

Research on Innovation of Engineering Drawing and CAD Course

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Abstract

Engineering drawing (ED) and computer aided design (CAD) are core basic courses for engineering majors, which integrate theory, practice and application, and serve as a key link connecting basic theories and engineering practice. In view of four major problems existing in traditional teaching, namely rigid classroom teaching forms, incomplete practical education system, backward assessment and evaluation mechanism, and insufficient teaching adaptability, this paper carries out curriculum reform under the guidance of outcomes-based education (OBE) philosophy. Four innovative measures including interactive classroom reform, project-based and interesting teaching, diversified evaluation optimization, as well as integration with workplace demands and artificial intelligence (AI) technology are adopted to accurately solve teaching difficulties. Meanwhile, curriculum ideological and political education is deeply incorporated to realize the coordinated development of skill training and value guidance. Teaching practice shows that the reform has effectively improved students' practical operation ability, engineering problem-solving capacity and digital innovation competence. Students' academic performance, competition achievements and course satisfaction have been greatly enhanced, and the overall teaching quality and educational efficiency of the course have been upgraded. This reform model features low implementation threshold and strong replicability, which can provide practical references and typical examples for the teaching reform of similar basic engineering courses.

Keywords

Engineering drawing, Computer aided design, Outcomes-based education philosophy, Curriculum ideological and political education

Introduction

With the accelerated digital transformation of the engineering industry, enterprises have set higher requirements for engineering talents in terms of drawing design capability, digital operation skills and comprehensive professional literacy. As an introductory core course for majors such as Civil Engineering and Engineering Management, Engineering Drawing and CAD undertake the important functions of cultivating students' spatial imagination, engineering drawing reading and drawing abilities, as well as engineering practical thinking. It lays a solid foundation for students' subsequent professional study, employment and competency improvement. CAD is widely used in professional engineering and design industries, making it a relevant educational tool for bridging school learning with workplace practice [1].

The traditional teaching mode has long been plagued by disconnection between teaching and students' learning

status, separation of theory and practice, detachment of classroom teaching from workplace demands, and failure to keep pace with technological iteration. These problems lead to students' low learning enthusiasm, weak practical ability and poor post adaptability, making it difficult to meet the demand for digital engineering talents in the new era. To break the bottlenecks of traditional teaching and implement the fundamental task of fostering virtue through education in colleges and universities, this paper constructs a brand-new curriculum teaching innovation system. It is based on the OBE philosophy, combined with students' learning situations and job requirements of the industry. The goal is to improve teaching efficiency, enhance students' comprehensive abilities, and upgrade the talent training mode.

Core problems in traditional course teaching

Based on long-term reflection on teaching practice,

surveys on students' learning status, and research on job demands of the industry, this study summarizes the original seven scattered problems into four core issues. These issues include rigid classroom teaching, a deficient practical teaching system, a lagging assessment and evaluation mechanism, and inadequate teaching adaptability. These problems interact with and restrict one another, becoming the main obstacles restricting the improvement of teaching quality and talent cultivation. In the engineering curriculum, engineering graphics is special in the respect that it is concerned with output in terms of visualization and accuracy, as opposed to analytical or theoretical recall that characterizes many other disciplines [2]. The ED course presents a challenging endeavor for the majority of engineering students [3].

Rigid classroom form and low learning efficiency

Traditional teaching mainly relies on one-way lecturing and software demonstration by teachers, with a lack of effective interactive links. Students passively receive knowledge and struggle to concentrate for a long time, resulting in low learning efficiency. In addition, the course content is dominated by repetitive operations such as line drawing and command input. The monotonous learning experience dampens students' initiative and makes it hard to maintain sustainable learning motivation. Class interactions can reawaken students' fading attention [4].

Fragmented practical system and inadequate engineering application ability

Knowledge points are taught in a fragmented way without systematic practical carriers. Most students can only master isolated theories and basic operations, and fail to integrate what they have learned to complete comprehensive drawing design tasks. Moreover, the absence of real engineering scenarios in teaching deprives students of training in analyzing engineering problems, correcting drawing errors and optimizing schemes. When faced with comprehensive design tasks, students often feel confused and do not know how to proceed, with poor ability to analyze and solve practical engineering problems. Rather than relying solely on traditional drawing methods, teachers should incorporate both physical and digital modelling activities more consistently into classroom practice [5]. If CAD learning can be carried out well by students, students will be able

to analyze, create, design, and evaluate [6].

Backward assessment and evaluation mechanism with weak educational guidance

The traditional assessment mainly depends on final examinations, which focus on theoretical knowledge and simple operations while ignoring the growth of students' practical abilities and comprehensive performance throughout the learning process. The evaluation dimension is single and cannot fully reflect students' overall competencies. Besides, evaluation results are released with a long delay. Students are unable to discover their deficiencies in a timely manner, and teachers cannot provide targeted guidance, which greatly weakens the diagnostic, motivating and guiding functions of assessment.

Insufficient teaching adaptability and disconnection from industry development

On the one hand, the teaching content is limited to basic theories and elementary operations, failing to meet the workplace requirements for efficient drawing, standard labeling and collaborative design. Graduates need to receive re-training after employment, resulting in weak core competitiveness. On the other hand, the teaching mode fails to integrate cutting-edge AI technologies. Students have no idea about the collaborative application of AI and CAD, lacking digital design thinking and the ability to adapt to technological upgrading in the engineering industry.

Innovation and implementation path of course teaching reform

Guided by the OBE philosophy, this research adheres to the principles of student-centered, outcome-oriented and problem-driven education. Corresponding targeted innovative measures are formulated for the four core teaching problems, forming a closed-loop teaching innovation system featuring targeted problem solving, whole-process teaching empowerment, all-round ability improvement and synchronous literacy cultivation.

Classroom mode innovation: Online and offline integration to vitalize classroom teaching

To address the problems of rigid classroom form, poor concentration and insufficient learning motivation, an interactive and interesting classroom mode combining online and offline teaching is established. Relying on the online learning platform, a complete teaching scenario

covering preview before class, interaction during class and consolidation after class is built. Diversified in-class activities such as quick answering, thematic discussions and on-the-spot achievement display are carried out, together with real-time reward mechanisms to mobilize students' participation and transform passive learning into active exploration. Educational institutions should strengthen programs that encourage student engagement through active learning approaches, digital simulations, and the use of interactive technologies. These approaches can increase student participation while improving their information and communications technology (ICT) literacy [7].

Meanwhile, diversified interesting teaching methods are adopted to change the dull learning status. Abstract knowledge such as the principle of three-view drawings and layer settings is visualized with animations to reduce learning difficulties. Characteristic drawing tasks combined with traditional culture and festivals are designed, including drawing national flags and mooncake construction drawings with CAD. AI tools are also used to optimize the artistic effect of drawings. The combination of professionalism, fun and cultural connotation effectively stimulates students' independent learning enthusiasm.

Reconstruction of practical system: Project and case-based teaching to improve engineering competence

A practical teaching system integrating knowledge points, projects and real cases is constructed to solve the problems of fragmented practical teaching and deficient problem-solving ability. The fragmented knowledge teaching mode is abandoned. All knowledge points and operation skills are transformed into standardized drawing projects with clear objectives and implementation standards. Students can systematically master drawing skills by completing phased projects, which eliminate confusion about learning goals and difficulties in practical operation. Group projects cultivate students' teamwork and problem-solving abilities [8].

In addition, real engineering cases are introduced into classroom teaching. Typical cases concerning coordinate deviation, unreasonable layout and non-standard labeling in engineering practice are analyzed. Students are organized to discuss the causes of problems, work out optimization schemes and revise drawings. Through the

training of real cases, students can gradually establish engineering thinking and improve their ability to identify, analyze and solve complex practical problems. The case method is relevant in CAD learning because it shifts the focus from mastering software commands to the ability to solve practical drawing problems [9]. Enrich case libraries to bridge theory and practical projects [10].

Optimization of evaluation mechanism: Multi-dimensional whole-process assessment to strengthen educational guidance

A three-dimensional assessment system consisting of formative evaluation, summative evaluation and real-time feedback is constructed to reform the single assessment mode. Formative evaluation runs through the whole teaching process, covering classroom performance, online learning data, homework quality, project completion and experiment reports, so as to fully record students' learning progress.

The final examination is redesigned into a comprehensive engineering drawing task of A1 size. Students are required to submit both electronic CAD files and printed drawings to comprehensively assess their overall design capabilities. A real-time feedback mechanism is also established. Teachers point out problems in students' drawings and put forward improvement suggestions immediately after receiving their work, enabling students to correct errors in time and achieve continuous progress.

Integration with workplace and AI technology:

Adapting to industry development demands

To bridge the gap between teaching and workplace requirements as well as digital development, the reform focuses on workplace skill training and AI application. On the one hand, practical skill packages are compiled based on teachers' extensive engineering practical experience. These packages include a catalog of frequently used CAD shortcut commands, self-developed List Processing (LISP) programs for batch processing and error checking, as well as industry-standard CAD blocks to support professional software teaching. Students can master efficient drawing skills for workplace application during school, shortening the adaptation period after graduation and enhancing their competitiveness.

On the other hand, the integrated teaching of AI and CAD is promoted. AI tools are used to generate LISP

programs, house type drawings and component models to lower the threshold of intelligent design. Students conduct in-depth design on the basis of AI-generated drafts to master the process of AI-aided design. AI is also applied to detect labeling errors and optimize drawing layout, cultivating students' digital design thinking to adapt to the technological development of the industry.

Integrated curriculum ideological and political education for coordinated development of skills and morality

To fulfill the fundamental task of cultivating morality and nurturing people, teachers organically integrate ideological and political education elements into every teaching procedure of this course. It avoids the separation of professional teaching and moral education. It realizes the joint development of skill training and moral cultivation.

Cultivate craftsmanship and patriotism

Thematic practical activities are carried out in combination with traditional festivals. During the Mid-Autumn Festival, students are guided to complete full sets of mooncake construction drawings. The teaching of drawing standards conveys the spirit of striving for perfection and rigorous professionalism. On National Day, students practice drawing national flags with CAD under strict requirements on proportion and color parameters, fostering their rigorous working attitude and patriotism.

Shape professional ethics and literacy

The high-precision requirements of engineering drawing are combined with professional ethics education. Teachers illustrate the impact of millimeter-level drawing errors on engineering safety, construction quality and project cost, and extend the connotation to the professional norms of abiding by rules and sticking to moral bottom lines in the workplace. Traditional cultural concepts are integrated into teaching to help students develop pragmatic and rigorous professional habits.

Strengthen value guidance and establish career aspirations

Professional knowledge is combined with positive value guidance. In the teaching of staircase drawings, the progressive structure of stair treads is compared to the attitude of making steady progress in life. It guides

students to be down-to-earth and persistent in learning and future work. Combined with the development history of the engineering industry, students are encouraged to devote themselves to their majors and pursue lofty career goals.

Achievements of teaching innovation

Comprehensive improvement of students' abilities

The teaching reform has achieved remarkable results in improving students' academic performance and practical abilities. The proportion of students with excellent grades (above 80 points) has increased significantly. Most students are able to independently complete full set engineering drawings, reversing the common problems of "having theoretical knowledge but no operational ability" and "being skilled in operation but unable to solve practical problems".

Students have achieved fruitful results in discipline competitions. They have won the Third Prize in the 15th Fujian University Students Structural Design Competition, the First Prize in the 17th Fujian University Students Structural Design Competition, and the Third Prize in the Undergraduate Group of the 9th National University Building Information Modeling (BIM) Graduation Design Innovation Competition. This fully proves their outstanding engineering practice and problem-solving abilities.

Meanwhile, the learning atmosphere has been greatly improved. According to the student feedback from 2024 to 2025, most students think the course is vivid, practical and closely connected with workplace demands. Students' initiative and sense of acquisition have been significantly enhanced. The module demonstrated high validity in content quality, instructional design, and user-friendliness, as well as high practicality, with students reporting clarity, interactivity, and support for independent learning [11].

Continuous improvement of teaching quality

The overall evaluation score of the course by students rose from 88.55 in the academic year of 2022-2023 to 89.32 in 2024-2025. Supervisors and peer teachers highly recognize the innovative teaching mode, commenting that the curriculum design is logical, teaching methods are diversified, and the course effectively connects classroom teaching, engineering practice and workplace requirements.

A complete three-dimensional teaching resource system

has been established, including online resource library, project task packages, LISP tool sets, ideological and political cases and real engineering case libraries, laying a solid foundation for the continuous optimization and promotion of the course.

Promotion value of innovative achievements

Theoretical value

Guided by practical teaching problems and the OBE philosophy, this research constructs an education system featuring problem diagnosis, innovative implementation, ideological and political integration and effect verification. It enriches the practical paths of applying OBE philosophy in applied engineering courses and provides systematic theoretical references for similar colleges to balance skill training and value guidance, connect classroom teaching with industrial demands, and integrate traditional teaching with digital technology.

Practical value

This teaching reform has the advantages of low cost, easy implementation and wide adaptability. All innovative measures can be carried out relying on existing online teaching platforms without large investment in hardware. The teaching resources such as shortcut command lists, intelligent programs, AI teaching cases and ideological and political materials are easy to share, which can reduce the curriculum construction cost of other colleges. Moreover, the achievements can be widely applied. Apart from the courses of Engineering Drawing and CAD in universities, they are also suitable for relevant majors in vocational colleges and CAD skill training for enterprise employees, showing great promotion potential across different education scenarios.

Conclusion

Aiming at four core problems in traditional teaching, this paper carries out teaching reform for ED and CAD course under the guidance of OBE philosophy, including classroom mode innovation, practical system reconstruction, evaluation mechanism optimization, as well as integration with workplace and AI technology. Curriculum ideological and political education is deeply integrated throughout the teaching process to realize the coordinated improvement of students' professional skills, engineering literacy, professional ethics and digital capabilities.

Teaching practice has verified that the reform effectively

activates classroom vitality, makes up for students' deficiencies in practical abilities, optimizes the assessment system, and realizes the in-depth integration of teaching content with industrial development and traditional teaching with digital technology. The reform mode is operable, low-cost and highly replicable. It can serve as a valuable reference for the teaching reform of similar basic engineering courses and help cultivate innovative and applied engineering talents adapted to the digital era.

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Conflicts of Interest

The author declares no conflict of interest.

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