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Reform and Implementation of "Mechanical Manufacturing Technology" Curriculum oriented by OBE under the Background of Engineering Education Certification

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Abstract: Under the background of engineering education accreditation, the reform and implementation method oriented by the Outcome-Based Education (OBE) philosophy are significant for universities to improve the quality of engineering education. "Mechanical manufacturing technology" is an important professional course for students majoring in mechanical engineering. Reform and implementation of the "Mechanical manufacturing technology" curriculum oriented by OBE under the background of engineering education certification is deeply explored in the work. The current situation and existing problems are analyzed in the work. To improve the teaching quality, a series of measures such as clarifying course objectives, optimizing teaching content, reforming teaching methods, and improving the evaluation system are carried out. The effectiveness of the reform has been demonstrated through practical cases in the thesis

1. Introduction

Engineering education accreditation is an internationally recognized quality assurance system for engineering education [1, 2]. It's also an important foundation for achieving international mutual recognition of engineering education and engineering qualifications. In 2016, China became a full member of the Washington Accord. Participating in the Washington Accord could acquire the international recognition for the achievements in engineering education and accredited programs [3]. Outcome-Based Education (OBE) is an advanced educational philosophy. It is one of the three core principles implemented in the engineering education accreditation [4,5]. The OBE philosophy emphasizes a student-centered approach in the whole educational process. The instructional design and implementation should focus on the learning outcomes that students achieve. The curriculum system is reverse-designed and continuously improved. It advocates that the instructional organization, implementation, and evaluation of teaching activities should be based on the overall learning outcomes of students.

The course of “Mechanical Manufacturing Technology” is a fundamental professional course in mechanical engineering, characterized by wide-ranging knowledge and strong practical applicability. However, traditional pedagogical approaches have been observed to exhibit several limitations, including excessive theoretical emphasis over practical application, monotonous teaching methodologies, and unreasonable course assessment method. These deficiencies have been identified as inadequate to meet the talent cultivation standards stipulated by Engineering education certification. Consequently, the curriculum reform of the “Mechanical Manufacturing Technology” course, guided by OBE philosophy, has been demonstrated to possess significant practical implications.

2. The Current Situation and Existing Problems

The current situation and existing problems of the “Mechanical Manufacturing Technology” course is illustrated in Figure 1.

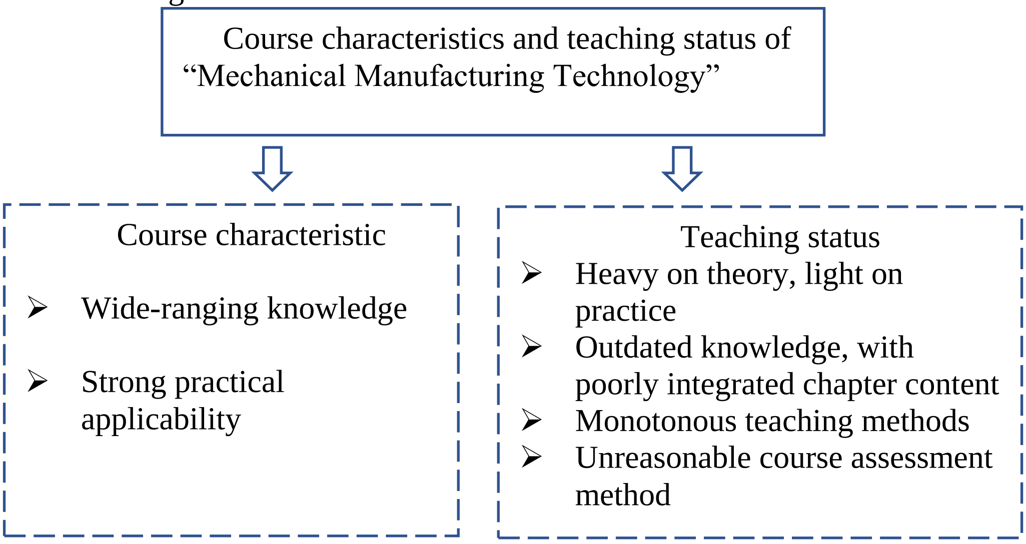

Figure 1: Course characteristics and teaching status of “Mechanical Manufacturing Technology”

Firstly, the teaching content and knowledge are outdated, and the chapter content lacks organic integration. Part of the teaching content still focuses on traditional manufacturing technologies, with little involvement in emerging digital and intelligent manufacturing technologies. Due to the fact that the “Mechanical Manufacturing Technology” course covers multiple modules such as metal cutting principles, machine tools and cutting tools, and the development of mechanical processing technology specifications, there is a lack of organic integration between each module. During the learning process, students often isolate and memorize various parts of knowledge, making it difficult to construct a complete knowledge system. For example, when studying the principles of metal cutting, students fail to fully understand its inherent connection with machine tool selection, tool design, and machining process formulation, resulting in the inability to flexibly apply knowledge to solve comprehensive problems in practical applications.

Secondly, the teaching method mainly relies on traditional lectures, with more theoretical knowledge and less practical operation. During class, teachers mainly teach theoretical knowledge, while students passively receive knowledge. Lack of interactivity makes it difficult to stimulate students' interest and initiative in learning. On the one hand, the aging and limited quantity of practical equipment limit students' opportunities for practical operation. For example, in mechanical processing internships, some machine tools are outdated and frequently malfunctioning, which affects students' normal internship progress. On the other hand, practical teaching content is not closely integrated with practical engineering applications. Students often follow established steps in practice, lacking the ability to solve practical engineering problems.

Finally, the course assessment method is unreasonable. Course assessment mainly relies on exam scores, with a relatively small proportion of homework and classroom performance, lacking process evaluation. This assessment method places too much emphasis on knowledge memory and neglects the evaluation of students' practical ability, innovation ability, and engineering literacy. At the same time, teachers are unable to make real-time adjustment to teaching strategies based on students' performance in the learning process, and students find it difficult to improve their learning methods based on evaluation results.

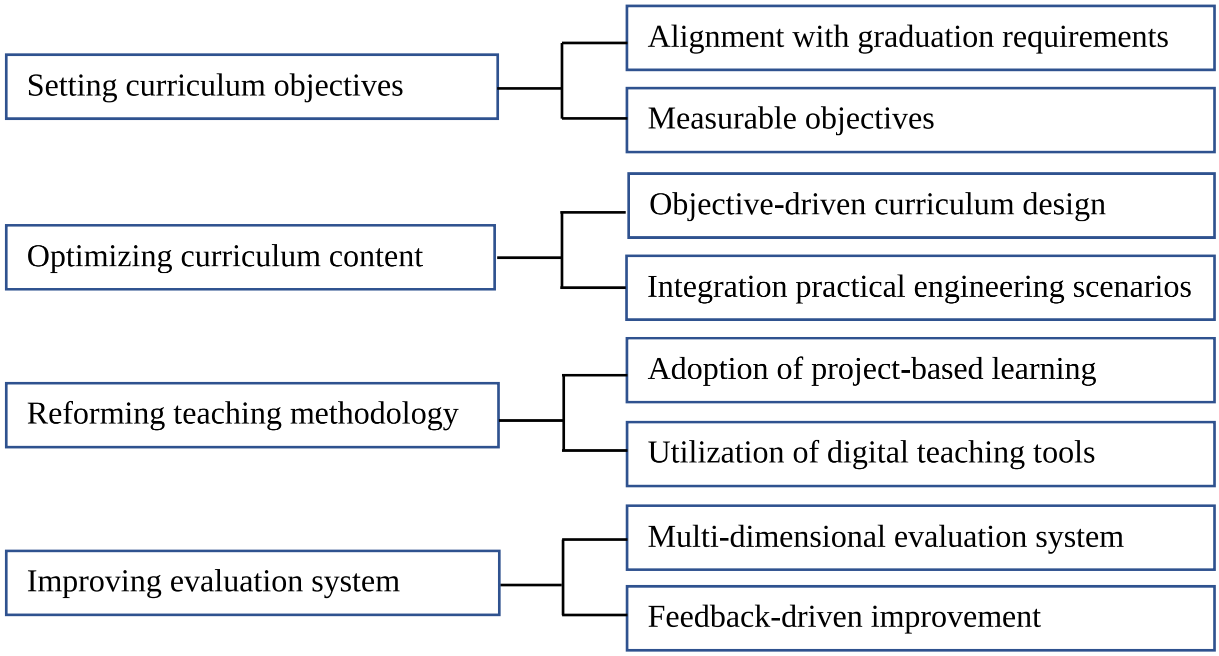

Figure 2: Curriculum Reforms for “Mechanical Manufacturing Technology” Based on OBE

3. Curriculum Reforms for “Mechanical Manufacturing Technology” Based on OBE

The curriculum Reforms for “Mechanical Manufacturing Technology” Based on OBE are shown in Figure 2.

3.1. Setting Curriculum Objectives Based on OBE Philosophy

According to the engineering education certification, the graduation requirements for mechanical engineering majors cover multiple aspects such as engineering knowledge, problem analysis, and design and development solutions. When setting the objectives of the mechanical manufacturing technology foundation course, it is necessary to conduct a thorough analysis of each graduation requirement and determine the specific role of the course in supporting the achievement of graduation requirements. What’s more, in order to make the course objectives measurable, each objective should be described in detail and corresponding evaluation criteria should be developed.

Taking the course objective of "students being able to choose machining methods and process routes reasonably based on given parts, and develop complete mechanical machining process specifications" as an example, the evaluation criteria have been refined. In the course design assignment, students are able to correctly select at least 80% of the machining methods for parts. The process routes are reasonable and the process specification documents are complete and standardized. Such assessment criteria are clear and concise which could facilitate accurate assessment of students' learning outcomes during the teaching process.

3.2. Optimizing Curriculum Content

The objective of the “Mechanical Manufacturing Technology” course is to cultivate students' mastery of the basic principles and process methods of mechanical manufacturing, as well as their ability to solve practical engineering problems. These closely align with the requirements for students' knowledge, abilities, and qualities in the engineering education certification standards. Therefore, in the selection of course content, it is necessary to consider multiple-dimensions such as theoretical knowledge, practical skills training, and practical skills training, to ensure that the teaching content accurately serves the achievement of course objectives.

In order to enhance students' understanding and application ability of course content, a large number of practical engineering scenarios are integrated into the teaching content. Aero-engine blades are made of a difficult-to-machine titanium alloy material. When instructing students on machining such components, it is essential to guide them to holistically consider factors including material properties, cutting tool selection, machining parameters, and cooling/lubrication conditions to meet the required manufacturing precision and surface quality specifications. To minimize the effects of cutting forces on the thin-walled structure of the blades, sharp cutting tools with high wear resistance should be employed, along with a parameter combination of small cutting depths and high feed rates. To ensure machining accuracy for the complex curved surfaces of the blades, five-axis simultaneous machining technology is commonly utilized, enabling multi-axis tool movement to achieve precise material removal in multiple dimensions. Through these case studies, students not only gain insights into the practical application of course knowledge in real-world engineering scenarios, but also develop problem-solving competencies for industrial challenges. Additionally, they acquire awareness of advanced manufacturing technologies employed in high-end equipment production. This greatly stimulates students' interest in learning and cultivates their ability to solve practical engineering problems.

3.3. Reforming Teaching Methodology

The course content is divided into multiple project-based unit to implement a project-driven pedagogical approach. For instance, during the curriculum design phase, students are assigned a specific mechanical component and required to complete the entire manufacturing process workflow, encompassing process analysis, machining method selection, process planning, and technical documentation preparation. Working in teams, each group engages in task allocation, literature research, and collaborative analysis throughout project implementation. During the project implementation process, teachers act as guides to provide necessary guidance and support to students. This project-based pedagogy not only enhances students' mastery of course content but also significantly improves team collaboration competencies, technical communication skills, and practical problem-solving capabilities through authentic engineering practice.

In addition, information technology teaching methods such as online course platforms and virtual simulation experiment software can be fully utilized to enrich teaching resources and improve teaching effectiveness. For example, using virtual simulation experimental software, students can perform various mechanical machining operations in a virtual environment, such as turning, milling, grinding, etc., observe cutting phenomena during the machining process, and understand the influence of different machining parameters on machining quality. Meanwhile, through online course platforms, teachers can publish teaching resources such as instructional videos, electronic courseware, and assignments, allowing students to learn anytime and anywhere, achieving personalized learning.

3.4. Reforming Teaching Methodology

A diversified evaluation system can be established to comprehensively consider students' performance in various aspects of the learning process. The evaluation methods include homework, classroom performance, lab reports, course design, exams, etc. Regular homework mainly tests students' mastery of course knowledge. Classroom performance tests students' participation, thinking ability, and teamwork ability. Experimental reports test students' experimental operation ability and data analysis ability. Course design tests students' ability to comprehensively apply course knowledge to solve practical problems, and exams comprehensively test students' understanding and application ability of course knowledge.

At the same time, timely feedback on the evaluation results should be provided to students, allowing them to understand their strengths and weaknesses in the learning process, so that they can adjust their learning strategies and improve their learning methods. Meanwhile, teachers analyze the problems that exist in the teaching process based on the evaluation results, and continuously improve the teaching content, teaching methods, and evaluation methods. For example, through the evaluation and analysis of course design assignments, it was found that students have many problems in developing process routes. Teachers could add case analysis and practice sessions on process route development in subsequent teaching to strengthen the cultivation of students' abilities in this area.

4. Reform Implementation Cases

A mechanical engineering program at a university implemented a reform based on the OBE concept in its Mechanical Manufacturing Technology course. During the reform implementation process, comprehensive measures such as setting course objectives, optimizing teaching content, reforming teaching methods, and improving the evaluation system had been strictly followed. In terms of achieving course objectives, a comprehensive evaluation was conducted on students' course assignments, lab reports, course designs, and exam scores. It was found that students achieved 0.85 on course objective 1 ("Master fundamental concepts, principles, and methodologies in mechanical manufacturing technology course, and apply this knowledge to analyze and interpret common mechanical manufacturing process phenomena") and 0.82 on course objective 2 ("Select appropriate machining methods and process routes for given components, and formulate comprehensive machining process specifications"). Both attainment levels met the predetermined target requirements.

In terms of improving students' abilities, through questionnaire surveys and their actual performance, it was found that students have made significant improvements in their ability to solve practical engineering problems, teamwork skills, and self-learning abilities. For example, in the course design defense, students can clearly articulate their design ideas and plans, and provide reasonable analysis and answers to the questions raised by the judges. In industrial internships, students were able to adapt quickly to the work environment and apply the knowledge learned in the course to practical work, receiving consistent acclaim from industry partners.

5. Conclusions

Under the framework of Engineering Education Accreditation, the outcome-oriented reform of the “Mechanical Manufacturing Technology” curriculum has yielded demonstrable achievements: (1) established explicit alignment between course objectives and graduation requirements; (2)

systematically optimized teaching content; (3) reformed teaching methods; (4) developed a multi-dimensional assessment system. These initiatives significantly enhanced teaching quality while cultivating students' engineering practice competencies and holistic professional capacities. However, curriculum evolution requires continuous quality improvement (CQI) mechanisms to address dynamic industry demands and learner variability. In future reforms, closer cooperation with enterprises should be developed by introducing more real-world enterprise projects into the curriculum. This will help make teaching more closely connected to actual engineering practices, building a strong foundation for training high-quality mechanical engineers who can meet social needs.

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