimulate their learning interest and initiative. Over time, this not only affects students' in-depth understanding of professional knowledge but also hinders the formation of their innovative thinking and engineering practice abilities. In contrast, the OBE-CDIO concept advocates a student-centered approach, enhancing learning experience through project-based and practical teaching, which can precisely make up for the shortcomings of traditional teaching and promote the all-round development of students. Therefore, advancing curriculum reform is not only an inherent requirement for educational development but also an inevitable choice to improve students' overall quality and employment competitiveness.

The teaching reform process still faces challenges from multiple aspects. In terms of resources, implementing the OBE-CDIO model requires corresponding software and hardware facilities, such as three-dimensional design software, virtual simulation platforms, and practical teaching venues. Some colleges and universities may find it difficult to meet these conditions due to financial constraints. In terms of faculty, the reform requires teachers not only to have solid theoretical knowledge but also rich engineering practice experience and project guidance abilities. Currently, many teachers lack relevant industry backgrounds, and adapting to the new model requires a long transformation and training period. Building a scientific and effective evaluation system is also a major difficulty. Traditional evaluation relies mostly on written exams and homework scores, while OBE-CDIO emphasizes process-oriented evaluation and ability assessment. How to design evaluation indicators that can comprehensively reflect students' practical abilities, teamwork, and innovation level still needs in-depth exploration (Zhang, Peng, Long et al., 2024). It is urgent to promote the reform of the "Mechanical Drawing" course, but it is necessary to systematically address challenges in resources, faculty, and evaluation mechanisms to ensure the reform achieves substantial results.

4. Course Teaching Reform Design Based on OBE-CDIO

4.1 Redefinition of Teaching Objectives and Competency Indicators

The reconstruction of curriculum teaching objectives based on the OBE philosophy centers on taking students' final learning outcomes as the guiding principle and reverse-designing the entire teaching system. This means that curriculum objectives no longer focus solely on what teachers "teach", but rather more on what students "learn" and what they "can do". In "Mechanical Drawing", an engineering foundation course with strong practicality, traditional teaching objectives often focus on mastering knowledge points such as national standards for mechanical drawing, projection theory, reading and drawing of part diagrams and assembly diagrams. Under the guidance of the OBE philosophy, teaching objectives need to be profoundly reconstructed, expanding from a single knowledge dimension to a comprehensive dimension integrating knowledge, abilities, and literacy (or attitudes). Specifically, at the knowledge level, students should not only memorize and understand the basic concepts and norms of mechanical drawing, but also be able to understand the spatial logic behind them and the engineering application context; at the skill level, teaching objectives should transcend the 初级 stage of "being able to draw", emphasizing high-level abilities such as digital expression using modern design tools (such as CAD software), effective technical communication based on engineering drawings, and solving geometric shape expression problems encountered in actual design; at the attitude level, it is necessary to cultivate students' engineering rigor, standardization awareness, team spirit, and professional literacy of being responsible for design quality. This redefinition of objectives ensures that the starting point and destination of teaching activities are directly aimed at enhancing students' comprehensive abilities.

After clarifying the macro teaching objectives oriented towards outcomes, it is necessary to further refine them into specific ability indicators that are observable, measurable, and evaluable. At this point, the CDIO model provides a highly operational framework for this refinement process. The four stages represented by CDIO - "Conceive-Design-Implement-Operate" - fully simulate the entire life cycle of modern engineering products. Integrating this model with the "Mechanical Drawing" course means that the formulation of ability indicators must be closely aligned with real engineering practice processes. In the "Conceive" stage, ability indicators can be set as "being able to conceive the basic structural shape of mechanical parts according to simple functional requirements and analyze their expression schemes"; in the "Design" stage, indicators should focus on "being able to draw and annotate part working drawings and assembly drawings in accordance with projection principles and national standards", as well as “being able to generate two-dimensional engineering drawings that meet production requirements based on three-dimensional models”; in the “Implement” stage, ability indicators can focus on “being able to correctly read engineering drawings designed by others and understand their manufacturing and assembly process intentions”; In the “operation” phase, although it is less involved, we can initially introduce the cultivation of awareness of “being able to conduct a simple evaluation of drawing designs from the perspectives of manufacturability and assimilability

Through the in-depth integration of OBE and CDIO, a systematic capability indicator system for the course has been established. It is no longer a discrete list of knowledge points but a clear capability map that guides students from theoretical cognition to engineering practice and innovation step by step. Behind each indicator corresponds to the core capability requirements of a certain CDIO link, and directly supports the final learning outcomes defined by OBE. This design effectively highlights the cultivation of engineering practical ability, as it requires students not to passively receive knowledge, but to actively participate in a micro "project" process: they need to "conceive" the expression method for a virtual or real part, "design" engineering drawings, "implement" its transformation from 3D to 2D, and initially "operate" to think about its downstream applications. In this process, the innovative thinking ability to solve unconventional problems is naturally exercised, such as how to clearly express a complex part with the most concise views, how to optimize annotations to facilitate automated processing, etc. The reconstructed teaching objectives and refined CDIO capability indicators together form the cornerstone of the teaching reform of the "Mechanical Drawing" course, ensuring that the cultivated students not only have a solid foundation in drawing but also possess the core competitiveness to support their future engineering careers.

4.2 Optimization of Teaching Content and Teaching Methods

In the teaching reform of the “Mechanical Drawing” course based on the OBE-CDIO concept, the optimization of teaching content and methods is a core link. Traditional course content often emphasizes the systematic transmission of theoretical knowledge while neglecting the connection with actual engineering needs. To address this, we first carried out modular reconstruction of the teaching content. Modular design aims to integrate scattered knowledge points into units with clear functional goals, such as modules like “Basic Drawing Standards”, “Part Drawings and Assembly Drawings”, “3D Modeling and Conversion”, and “Project Comprehensive Practice”. Each module corresponds to specific ability output goals, making students’ learning process more directional and phased. This design not only conforms to the principle of outcome-oriented education (OBE) but can also naturally integrate the “Conceive-Design-Implement-Operate” (CDIO) full-cycle engineering thinking emphasized by the CDIO mode.

In terms of teaching methods, project-driven learning and case-based teaching have become the main approaches. The project-driven method simulates real engineering tasks, requiring students to complete the entire process from product conception to drawing design in group form. In the “Assembly Drawing” module, students need to conduct functional analysis, structural design for a certain mechanical device, and finally output standard engineering drawings. This process covers multiple links of CDIO, effectively promoting the cultivation of practical abilities and teamwork. Case-based teaching introduces actual industry cases (such as automotive parts drafting or machine tool assembly drawings) to help students understand how theoretical knowledge is applied to engineering practice, thereby enhancing their ability to solve complex problems. Both methods emphasize students' subjectivity and participation, forming a sharp contrast with traditional didactic teaching.

The application of information-based teaching methods has further improved teaching effectiveness. Virtual simulation technology allows students to repeatedly practice drawing and reading drawing skills in a digital environment, for example, by deepening their understanding of assembly structure through virtual disassembly and assembly experiments. The application of three-dimensional modeling software (such as SolidWorks or AutoCAD) enables students to transition from two-dimensional plane drawing to three-dimensional space design, which meets the needs of modern manufacturing for digital design capabilities. Studies have shown that classes using three-dimensional modeling tools have improved in spatial imagination and drawing accuracy. After reform, a college found through comparative experiments that students using virtual simulation-assisted teaching had a reduced error rate of about 25% in drawing projects and an improvement of more than 30% in design efficiency. These tools not only enhance students' practical experience but also lay a solid foundation for their future engineering design work.

Teaching optimization also focuses on the diversification of evaluation methods. In addition to traditional written exams, we have introduced methods such as project outcome reviews, peer group evaluations, and process-based evaluations to comprehensively assess students' mastery of knowledge and achievement of abilities. This diversified evaluation system can more accurately reflect the "outcome-oriented" emphasis of OBE, while motivating students to continuously invest throughout the CDIO process. Through modular content design, project and case-driven approaches, and the integration of information technology, the optimization of teaching content and methods has not only improved the teaching quality of the “Mechanical Drawing” course but also effectively cultivated students' engineering practical abilities and innovative thinking, providing a feasible path for the training of applied talents.

5. Implementation and Effect Evaluation of Teaching Reform

5.1 Specific Implementation of the Reform Plan

During the implementation of the teaching reform program for the “Mechanical Drawing” course based on the OBE-CDIO concept in pilot classes, systematic adjustments were mainly carried out in three aspects: teaching organization, resource allocation, and teacher-student interaction methods. In terms of teaching organization, the course broke away from the traditional pattern of teaching according to chapter sequence and adopted a teaching structure combining modularization with project-driven approach. Each teaching module is centered around a specific engineering task, such as part mapping or assembly design, enabling students to integrate into the complete process of “conception-design-implementation-operation” from the early stage of the course. The course schedule emphasizes step-by-step ability progression. In the early stages, emphasis is placed on basic theory instruction and familiarization with software tools, while in the later stages, the proportion of comprehensive and innovative projects is gradually increased, ensuring that students continuously consolidate and apply the knowledge they have learned in practice.

Resource allocation is an important foundation for supporting the implementation of reforms. The teaching activities in the pilot classes have made full use of digital teaching platforms and virtual simulation laboratory resources. The teaching team has integrated various digital resources, including 3D modeling software, virtual simulation experiment platforms for engineering graphics, and online collaboration tools, to build an online-offline blended learning environment. These resources not only ensure the possibility for students to conduct practical operations anytime and anywhere but also provide necessary technical support for project-based teaching. The teaching team has also compiled project task books, evaluation standards, and learning guides supporting the reforms to ensure the standardization and operability of the teaching process.

In terms of interactive methods between teachers and students, the reform emphasizes a shift from “teacher-centered” to “student-centered”. The teacher’s role gradually transforms from a knowledge transmitter to a guide in the learning process, a coordinator for project advancement, and a promoter of ability development. In class, teachers stimulate students’ active exploration by posing questions, setting scenarios, and organizing group discussions; during the project implementation phase, they adopt a combination of individual tutoring and team guidance to provide differentiated support based on students’ varying learning progress. Interaction among students is also enhanced, with group collaboration becoming the primary learning format. In the process of completing projects, students need to communicate, divide tasks, and negotiate to jointly solve engineering problems. This not only improves their professional skills but also cultivates teamwork and communication abilities.

Through the typical application of project-based teaching methods, the teaching process of the pilot class has shown strong practicality and integration. In the project "Reducer Design and Expression", students need to go through the entire process from functional analysis, structural conception to engineering drawing. During the project implementation, students conduct research in groups, discuss plans, and complete sketch design, three-dimensional modeling and engineering drawing output through division of labor. Teachers conduct inspections and guidance in stages to ensure that the project progress meets the teaching goals. After the project is completed, students are required to conduct result presentations and group mutual evaluations. This link not only exercises their expression and reflection abilities, but also exposes them to diverse design ideas and methods.

From the perspective of student feedback, project-based teaching effectively stimulates learning interest and initiative. Most students believe that through the practice of actual projects, their understanding of mechanical drawing knowledge has become more profound, and their application abilities have been improved. At the same time, the experience of team collaboration has also helped them better adapt to the needs of future engineering practice. Although some students showed maladjustment to independent learning and team coordination in the initial stage of the project, these problems were gradually alleviated through timely guidance from teachers and resource support. Overall, the implementation of the reform plan has achieved relatively good results in improving students' comprehensive abilities and course satisfaction.

5.2 Evaluation and Analysis of Teaching Effectiveness

The evaluation and analysis of teaching effectiveness are crucial links to test the success or failure of the curriculum reform of "Mechanical Drawing" based on the OBE-CDIO concept. The traditional single-examination evaluation method is difficult to comprehensively reflect the improvement of students in engineering practice ability, innovative thinking and overall quality. Therefore, it is of great importance to construct a scientific and diversified evaluation system. This reform has designed and implemented a multi-dimensional evaluation scheme covering the learning process, practical achievements and subjective feelings, aiming to objectively measure the actual effect of teaching reform.

This diversified evaluation system is mainly composed of three parts: academic performance evaluation, practical ability evaluation, and satisfaction survey. Academic performance evaluation is no longer limited to the final written exam, but instead introduces a formative evaluation mechanism, including regular project assignments, phased tests, classroom participation, and final comprehensive exams, where the proportion of written exam scores is reduced to 60%, and project assignments and experiment reports account for 40%. This structural adjustment aims to reduce the tendency towards examination-oriented learning and pay more attention to students' application and understanding of knowledge. Practical ability evaluation is mainly reflected through CDIO project achievements, where projects such as component mapping, three-dimensional modeling, and engineering drawing completed by student groups are quantitatively scored by teachers and enterprise mentors based on the rationality, standardization, innovativeness, and team collaboration of the design. Satisfaction survey adopts an anonymous questionnaire form, which is distributed to students after the course ends to collect their subjective feelings and opinions on aspects such as course content, teaching methods, and their own ability improvement.

To verify the effectiveness of the OBE-CDIO model, the study compared comprehensive data of students from two consecutive classes before and after the reform. In terms of academic performance, the average score of students after the reform increased from 78.5 (Class of 2022, n=120) to 85.2 (Class of 2024, n=118), and the score distribution became more balanced with an increase in the number of students in the high-score range. The evaluation results of practical abilities showed that the average score rate of students in projects increased from 72% before the reform to 88%, with particular progress in three-dimensional modeling and drawing standardization. These data indicate that the new teaching model has effectively promoted the integration of students' theoretical knowledge and practical skills. The feedback from the satisfaction survey was also positive, with over 90% of students believing that project-driven teaching improved their learning interest and initiative, and 85% of students feeling that their ability to solve engineering problems had been enhanced.

Through a comprehensive analysis of this data, it can be concluded that the teaching reform based on the OBE-CDIO concept has achieved results in the Mechanical Drawing course. The diversified evaluation system not only provides a more comprehensive perspective for assessment but also verifies the dual advantages of OBE’s outcome-oriented approach and CDIO’s emphasis on engineering practice. The improvement in academic performance indicates that students have a more solid grasp of basic knowledge; the enhancement of practical abilities reflects progress in the cultivation of engineering literacy and innovative thinking; and the high satisfaction demonstrates students’ recognition and acceptance of the new teaching model. Of course, some areas needing improvement were also identified in the evaluation, such as uneven participation of some students in team projects and occasional tension in hardware resources in practical sessions. Overall, these evaluation results fully validate the effectiveness of the OBE-CDIO model in improving teaching quality and students’ comprehensive abilities, providing a basis and direction for the continuous optimization of subsequent courses.

6. Conclusion

This study carried out teaching reform on the “Mechanical Drawing” course based on the OBE-CDIO concept and achieved results. By reconstructing teaching objectives, optimizing teaching content and methods, students’ engineering practical abilities and innovative thinking have been improved. The outcome-oriented characteristics of the OBE concept ensure that teaching is always centered on ability cultivation, while the CDIO model provides students with a complete engineering experience from conception to operation. The organic combination of the two makes the course teaching more close to actual engineering needs, effectively solving the problem of disconnection between theory and practice in traditional teaching models. In terms of practical value, the OBE-CDIO model strengthens students’ active learning awareness, enabling them to gradually master the core skills of mechanical drawing under project-driven learning. The diversified reform of the teaching evaluation system not only focuses on the final grades but also emphasizes process assessment, making the evaluation of learning outcomes more comprehensive. The introduction of information-based teaching methods, such as the application of three-dimensional modeling and virtual simulation technologies, further improves teaching efficiency and enhances students’ spatial thinking abilities and engineering expression abilities.

This study still has certain limitations. The scope of the reform pilot is limited, and the sample size is small, which may affect the universality of the conclusions. The implementation of the OBE-CDIO model imposes higher requirements on teachers’ abilities, and some teachers still need to adapt to new teaching concepts and methods. Curriculum reform requires supporting hardware facilities and school-enterprise cooperation resources, but the practical conditions of some colleges and universities still need to be improved. In the future, teaching reform can be further deepened from the following aspects. First, strengthen interdisciplinary integration, combine mechanical drawing with cutting-edge technologies such as computer-aided design and intelligent manufacturing to expand the application scenarios of courses. Second, deepen school-enterprise cooperation, introduce real engineering projects as teaching cases to enhance students' professional adaptability. Third, optimize the evaluation system, explore more scientific quantitative indicators to more accurately reflect students' ability improvement. Fourth, strengthen teacher training, improve teachers' understanding and practical ability of the OBE-CDIO concept to ensure the sustainable advancement of teaching reform.

Overall, the OBE-CDIO concept provides an effective path for the reform of the Mechanical Drawing course, but it still needs to be continuously adjusted and improved in practice. Future research can further expand the sample size, explore its applicability in different colleges and universities and different professional backgrounds, so as to promote the overall improvement of engineering education quality.

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