

Teaching Reform in the Context of Engineering Education Accreditation—Taking the Mechanical Design, Manufacturing and Automation Major as an Example

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Abstract: Engineering education accreditation is primarily aimed at assessing the quality of engineering education, ensuring that higher education in engineering aligns with the demands of modern society, thereby cultivating more excellent engineering and technical talents. The concept of continuous teaching reform is embodied by strengthening the process-oriented assessment of engineering accreditation, deepening the standardization of curriculum teaching, and integrating the philosophy of Outcome-based Education (OBE). The reform organically integrates ideological and political education with teaching activities and simultaneously improves students' comprehensive capacity and practical ability through measures such as monitoring students' behaviors, providing personalized guidance, and implementing personalized assessment. Eventually, the teaching reform driven by engineering education accreditation helps achieve the improvement of the education system, the standardization of the teaching methodology, the optimization of the curriculum matrix, the deeper involvement of the teachers, and the more fair assessment of their teaching qualities.

1. Introduction

Engineering education accreditation is an internationally recognized quality assurance system for engineering education that conducts qualification assessments based on the educational objectives and graduation requirements of students [1,2]. In 2016, China became the 18th official member of the Washington Accord, signifying the international recognition of the quality of its engineering education accreditation program [3]. According to statistics from the Chinese Association for Engineering Education Accreditation, by the end of 2021, a total of 288 universities had undergone the accreditation, with 1977 programs successfully passing the accreditation [4]. Engineering education accreditation, with its founding philosophy of "Student-Centered (SC), Outcome-Based Education (OBE), and Continuous Quality Improvement (CQI)" and the ultimate goal of "international mutual recognition," has become an important guiding standard for becoming a "double

first-class" university in China. As a key applied research institution in Shanghai, the University of Shanghai for Science and Technology's mechanical engineering program has been awarded the "National Distinctive Program" and the "First-Class Doctoral Program in Mechanical Engineering." Since the initiation of engineering education accreditation in 2017, the mechanical engineering program has been continuously optimizing and standardizing the teaching process according to the standards of the accreditation, committed to cultivating "engineering-oriented, innovative, and international" professional engineers. This paper takes the "Mechanical Design, Manufacturing and Automation" major in our school's mechanical engineering program as an example and introduces student-centered and outcome-oriented reforms that meet the requirements of engineering education accreditation under the concept of continuous teaching improvement.

2. Current Status of the Teaching System

The Mechanical Design, Manufacturing and Automation major is one of the accredited specialties in our school, with specific graduation requirements for students summarized in 12 objectives. They are engineering knowledge, problem analysis ability, design/development of solutions, research experience, use of modern tools, engineering for society, environment and sustainable development, professional ethics, individual work and teamwork, communication, project management, and lifelong learning. Adhering to the teaching philosophy of "Student-Centered, Outcome-Oriented, and Continuous Improvement," the Mechanical Design, Manufacturing and Automation courses strengthened the supervision and execution of the teaching process in 2018, improved the standards for assessing the teaching process and the achievement of course objectives, as well as the coordination between various evaluation metrics. But the following issues still persist: inadequate process-based assessment on courses [5], lack of a personalized teaching assessment system, lack of guiding standards in exam design, inadequate process-based assessment on courses [6] and failure to truly embody a student-centered and goal-oriented philosophy [7].

3. Teaching Reform Adapted to Engineering Education Accreditation

Against the backdrop of engineering education accreditation, the Mechanical Design, Manufacturing, and Automation program at the University of Shanghai for Science and Technology has strengthened the student-centered process assessment, the objective-oriented exam design, and the personalized teaching quality evaluation. It deeply embeds the Outcome-Based Education (OBE) idea and follows the philosophy of continuous improvement for regular ideological and political education.

3.1. Refinement of Process Assessment

Traditional assessments in professional courses prioritize knowledge tests over process and skill evaluations, lacking a uniform system and fairness. Engineering education accreditation, however, is student-centric, valuing learning processes and methods. It requires comprehensive documentation of course materials, assessments, and outcomes from the past three years to ensure completeness. Assessments must be scientific, covering not just knowledge but also students' overall abilities, and include practical, innovative courses such as "Mechanical Innovation Design" that showcase key engineering skills [8], as shown in Table 1. Student engagement is heightened through varied assessments like homework, exams, and projects, highlighting the importance of process evaluation and balanced focus on objectives and abilities in driving educational reform.

Table 1: Teaching and Examination Contents of "Mechanical Innovation Design" [8]

No.	Chapter Title	Teaching Content	Examination Content
1	Chapter 1 Overview	Categories, characteristics, and objectives of mechanical innovation	Spirit of innovation, innovative ability, dedication
2	Chapter 2 Innovation Principles and Thinking	Triz theory, innovative techniques, innovation principles	Methodology, research methods
3	Chapter 3 Methods for Mechanical Innovation Design	Modern design methods	Environmental awareness, sustainable development, social responsibility
4	Chapter 4 Innovation Direction and Patent Application	Methods for selecting mechanical innovation design projects and the patent application process	Social awareness, values, intellectual property and its protection
5	Chapter 5 Introduction to Innovation Competitions	Mechanical innovation competitions	Concern for people's livelihood, love for life, care for public welfare
6	Chapter 6 Mechanical Innovation Design Cases	Case study	Organizational ability, collaboration ability, and craftsman spirit
7	Chapter 7 Enterprise Engineering Cases	Analysis of enterprise engineering cases	Industry recognition, social responsibility, professional ethics, engineering ethics

3.2. Personalized Assessment

To implement personalized assessments [9], our program profiles students by tracking their learning status, interests, and challenges, aiding tailored guidance. We employ various assessment methods to cater to individual learning styles and allow students to select courses aligning with their goals, promoting self-driven learning. Modern tech enhances teacher-student communication, enabling real-time feedback. A "three-dimensional evaluation" system by students, supervisors, and peers ensures teaching quality, as seen in Table 2. Student evaluations are conducted online pre-finals, while supervisor and peer reviews focus on teaching effectiveness. Feedback is given post-semester for teaching improvement.

Table 2: Monitoring and evaluation of teaching quality

Source	Students	Supervisors	Peers
Evaluation Content	Course Teaching Quality	Operation of Teaching Activities	Student Learning Outcomes
Proportion (%)	50	30	20

3.3. Standardization of Exam Design

Exams gauge teaching effectiveness and student learning, requiring a question plan aligned with course goals. Yet, they often miss skills like analysis and application [10]. To better capture teaching and learning outcomes, syllabus revisions should align with course systems and exam standards, focusing on skills [11]. Assessments need clear, standardized criteria that emphasize ability development alongside knowledge evaluation.

Our program's teaching assessments align with engineering accreditation goals, detailing exam principles and course objectives. Syllabi outline knowledge points and ability metrics, ensuring exams reflect these aims. Review standards for syllabi and exams, overseen by coordinators, ensure

consistency. To ensure the standardization of the course syllabus and exam question formulation, the college has established corresponding review standards, which are executed under the supervision of the major coordinator and the dean of teaching. These steps standardize exams, tailor content to objectives, and support teaching innovation through a feedback loop.

3.4. Continuing Integration of Ideological and Political Education

Our program weaves ideological education with academics and practice, fostering well-rounded growth. We boost ideological teaching, link disciplines with politics, and encourage civic-mindedness. Students engage in critical discussions on societal issues, boosting critical thinking and innovation. Practical education includes social and volunteer work, nurturing social responsibility and creativity. Teachers' ideological awareness is heightened to support this integration. We also create exemplary courses and cases, with external experts blending ideology into teaching subtly, cultivating students with strong morals and social responsibility. Through the above various forms of educational and practical activities, students' ideological and political qualities and practical abilities are continuously enhanced, cultivating talents with good morals and a sense of social responsibility.

3.5. Deepening the OBE Concept

Table 3: Monitoring and evaluation of teaching quality

No.	Document Name	Formulating Unit	Establishment Time	Implementation Start Time	Operating Period	The Year of Graduates Covered
1	The Management Measures for Evaluating the Achievement of Undergraduate Talent Training Quality by University of Shanghai for Science and Technology Science	Academic Affairs Office	Dec 2020	Dec 2020	Dec 2020 - Sep 2022	2021/2022
2	The mechanism for Evaluating the Achievement of Graduation Requirements	School of Mechanical Engineering	May 2015	Sep 2015	Sep 2015 - Jul 2018	2016/2017/2018
3	Implementation Measures for Evaluating the Achievement of Graduation Requirements	School of Mechanical Engineering	May 2018	Sep 2018	Sep 2018 - Jul 2021	2019/2020/2021
4	Implementation Measures for Evaluating the Achievement of Graduation Requirements (Revised)	School of Mechanical Engineering	Sep 2021	Sep 2021	Sep 2021 - Present	2022

Our school's teaching committee evaluates the program's syllabus against OBE (Outcome-Based Education) standards, ensuring course objectives align with graduation needs and assessments are standardized. Issues prompt revisions every four years. A dynamic "monitoring-evaluation-improvement" cycle ensures teaching quality supports training goals. Feedback from evaluations leads to continuous course improvement, with student and teacher feedback informing reforms. As seen in Table 3, results are tracked in achievement tables, guiding enhancements in course design and

teaching to boost student engagement and course relevance.

4. Teaching Assurance and Assessment System Reform in the Context of Professional Accreditation

To ensure professional training goals and graduation requirements, our program focuses on course quality. We evaluate courses, track progress, and ensure objectives are met. In 2018, the Mechanical Design, Manufacturing and Automation program emphasized better monitoring and auditing of teaching processes, aligning evaluations with the "student-centered, outcome-oriented" philosophy. Revised measures for monitoring and achieving course objectives were introduced, with updated evaluation methods and data sources in 2020.

Firstly, a series of course audit and assessment documents are created (see Table 3) to establish the professional training objectives and system, and serve as the safeguarding documents for engineering education accreditation. These documents are intended to be the guiding programmatic documents for professional engineering accreditation, making the objectives of the program more targeted and fully reflecting the achievement of graduation requirements and the cultivation of competencies. The course matrix system was optimized under the guidance of the graduation requirements by finding the best mixture of basic, technical, professional, and practical courses that best cultivates students' various competencies.

Secondly, course evaluation combines quantitative assessment based on course grades (direct method, see Table 4) and qualitative evaluation based on questionnaire surveys (indirect method, see Figure 1). The direct method involves course instructors, guiding teachers, and lab teachers who give grades based on the assessment components corresponding to the course objectives, referring to the syllabus and grading standards, and form record documents. The indirect method involves creating a survey based on the course objectives, distributing the survey questionnaires at the end of the course, and investigating students' self-evaluation of their mastery of knowledge corresponding to each course objective.

Third, a standardized system for process-oriented assessment procedures and indicators has been established. In this system, different types of courses have different process-oriented assessment objectives, making process-oriented assessment more extensive and flexible. At the same time, the system stress the evaluation of abilities and innovation, making the classroom content richer. The system thus reflects characteristics of personalization and diversification in formulating the assessment process.

Fourth, a new mechanism for ideological and political education in courses, both inside and outside the university, has been established, which includes innovation and entrepreneurship, graduation internships, course internships, joint graduation projects, the involvement of the Industrial Technology Institute and invited external engineering lectures, as shown in Figure 1. The diverse modes of course teaching allows for a more natural integration of ideological and political education, where students can naturally experience it in various forms of teaching processes, with more evident effects. Ideological and political education outside the classroom is often more readily accepted by students and more likely embed correct values. Thus, ideological and political education is organically integrated into both in-class and out-of-class teaching, like salt dissolving in water, achieving a subtle and imperceptible influence.

Table 4: ****Level Table of Achievement of Course Objectives for " **** "

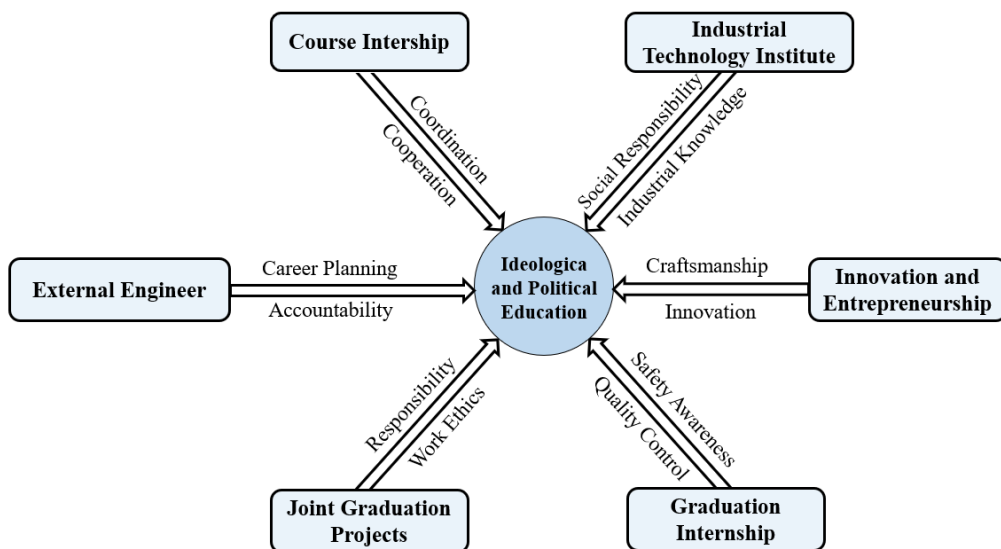
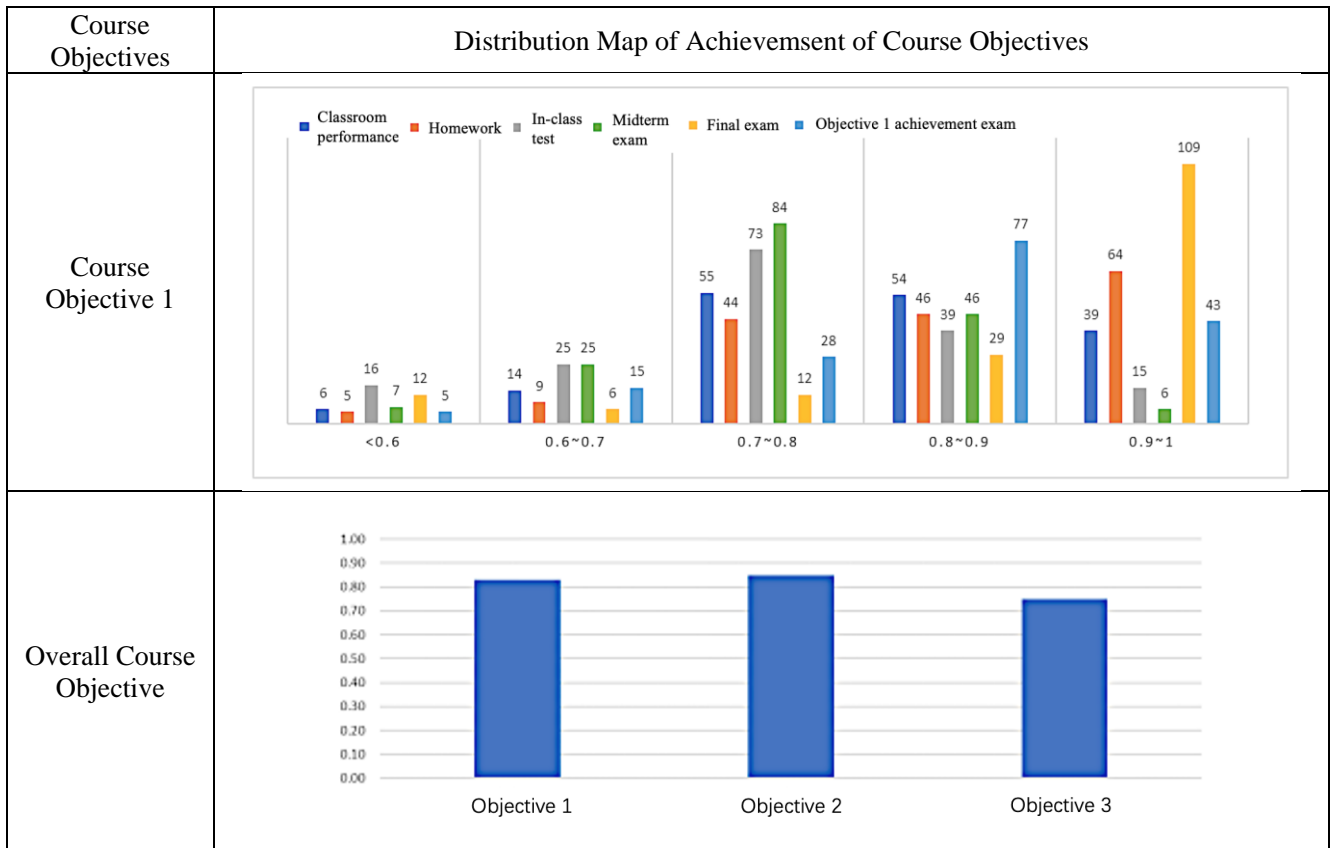


Figure 1 Diagram of the integrated in-class and out-of-class program of ideological and political education

5. Conclusion

In the context of engineering education accreditation, a teaching and training system for the Mechanical Design, Manufacturing and Automation major has been developed to meet the demands

of modern society for engineering and technical talent. This system reflects the core philosophy of engineering accreditation, which is centered on "Student-Centered learning (SC), Outcome-Based Education (OBE), and Continuous Quality Improvement (CQI)." Through the perfection of teaching mechanism documents, optimization of the course support matrix, and development of a course audit and evaluation system that aligns with graduation requirements, guidelines are provided for course teaching reform, promoting the diversification of teaching methods and tools.

Our example illustrates that engineering accreditation can help a education program to understand its problems and deficiencies, quickly formulates improvement plans, optimizes the teaching system, and enhances the quality of teaching and the learning of students. The process of engineering accreditation is a means of realizing self-discovery and self-improvement in professional teaching, thereby driving the reform of teaching in the program.

In the context of engineering accreditation, the Mechanical Design, Manufacturing and Automation major continuously optimizes the construction of the course system, strengthens process-oriented assessment, enriches classroom teaching content and methods, and achieves standardized management of courses and graduation project materials. It standardizes teaching content and objectives, significantly improving teaching quality and forming a closed-loop system for teaching evaluation feedback.

In this paper, we analyze and study the directions of the competition themes, including industrial orientation, practical problems, physical manufacturability, and self-selected themes, in conjunction with the past themes of the Mechanical Innovation and Design Competition. Based on this, a set of competition strategies is proposed including preparing innovation projects in advance, selecting topics in the integrated closed-loop innovation teaching model, and forming a professional innovation mentoring team. These strategies will provide students with an excellent platform for innovation design, effectively improve the teaching quality of the innovation and entrepreneurship practice course, and realize the organic integration of innovation project application, innovation practice course and innovation competition participation. At the same time, in the production of innovative works, ideological and political education is integrated in each link so that positive political thinkings are naturally imbued in students' mind in a subtle way.

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