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Teaching Reform and Practice of the "Civil Engineering Drawing" Course Based on the OBE Concept

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Abstract: With the rise of engineering education and professional accreditation, outcome-based education (OBE) is one of the key guiding principles of curriculum reform in application-oriented undergraduate institutions. "Civil Engineering Drawing" is a basic core course in civil engineering, and it influences the practical skills and innovative capacities of students directly. Facing problems such as differences in students' backgrounds, the rigidity in content, the monotonous teaching mode, and the narrow assessment, in this paper, we propose a four-dimensional OBE-based reform framework: the setting of goals, content restructuring, the innovation of methods, and diversified evaluation. The measures are the modularity of content, online-offline teaching in a blended way, case- and project-based learning, the tiered practical system, and diversified assessment throughout the whole process. The intervention has improved the students' graphical communication, spatial reasoning, and competence overall. The initial result shows that this reform is well in line with applied talent development, and can be a replica model for similar institutions.

Keywords: Application-oriented undergraduate education; Diversified assessment; Teaching reform; Civil Engineering Drawing; OBE framework

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1. Introduction

Deepening engineering education reform and building a strong engineering education nation is the strategic task of higher education in the new era. "Implementation Opinions on the Construction of First-class Undergraduate Courses" issued by the Ministry of Education emphasizes strengthening curriculum development guided by the objective and promoting classroom teaching revolution. The concept of OBE, which is the core orientation for the professional accreditation of engineering education, puts forward the idea of "student-centeredness, outcome-orientation, and continuous improvement", becoming an important direction for teaching reform in some universities [1–3]. "Civil Engineering Drawing" is a fundamental

professional course of civil engineering majors. It has the characteristics of systematic theory and strong practicability. It bears the responsibility of cultivating the students' spatial thinking, engineering expression, and drafting literacy, and it will directly affect the learning outcomes of subsequent professional courses and students' employability competitiveness [4].

At present, the teaching of "Civil Engineering Drawing" in the application-oriented undergraduate institutions still exists many problems: there are great differences in students' basic backgrounds and ability of space visualization; there is too much stress on the completeness of the theory system without reference to engineering practice; the teaching model is mainly lecture type and there is not enough embodiment of the subjective position of students; the evaluation method is too simple, only the final result is considered and the process is ignored, which can not reflect students' comprehensive ability in an objective way [5–7]. It is very hard for the instruction of the course to support the aims of the application-oriented talent cultivating.

Undergraduate institutions of application orientation are determined to foster high-quality applied talents adapted to the needs of the regional economic and social development. Taking the course "Civil Engineering Drawing" as its vehicle, in this paper, the teaching reform exploration and practice are conducted on the basis of the OBE concept. The aim is to build the course teaching system of application-oriented talent cultivation, and to improve the students' engineering practice abilities and innovative competence.

2. The essence of the OBE concept and its implications for curriculum reform

2.1. Essence of the OBE concept

American scholar William Spady systematically proposed the OBE concept in the 1990s. The OBE concept proposes to design and implement curricula oriented towards the learning outcomes of the students. The concept of OBE is the teaching logic of "reverse design, forward implementation", that is, first to determine what competencies the students should have after graduation, and then to design the curriculum system, teaching content, and assessment according to this [8]. The OBE concept has three core elements: first, student-centeredness: the teaching activities should revolve around the development needs of the students; second, outcome-orientation: all the teaching segments are for the achievement of the expected learning outcomes; third, continuous improvement: the teaching process is continuously optimized through the feedback mechanism [9,10].

2.2. Implications of the OBE concept for curriculum reform

It is of great guiding value to introduce the concept of OBE into the reform of the course of "Civil Engineering Drawing". First, the course objectives should be consistent with the goals of professional talent cultivation and the standards of engineering education accreditation; the drafting competency as well as the engineering literacy that the students should have should be made clear. Second, the teaching content should change from "what the teachers teach" to "what the students can learn"; the knowledge points should be combined and optimized in terms of the development of competency. Third, the teaching methods should change from "transmission type" to "participatory type", to motivate the students to take the initiative to learn. Finally, the assessment mechanisms should change from "the single outcome evaluation" to equal emphasis on "the process and the outcome", to measure the student learning effectiveness comprehensively.

3. Current teaching status and problem analysis of the "Civil Engineering Drawing" course

3.1. Basic course information

The course "Civil Engineering Drawing" is available for first-year undergraduates in civil engineering and related majors. The contents of the course include the module of descriptive geometry, basic drafting, professional drafting and drawing reading, and so on. In recent years, with the expanding enrolment, the structure of the students is more and more diversified, and there is a marked difference in the learning bases; this puts bigger pressure on the teaching of the course.

3.2. Prominent problems

There are several interrelated problems with the course that it currently suffers from. First, there is wide variation in students' entry levels, which the traditional instructional models do not well accommodate. Second, the content is still somewhat fragmented and too theoretical, with weak connections to engineering practice and subsequent design courses, so that drawing and reading skills are not transferred. Third, the instruction is mostly in the form of lectures with little interaction and little student participation. Fourth, the practical training tends to stress the rote copying of those standard drawings, rather than the open-ended design tasks. And as the course is given rather early in the curriculum, there is a gap between the content of the course and the upper-level project work, so that the students have insufficient awareness of the professional standards. Finally, the assessment is almost exclusively based on a final closed-book examination, with little process orientation and no formative feedback. All these problems are mutually reinforcing and call for systematic reform.

4. Course teaching reform design based on the OBE concept

4.1. Reform objectives

Under the guidance of the OBE concept, this reform is intended to build a four-in-one course teaching system called: "goal orientation--content reconstruction--method innovation--diversified evaluation". The specific goals are as follows: 1) Improve the content of the course to form a modular curriculum system suitable for training application-oriented talents; 2) Innovate the teaching method of online-offline, case-based method, and project-driven method; 3) Establish the layered and progressive practical training model; 4) Improve the diversified assessment mechanism with process evaluation and result evaluation. The final goal is to improve the comprehensive ability of students such as engineering expression ability, modern tool application ability, and innovative practice ability.

4.2. Reform approach

Following the OBE principle of "reverse design, forward implementation", this reform takes the professional cultivation objectives and engineering education accreditation standards as the logical starting point, and in accordance with the graduation requirements, it reverses the design of the course objectives, the teaching content, and the assessment method. The detailed way is: (1) find out the problems of the existing courses; (2) design the reform plan in five dimensions of the teaching objective, the contents, the methods, the practical system, and the evaluation mechanisms; (3) implement by classroom practice and subject competition; (4) do the effectiveness evaluation and continuous improvement based on the data of five dimensions, which is a

close loop research way (see **Figure 1**).

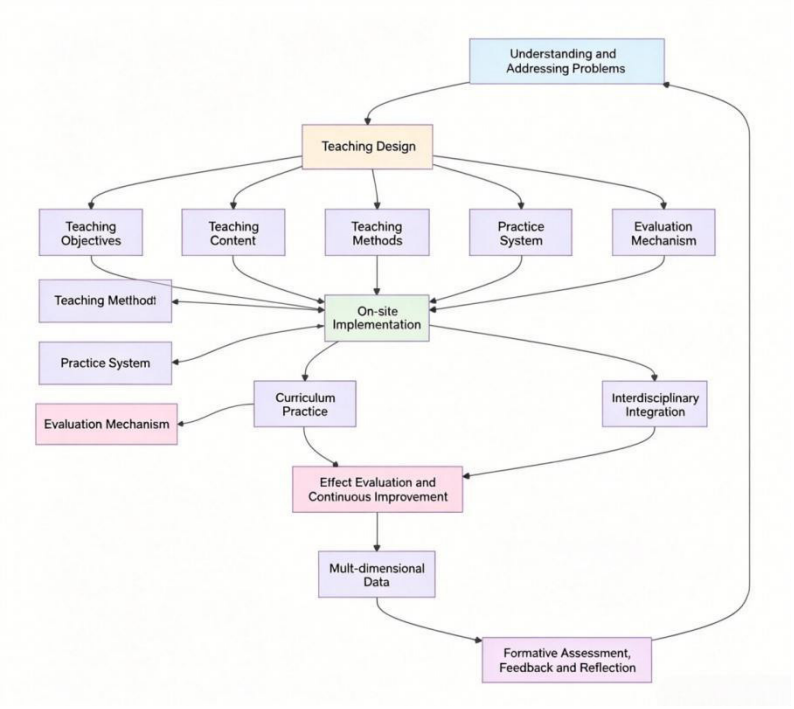

Figure 1. Course Reform Pathway Diagram Based on the OBE Concept.

4.3. Teaching content reconstruction

The teaching content is systematically reviewed and integrated, all of which are centered on the professional cultivation objectives and engineering education accreditation standards to construct the three-tier course system: "Public Basic Module-Professional Basic Module-Professional Advanced Module".

The Public Basic Module covers basic drafting knowledge, the theory of projection, the basic projection of solids, axonometric projection, etc. This module aims to cultivate the spatial visualization ability of students and the basic drawing skills of students. The Professional Basic Module covers the representation methods of the form of architecture, etc. This module aims to strengthen the ability of students to read and draw engineering drawings. The Professional Advanced Module covers the reading and drawing of architectural and structural drawings, computer-aided drafting (AutoCAD), etc. This module aims to expand the ability of students to apply modern tools.

The three modules are progressively built and mutually supportive. They achieve a gradual training from basic knowledge to professional application, and from manual drawing to computer-aided drafting. At the same time, the three modules clearly set the expected learning outcome indicators, which can help the teaching implementation and the effect of the teaching verification.

4.4. Teaching method innovation

4.4.1. Blended online-offline teaching

For example, relatively easy content, such as basic drafting knowledge and projection principle, is made into a video of teaching on the basis of the teaching platform (e.g., XuexiTong). The students need to watch it autonomously before class and do some online quizzes. The teacher can also use the data of the platform

to know the preview of the students. In the offline class, the teacher will focus on explaining the key and difficult points and the practice of the class. For example, in the teaching of section view drawing, the students will learn the concept and classification of section view in the video before the class. In the class, the teacher uses the software to show the internal structure dynamically for three-dimensional cutting. After that, the students do the manual drawing practice and use the software to check the projection. In this model, it can really improve the efficiency of the class and the students' participation.

4.4.2. Case-driven and project-based practical teaching

We have put in the curriculum the real engineering cases we have encountered in the work, to make the change from the abstract problem to the real engineering problem to solve. We have collected a case library from common engineering drawings. The cases are used to lead the students to analyze the logic of graphical representation, understand the drafting standard, and master the reading method. Then, we have designed the projects from the complete cycle: the task of project, plan, implementation, presentation, and evaluation (see **Table 1**). The students work in teams on the tasks of component surveying and mapping, representation scheme discussion, manual drafting and 3D modeling, then presentation and peer review. The combination of a case to guide the instruction and a project to apply it can make the step from the cognition of the case to the application based on the project, to make the team stronger, to improve the practical engineering ability and the creative thought.

Table 1. Practical Training Project Settings for "Civil Engineering Drawing"

No.	Item Name	Item Type	Core Knowledge Points	Brief Description of Item Tasks
01	Tracing and Reading of Architectural Floor Plans	Basic Type	Architectural drawing standards, representation methods of floor plans	Trace the standard floor plan of a given residential building; read and mark each functional zone and dimensions
02	Drawing of Architectural Elevations	Advanced Type	Elevation drawing, elevation labeling	Draw the architectural elevation based on the given floor plan
03	Drawing of Architectural Sections	Advanced Type	Section drawing, elevation labeling	Draw Section 1-1 based on the given floor plan
04	Design and Drawing of Stair Details	Comprehensive Type	Stair floor plans, stair sections, joint details	Design stairs and draw stair floor plans & sections with given floor height and tread parameters
05	Comprehensive Drawing of Complete Architectural Construction Drawings	Innovative Type	Full set of architectural construction drawings	Complete a full set of construction drawings for a small civil building in groups.

4.4.3. Layered and progressive teaching

In order to cope with the differences in the foundation of the students, we establish the cultivation system: "First Classroom + Second Classroom + Subject Competitions". In First Classroom, the course for all students, the basic ability of engineering practice is summarized. In Second Classroom, we select the interested and talented students to do intensive training, strengthen the students' ability to read more complicated drawings and use the software CAD by participating in national competitions such as the Advanced Graphics Competition for College Students; better students will be cultivated in innovative design. In the last two years, more than 60 students participated in the selection competition at the university level; 12 students participated in the competition at the provincial level or above; and 5 national-level awards have been won.

4.5. Construction of diversified assessment and evaluation system

We broke the old model called single exam determines all, and set up a diversified evaluation system with process assessment + outcome assessment, where the process assessment is 40% of the total grade, and the outcome assessment (final exam) is 60%.

The specific components of process assessment are: (1) Pre-class online platform learning (10%), among which are video viewing completion (4%), online quiz scores (4%) and discussion board participation (2%); (2) Classroom performance (10%), among which are discussion contributions (2%), group collaboration performance (4%) and in-class quizzes (4%); (3) After-class practical assignments (20%), among which are manual drafting assignments (10%), CAD drafting assignments (5%) and project based practical reports (5%). The students who win awards in national advanced graphics competitions get bonus points.

The evaluation subjects are expanded from only instructor evaluation to the combination of instructor evaluation, student self-assessment, and peer assessment. The learning trajectories are followed by the data of the teaching platform, and the evaluation results are fed back to the students regularly so that they know how to improve. According to the feedback of evaluation, the teachers change the teaching strategies; this makes the cycle of evaluation - feedback - improve.

5. Implementation effects and reflections

5.1. Implementation effects

5.1.1. Significant improvement in student learning enthusiasm

The blended online-offline teaching model has made the students from being passive recipients to be active inquirers. The rate at which students watched the video pre-class and the number of times the students interacted with each other in the classroom have increased a lot compared to before the reform. Most of the students said that the course became more interesting and practical, and the learning initiative has increased a lot.

5.1.2. Notable improvement in course assessment scores

If we compare the grades between the cohorts before and after the reform, we found that for the course, the pass rate increased from 74.6% to 86.3% and the rate of excellence from 8.2% to 15.7%. We can say that both the standardization of students' manual drafting and computer-aided drawing were improved.

5.1.3. Enhanced student engineering practice abilities

The teaching of project-based learning and the cultivation of layered progressivism did well for the development of students' engineering practice ability. In the provincial advanced graphics competition and the national BIM graduation design competition, students obtained the first prize at the national and provincial levels, which was a historical breakthrough. The feedback from the employers indicated that the intern students have obviously better drawing standardization and engineering consciousness than that of the previous classes.

5.1.4. Substantial achievements in teaching resource development

In total, 32 instructional videos, 25 engineering cases, 7 practical training projects, and over 300 online test questions were made. A relatively complete course teaching resources repository was formed, which is a foundation for continuous teaching improvement.

6. Conclusions

Based on the OBE framework, in this paper, we conducted system reform of the course "Civil Engineering Drawing" from five aspects: teaching purposes, teaching contents, methods, practical training and examination, guided by the OBE framework. In this paper, a three-level modular curriculum (basics, specialized, advanced) was set up, combined with blended teaching, case teaching, and project teaching. Also, a diversified assessment mechanism of the balance of process and results was carried out. Practice proves that the reform has improved the students' learning motivation, good grades and practical engineering ability.

There are also some problems, such as the weak CAD foundation of the students who transferred from vocational colleges, the lack of integration between the online and offline parts, the free-riding in the team project, and the increase in the workload of the faculty. For the future, we will pay more attention in our efforts to improve tiered instruction, to introduce AI-assisted assessment, to strengthen industry-university collaboration, to embed craftsmanship and engineering ethics into the curriculum, and to facilitate the further development of professional education and value guidance in synergy.

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Disclosure statement

The author declares no conflict of interest.

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