Exploring Teaching Reform of Engineering Surveying Courses in Universities under the Background of First-Class Undergraduate Major Construction

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Abstract: Against the backdrop of first-class undergraduate program development, the teaching reform of engineering surveying courses in higher education institutions aims to comprehensively improve teaching quality and students' comprehensive qualities. This paper systematically explores and practices the construction of the engineering surveying course, deeply analyzes the main challenges faced by the course in the current educational environment, and based on the teaching research and practical experience of the surveying and mapping engineering major at Heilongjiang Institute of Technology, proposes key measures for course construction from the aspects of knowledge system construction, teaching model innovation, feedback mechanism improvement, and continuous improvement. These measures have promoted the quality improvement and efficiency optimization of engineering surveying course teaching, cultivated students' comprehensive qualities and professional abilities, and better adapted to the needs of discipline development and industry application requirements.

Keywords: Engineering Surveying; Curriculum System; Teaching Model; School-Enterprise Integration; Virtual-Real Competition and Teaching; Evaluation and Feedback Mechanism

1. Introduction

The construction of first-class undergraduate majors is an important foundation for the cultivation of first-class talents, the core support for promoting the development of high-quality undergraduate education, and the key starting point for improving the talent training ability of colleges and universities[1-3]. To build a first-class undergraduate major in geographic information science, we must focus on improving students' multidisciplinary literacy and practical innovation ability, promote the transformation of teachers' roles from traditional "lecturers" to "guides" and "leaders", innovate teaching models and methods, carefully design efficient classrooms, and comprehensively optimize teaching effects and students' learning experience[4]. As a core professional course, engineering surveying plays a key role in promoting high-quality undergraduate education and cultivating outstanding talents. Driven by emerging technologies such as big data, the Internet of Things, and artificial intelligence, the content of engineering surveying is richer, and data acquisition is more convenient and diverse[5-8]. At the same time, users' demand for participation, interactivity, and real-time has increased significantly, promoting profound changes in the objectives, subjects, objects, and application environments of engineering surveying[9,10], making engineering surveying enter a new stage of development(Lu,2024). This change poses new challenges to the traditional engineering surveying theory and teaching mode, especially for local colleges and universities to improve the teaching quality, and it is urgent to accelerate the teaching reform and practical exploration[11-15]. Based on this, this paper takes the engineering surveying course of Heilongjiang Institute of Technology as the research object, and puts forward reform measures in view of the problems and challenges existing in the current teaching, aiming to comprehensively improve the teaching quality and effect, provide reference for the teaching innovation of engineering surveying courses in similar colleges and universities, and accumulate practical experience for the optimization of the training mode of engineering surveying talents in local universities.

2. Shortcomings in the Construction of Engineering Surveying Teaching

Engineering Surveying plays a crucial role in the curriculum of the Surveying Engineering major, serving as a bridge between foundational and advanced studies. The course aims to systematically cultivate students' mastery of core theories, key methods, and application skills in engineering surveying, comprehensively enhancing their professional competence and practical abilities. In recent years, the rapid development of emerging technologies has expanded the connotation and extension of the discipline of engineering surveying, bringing significant opportunities for course construction. However, it has also raised higher demands on traditional teaching models, course content, and talent cultivation objectives. Currently, there are still the following main shortcomings in the teaching of Engineering Surveying:

2.1 Broad Knowledge Scope, Outdated Content, and Low Student Interest

"Engineering Surveying" encompasses interdisciplinary knowledge such as "Highway Engineering," "Tunnel Engineering," and "Mining Engineering." Due to the limitations of traditional surveying disciplines, its theoretical content is relatively outdated and the material is somewhat monotonous, leading to low student interest in traditional classroom settings.

2.2 Theoretical Connection with Practice is Weak, Creating a Barrier to the Discipline's Frontiers

Traditional classroom settings are limited by practical teaching conditions, making it difficult to integrate theoretical knowledge with production practice. Frontier technologies in the discipline are mostly controlled by a few leading enterprises, and there is limited technological exchange with local universities, leading to the problem of "disconnect between learning and application."

2.3 It is Difficult to Internalize the Spirit of Craftsmanship, Resulting in Poor Effectiveness of Ideological and Political Education

As a highly theoretical engineering course, it is challenging to develop relevant cases for ideological and political education. The connection between these cases and actual teaching content is not close enough, resulting in low integration and unsatisfactory student acceptance.

4) The assessment methods are monotonous, failing to reflect participation and high-level thinking

Traditional assessment methods only include regular performance and final exam scores, resulting in a rather monotonous evaluation approach.

3. Teaching Reform Measures for Engineering Surveying Course

3.1 Build the "11665" Course Content

In response to the above issues, in accordance with the course objectives, the course adopts a "11665" teaching design approach, guided by the OBE concept and centered on student development. It focuses on cultivating six major abilities including design, measurement, and layout, dividing the course into six major teaching modules: topographic surveying, route surveying, construction layout, and others. Meanwhile, the course vigorously promotes "5-dimensional deep integration." First, it deeply integrates the five ideological and political elements into the entire teaching process. Second, relying on the "5-step teaching method," it achieves progressive improvement of students' professional abilities. Finally, through the "5-element collaborative education" model, it cultivates high-quality talents in the field of engineering measurement from multiple dimensions, as shown in Figure 1.

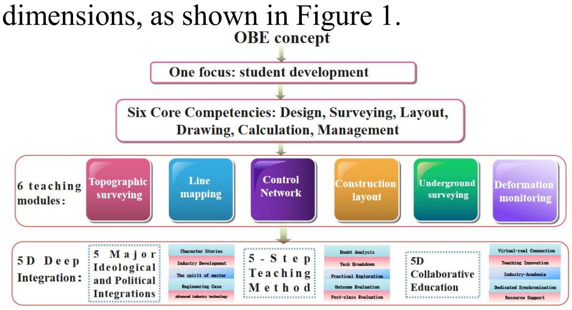

Figure 1. Teaching Design Approach

Based on the characteristics of engineering surveying, the teaching content has been reorganized. In the teaching process of engineering surveying, the course is divided into 6 major modules and 16 projects. Each module is project-led, with in-depth exploration of the tasks contained in each project, selection of corresponding real engineering projects, and equal emphasis on knowledge transmission, ability development, and value shaping, with both moral and technical cultivation. At the same time, during the teaching process, attention is paid to the transmission of advanced knowledge, in line with the "two properties and one degree" curriculum standards.

The teaching environment serves as the "hardware foundation" for the implementation of teaching design. Schools build diverse on-campus teaching scenarios based on this foundation: using smart classrooms for discussion-based teaching; practical training rooms provide students with professional equipment to hone their skills, while professional mentors accompany them throughout the process, offering real-time guidance on operational difficulties, thus supporting multi-dimensional enhancement of students' professional abilities. After strengthening the on-campus practical foundation, schools actively expand external practice platforms by co-building teaching and training bases with 34 enterprises. Through these external practice bases, students are immersed in engineering frontlines. In real projects, they transform knowledge acquired on campus into the ability to solve engineering problems, achieving a transition from classroom to field, from theory to application, allowing professional skills to grow within real engineering contexts, and establishing the framework of "on-campus foundation building—off-campus practice."

Teaching resources are an important support for instructional design. Using Zhihui Tree (Smart Tree) to establish a database of scientific and technical literature and regulations and standards allows students to conveniently and centrally access the latest developments in modern measurement technology and industry standards, promoting their professional knowledge learning, research, and exploration. At the same time, establish a database of ideological and political cases for engineering surveying, enabling students to draw on the spirit of previous generations of surveyors from classic cases; and create a test bank with diverse question types to consolidate knowledge and skills.

3.2 Heuristic Classroom, Student-Centered, Redefining "Teaching" and "Learning"

The BOPPPS+PAD teaching method is adopted. Before class, teachers release learning content, clarify objectives, and assign pre-class tests, while students conduct previewing and communication through the platform; during class, teachers deliver concise lectures with intentional pauses, using diverse teaching formats to guide students in absorbing knowledge and participating in discussions; after class, teachers assign learning tasks, and students engage in communication, review, and complete homework. This establishes a closed-loop teaching process characterized by clear objectives, high participation, and timely feedback.

3.3 Linking Objectives, Building Knowledge Maps, and Practicing OBE Philosophy

By using the Wisdom Tree online teaching platform, we connect graduation requirements, course objectives, knowledge maps, teaching resources, and teaching activities. This approach ensures that graduation requirements are reflected in each knowledge point, reasonably sets target achievement indicators, breaks away from traditional outcome-based assessment methods, and implements formative assessment primarily influenced by achievement levels, achieving quantitative analysis.

3.4 Industry-Academia Integration, Real Context, Extended Classroom

Graduates, graduation projects, and on-the-job internships feed back into course teaching, using actual production cases as teaching materials and practical teaching backgrounds to create a real engineering surveying context. In addition to classroom hours, online self-study hours and post-class exploration hours are set up to extend the depth of the classroom and enhance the educational dimension.

3.5 Virtual-Real Competitions, Industry-Academia Integration, and Competency Development

Following the progressive logic of "question analysis → task decomposition → practical exploration → outcome verification → post-class evaluation," we have developed an educational model that connects virtual and real scenarios to expand learning environments, stimulates vitality through competition and teaching innovation, meets industry needs through school-enterprise interaction, cultivates professional literacy through synchronized professional thinking, and ensures teaching effectiveness with resource support. Leveraging existing competition and innovation projects such as digital mapping, airborne LiDAR, and UAV aerial surveying, we achieve the integration of virtual and real scenarios and innovation in competition and teaching, breaking down barriers between theoretical and practical teaching that cannot be effectively connected and organically merged. This approach addresses challenges such as expensive training equipment, insufficient training space, untimely technology updates, abstract and difficult-to-understand content, and limitations in time and space for autonomous learning. Through case-based teaching, we integrate ideological elements such as craftsmanship, industry frontiers, and professional ethics into both theoretical and practical teaching, achieving school-enterprise interaction and synchronized professional thinking. While solidifying students' theoretical knowledge and enhancing their practical innovation abilities, we steadily improve their professional literacy, as shown in Figure 2.

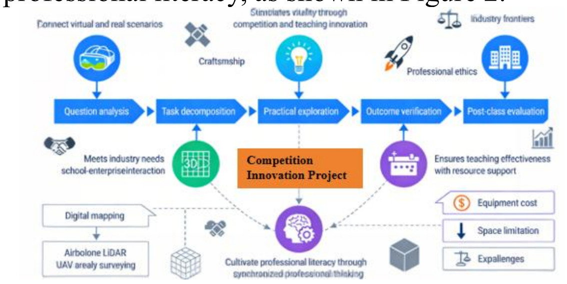

Figure 2. "Five-Progression" Teaching Model

3.6 OBE Assessment, Chain-through Connection, Formative Evaluation

Replacing traditional single-form assessment with outcome-based education (OBE) concept achievement assessment based on the Smart Tree teaching platform, following the formative chain of "teaching resources, knowledge points, teaching tasks, ability objectives, quality objectives, and graduation requirements," to achieve course objective achievement reports and individual student achievement reports, thereby obtaining formative evaluation.

4. Course Evaluation and Reform Effectiveness

4.1 Supervision Feedback and Student Teaching Evaluations

The course teaching effectiveness is significant, with high student classroom participation, solid knowledge mastery, and outstanding practical operation skills. In course satisfaction surveys, the positive rating reached 98%. Teaching supervisors have given high praise to the logical course design and innovative teaching methods through regular classroom observations.

4.2 Student Capability Enhancement

Over the past 5 years, students have won over 100 awards in national and provincial surveying and mapping competitions, as well as 15 university innovation and entrepreneurship awards. The employment rate of graduates in state-owned enterprises in the engineering surveying field has steadily increased by approximately 2%. Graduates have received widespread acclaim from employers, and the postgraduate admission rate has surged from 5% for the 2018 cohort to 12% for the 2021 cohort.

4.3 Radiation Leading Role

The reform ideas and construction experience of this course have been effectively promoted to related courses in the college through online exchanges, forum lectures, and other means, achieving positive results. Similar institutions have drawn on this course's experience to improve teaching effectiveness. Based on this course, a total of 4 teaching achievement awards and 4 other teaching awards have been obtained, and 8 provincial and university-level projects have been completed. Among them, "Research on Cultivating Applied Technical Talents in Surveying and Mapping Major Based on School-Enterprise Cooperation under the New Era's '1345' Model" has been applied and promoted at Liaoning Technical University, Liaoning University of Science and Technology, Anhui Jianzhu University, and Heilongjiang University of Science and Technology.

5. Curriculum Development Plan

5.1 Continuous Curriculum Development Plan

First, update educational and teaching philosophies by adopting a student-centered, outcome-based education (OBE) approach. Create a specialized case collection and teaching resource library for engineering surveying by incorporating major engineering construction cases and local characteristic surveying projects. Promote the organic integration of curriculum-based ideological education with surveying skills and professional development, cultivating patriotism and craftsmanship.

Second, increase teacher training efforts by organizing teachers to participate in specialized training programs on intelligent measurement technology, precision engineering measurement, and other related topics. Through expert seminars, practical training in enterprises, and inter-school exchanges, enhance teachers' abilities to implement curriculum reforms and meet industry needs in their teaching.

Third, continuously advance curriculum reform and innovation by optimizing teaching through multi-dimensional approaches including project-based teaching models, integration of "post-course-competition-certificate" methods, and diversified assessment and evaluation, thereby enhancing students' professional competence and career adaptability.

5.2 Issues Requiring Further Resolution

First, to consolidate the teaching efforts to cultivate students' comprehensive application ability in engineering surveying, achieve the coordinated advancement of knowledge transmission, skill development, and professional quality shaping, and nurturing through subtle influence

Second, enhance teachers' ability to integrate new industry technologies (such as intelligent surveying and mapping equipment, digital twin measurement) into curriculum reform, ensuring that teaching concepts resonate with industry development.

5.3 Reform Direction and Improvement Measures

First, expand the radiation and demonstration effects of reform. Relying on school-enterprise cooperation projects, use the "Engineering Surveying" core course as a breakthrough to create a curriculum cluster covering directions such as construction surveying and deformation monitoring, forming replicable teaching experience that integrates theory with practice and promotes mutual enhancement between competition and education.

Second, optimize the teaching content supply by highlighting cutting-edge content such as intelligent measurement technology, green surveying concepts, and measurements in complex scenarios, providing students with advanced and innovative learning materials that adapt to the industry's digital transformation needs.

Third, leverage information technology support by using virtual simulation experiments and digital teaching platforms to innovate project-based and case-based teaching methods, Stimulate students' enthusiasm for autonomous learning, and enhance the ability to solve complex engineering measurement problems.

6. Conclusion

Under the guidance of first-class undergraduate program construction, engineering surveying courses in higher education institutions are continuously developing toward specialization, application-oriented approaches, and humanistic dimensions. Taking the engineering surveying course of the surveying and mapping engineering program at Heilongjiang Institute of Technology as an example, this paper deeply analyzes the current challenges and implements comprehensive reforms in aspects such as curriculum content renewal, integration of ideological and political education, enhancement of practical teaching, and innovation in teaching methods. This has constructed a teaching system that adapts to the needs of the times. The reform practice has significantly improved students' professional competence and innovative abilities, guiding them to pay attention to industry development and social needs, and enhancing their sense of responsibility to serve society. This has enabled the engineering surveying course to play a more prominent role in serving national strategic needs and cultivating applied talents. Practice shows that the reform has achieved remarkable results, providing valuable references and insights for teaching innovation in engineering surveying courses in similar higher education institutions.

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