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Reform and Practice of Teaching Engineering Economics Courses for Applied Undergraduate Based on the OBE Concept

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Abstract: *Engineering Economics is a core course in Civil Engineering, encompassing interdisciplinary and multi-scale theoretical knowledge and practical applications. The course content is extensive, involving numerous economic terms, abstract and intricate calculations, posing significant challenges for students with an engineering background. To address the disconnect between traditional theoretical teaching and practical application abilities in current Engineering Economics courses, this paper proposes a four-in-one teaching system based on the Outcome-Based Education (OBE) concept, encompassing "three-dimensional teaching objectives, professional qualification orientation, business analysis skills enhancement, and multi-dimensional evaluation system feedback." This reform aims to comprehensively enhance teaching quality and provide a reference for cultivating high-level applied talents.*

Keywords: *Engineering Economics; Outcome-Based Education (OBE); Professional Competence; Excel; Ideological and Political Education in Courses*

1. Introduction

Engineering Economics, a discipline that analyzes the economic benefits of engineering projects and provides scientific basis for engineering project decisions by comprehensively applying principles and methods of engineering, economics, and mathematics, serves as one of the core courses in civil engineering and engineering management majors [1]. It bears the important task of providing students with necessary theoretical and practical skills in economic analysis and decision-making, and is a crucial course for cultivating high-level application-oriented talents. As the construction industry transforms and the standards for engineering talent continue to elevate, there is a pressing need to cultivate high-level interdisciplinary talents in civil engineering who are proficient in both technology and management [2]. To bridge the gap between course content and industry practice and address the challenges faced by university graduates in finding employment, this paper focuses on the construction of the Engineering Economics course, tailored to the needs of application-oriented undergraduate education.

Applying the Outcome-Based Education (OBE) framework, this paper has reconstructed teaching objectives centered on student learning outcomes, aligned them with industry requirements, and adjusted teaching content and methodologies. We have developed a "trinity" teaching system for application-oriented undergraduate engineering economics courses, guided by three-dimensional teaching objectives, career competency orientation, and innovation in business intelligence analysis skills. This system aims to enhance students' learning efficiency and problem-solving abilities through a more technically focused teaching approach. Additionally, ideological and political elements are organically integrated throughout the teaching process, leveraging the synergistic effects of Engineering Economics knowledge and ideological and political education in the classroom. This holistic approach ensures the cultivation of high-caliber professionals with both professional competence and a sense of patriotism and social responsibility.

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2. Current Status of Engineering Economics Teaching and Research

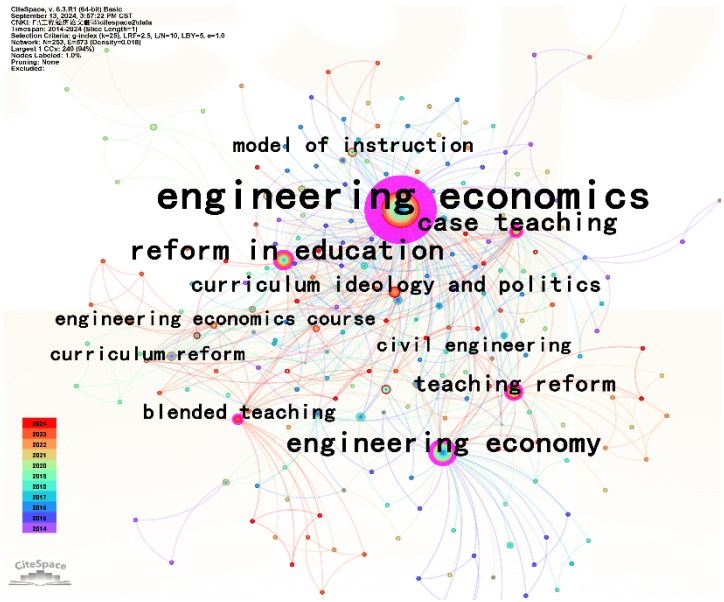

Figure 1: Co-occurrence map of research hotspots in the teaching of engineering economics

This paper constructs a knowledge map of teaching research in engineering economics by analyzing 318 relevant articles retrieved from the CNKI database since 2015 using keywords such as "engineering economics," "course," "teaching," "reform," and "universities." The objective is to analyze the research hotspots and evolutionary trends in the reform of engineering economics courses. Figure 1 presents the key research hotspots in the reform of engineering economics teaching in China, including case-based teaching, ideological and political education integration in courses, blended learning, and practical teaching. As evident from the figure, research on the reform of engineering economics course teaching in China primarily clusters around teaching content, course design, and teaching modes. In recent years, it has gradually expanded to include case-based teaching, blended learning, and practical teaching, and has shown increasing interest in emerging engineering disciplines and professional field orientations.

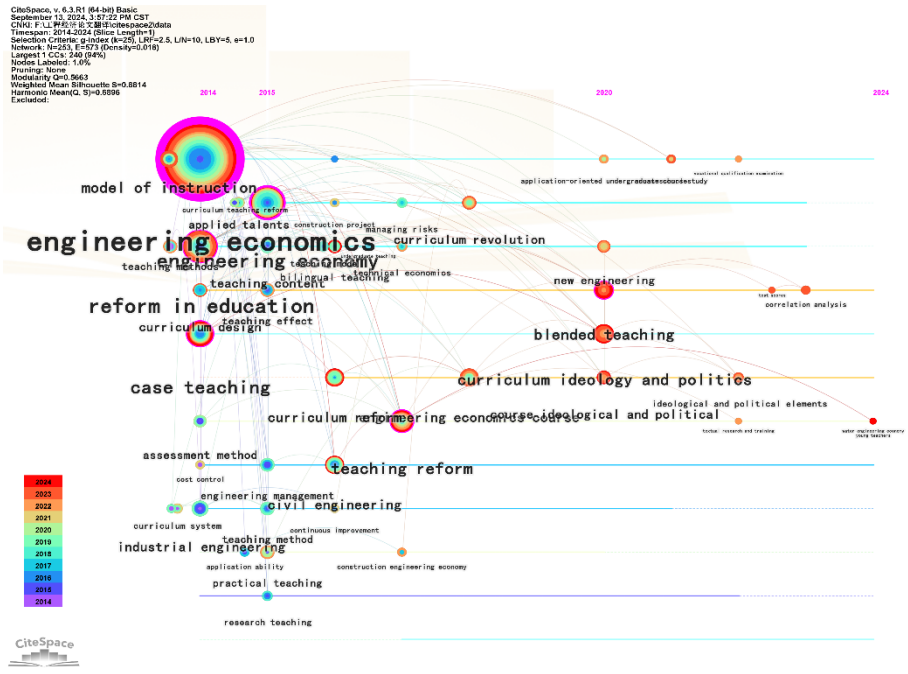

Figure 2: Time line map of engineering economics curriculum teaching

Figure 2 is a timeline map of teaching hotspots in engineering economics courses analyzed by keyword frequency. It can be seen that the research on the reform of engineering economics course

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teaching currently exhibits trends of diversification and deepening. In terms of course content, the latest theoretical and practical achievements are introduced into the classroom, such as flipped classrooms, Problem-Based Learning (PBL), online courses, and blended learning. There is also an increased focus on students' engagement in case analysis and practical project operations. Meanwhile, the curriculum reform has begun to emphasize the integration of ideological and political elements into professional teaching. Figure 3 is a map of strongest citation bursts in teaching research hotspots for engineering economics courses. It can be observed that research areas such as "ideological and political education integration in courses" and "ideological and political elements" continue to maintain high research demand and popularity.

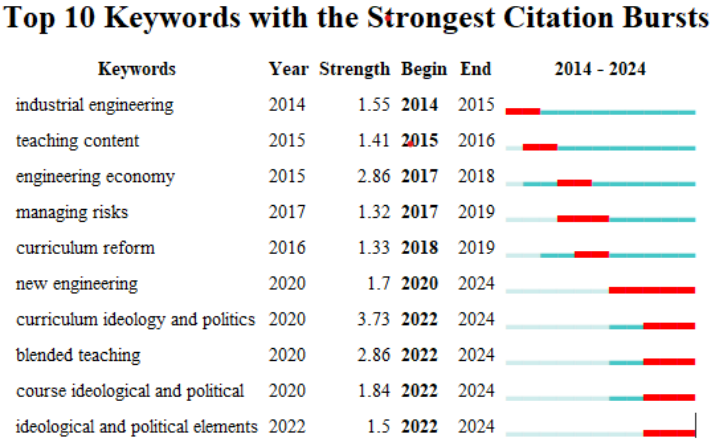

Figure 3: Keywords with the strongest citation bursts of engineering economics curriculum teaching

Engineering economics, as a professional course offered in many engineering and technical majors, aims not only to equip students with a solid foundation in engineering economics knowledge but also to cultivate their engineering knowledge, data analysis skills, communication and decision-making abilities, as well as a certain level of scientific research and innovation capabilities [3]. Although some achievements have been made in curriculum and teaching reforms, there are still issues in teaching, such as interdisciplinary complexity, abstract theories, complicated calculations, and difficulties in connecting theory with practice. These issues are manifested in the following ways:

(1) The teaching objectives lack clarity and there is an absence of assessment criteria for measuring learning outcomes. A considerable discrepancy exists between the course content and its practical relevance within the industry. Furthermore, the teaching approach is deficient in incorporating business intelligence analysis techniques to thoroughly analyze decision-making metrics for investment strategies.

(2) The course tends to focus excessively on exercises and calculations based on individual knowledge points, with a lack of training in real-world application scenarios and comprehensive cases. This results in inadequate cultivation of data analysis thinking, making it difficult for students to apply what they have learned to practical work, thereby weakening the practicality and application value of the engineering economics course.

(3) Another issue that cannot be ignored is the lack of a high level of sentiment and perspective. In the engineering economics course, students need not only to master professional knowledge and skills but also to possess a high sense of social responsibility and professional ethics.

3. Practice of "Four-in-One" Teaching Reform in Engineering Economics Based on OBE (Outcome-Based Education).

3.1 Three-Dimensional Teaching Objectives

The Outcome-Based Education (OBE) concept is a curriculum system construction concept that orients around students' learning outcomes, emphasizing that students should grasp knowledge, skills, and abilities, and apply them to solve practical problems. OBE follows the principle of "implementing forward and designing backward," starting from industry needs and student development, and establishing a curriculum system that supports talent cultivation and the fulfillment of graduation

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requirements [4]. Based on engineering certification standards and graduation requirements for civil engineering majors, through visits and discussions with industry units, as well as surveys of graduates and current students, the course objectives for Engineering Economics are established as shown in Table 1.

Table 1: Course Objectives for Engineering Economics

Course Objective	Objective Connotation
Course Objective 1: Identification and Judgment of Engineering Economic Problems	Ability to apply basic concepts, principles, and methods of engineering economics to conduct calculations of investments, costs, benefits, depreciation, as well as evaluations and comparisons of engineering project proposals, cash flow diagrams, and the time value of money.
Course Objective 2: Evaluation of Technical Scheme Economic Effects	Ability to analyze the cash flow situation of a project based on its expected goals and available resources and conditions, and select suitable technical schemes to achieve the best economic effects.
Course Objective 3: Financial Analysis of Engineering Projects	Proficient in conducting project financial analysis, project cost-benefit analysis, project cost-effectiveness analysis, risk and uncertainty analysis, equipment replacement analysis, and value engineering, providing comprehensive bases for project investment decisions, financing decisions, and operational management. Proficient in using data analysis software such as EXCEL to prepare financial analysis reports.
Course Objective 4: Ideological and Political Education Integration	Cultivate awareness of autonomous and lifelong learning, and develop good professional ethics and social responsibility that adhere to engineering ethics.

3.2 Course Design Oriented towards Professional Competencies

Table 2: Teaching Modules for Engineering Economics Course

Knowledge Module	Module 1	Module 2	Module 3	Module 4
Theme	Basic Knowledge	Project Evaluation	Risk Decision-Making	Applied Practice
Corresponding Exam Points in "First-Class Constructor" Professional Qualification Exam Syllabus	1Z101010	1Z101020; 1Z101040; 1Z101050;	1Z101030	1Z101060; 1Z101070
Knowledge Units	1. Identification and Estimation of Cash Flow for Engineering Project Investments; 2. Calculation and Application of the Time Value of Money	1. Equipment Renewal Analysis; 2. Compilation of Cash Flow Statements for Technical Schemes; 3. Evaluation of Economic Effects of Technical Schemes	1. Uncertainty Analysis of Technical Schemes; 2. Risk Analysis; 3. Multi-Factor Sensitivity and Criticality Analysis	1. Application of Value Engineering in Engineering Construction; 2. Techno-Economic Analysis of New Technologies, Processes, and Materials Application Schemes
Special Modules	Engineering Case Studies Module Ideological and Political Education" Modul			

Notes:

- The knowledge modules are structured to align with the key exam points of the "First-Class

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Constructor" professional qualification exam, ensuring that the course content is directly relevant to students' future career paths.

- Each module contains specific knowledge units that are designed to build a comprehensive understanding of engineering economics.
- The "Engineering Case Studies" module is a special feature that emphasizes practical application, helping students bridge theory with real-world scenarios.
- The "Ideological and Political Education" module integrates ethical and professional values into the curriculum, fostering a well-rounded educational experience.

For engineering industry practitioners who are not economics majors, they are typically not "processors" of economic information, but rather "stakeholders" in engineering projects and "users" of economic information. Therefore, the Engineering Economics course offered for civil engineering majors should aim to expose students to job requirements as early as possible, enabling them to learn and grasp the basic principles and processes of economic analysis in engineering projects, rather than getting bogged down in repetitive economic modeling and calculation exercises. In the civil engineering industry, national qualifications such as Registered First- and Second-Class Constructors and Cost Engineers of China conduct systematic and direct assessments of Engineering Economics. Based on this, the course team focuses on enhancing students' employability and, combining the course training objectives with the professional qualification exam syllabus officially released by the examination authorities, innovatively designs a "4+2" modular curriculum system as shown in Table 2. The teaching aligns with the entire process of project investment decision-making, reconstructs the basic knowledge framework with reference to actual project feasibility study reports, and integrates theoretical knowledge, seeking decision-making theories from practical investment problems. At the same time, considering the current employment situation in the construction field, the theoretical knowledge teaching is integrated with the requirements of professional qualification exams, integrating quality testing with engineering practice. This guides students to adapt to the professional transition from students to engineers while in school, effectively meeting the demand for "graduation to employment".

3.3 Enhancement of Business Analysis Skills

Engineering economics problems are diverse and complex, each with its unique characteristics yet sharing certain similarities, often involving multiple varying parameters. These structured calculations encompass numerous repetitive steps, making them highly suitable for resolution through functional relationships in spreadsheets (EXCEL). Spreadsheets not only simplify these complex and arduous manual calculations but also visually present results through chart outputs, while providing flexible parameter control. This enhances the efficiency and accuracy of solutions, freeing students from a multitude of mechanical hand calculations. This approach is conducive to helping students efficiently construct knowledge frameworks, grasp concepts, and effectively enhance their ability to solve practical problems. During teaching, students are encouraged to actively refer to relevant materials from foundational computer courses for college students and are guided to independently complete function calls and value indexing step by step.

3.4 Feedback on diversified evaluation system

Closely centering on the course objectives and focusing on assessing students' comprehensive abilities in learning attitude, cooperation and communication, autonomous learning, as well as innovative practice, a diversified evaluation system that emphasizes students' overall development and continuous improvement has been constructed with the support of the Rain Classroom online teaching platform. This system integrates evaluations from teachers, students, and industry mentors. It emphasizes the tight integration of process (regular) and summative (final) assessments: process assessment tracks students' learning progress in real-time through various means such as classroom interactions, quizzes, flipped classrooms, and after-school assignments, providing timely feedback; while summative assessment flexibly employs case studies, real questions from professional qualification exams, and engineering practice applications to deeply examine students' ability to apply engineering economics knowledge to solve practical problems. Through this series of meticulously designed evaluation links, we strive to accurately assess the achievement of course objectives, promptly update teaching methods.

4. Conclusion

The "Four-in-One" teaching system for the application-oriented undergraduate course in Engineering

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Economics, based on the Outcome-Based Education (OBE) concept, is oriented towards learning outcomes that fully consider the demands of professional skills. It clarifies teaching objectives, emphasizes the application of practical business skills, aligns with national professional qualification exams, integrates ideological and political education, and establishes a diverse and comprehensive evaluation system. The aim is to enhance students' technical application skills and bridge the gap between coursework and industry applications. The reform has effectively increased students' interest, participation, and practical abilities, deepening their understanding and application of Engineering Economics knowledge. This reform has promoted the improvement of engineering economics professional qualities and abilities among engineering talents in application-oriented undergraduate institutions, holding significant importance for cultivating high-quality civil engineering professionals who can adapt to the demands of modern engineering industries.

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