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Research on the Teaching Reform and Assessment Method of "Materials for Mechanical Engineering" Course Based on Outcome-Based Education

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Abstract: Under the background of engineering education professional certification, the teaching reform and assessment method inspired by the Outcome-Based Education (OBE) philosophy are significant for universities to improve the quality of engineering education. "Materials for Mechanical Engineering" is an essential foundational course for the students majoring in mechanical engineering. To improve the teaching quality of "Materials for Mechanical Engineering" and align with the requirements of engineering professional accreditation, the teaching reform is explored in this work, including enriching the course contents and optimizing the teaching mode. Meanwhile, the assessment method based on OBE is also investigated. The assessment component and evaluation criteria for "Materials for Mechanical Engineering" course are proposed.

1. Introduction

Engineering education accreditation is an internationally recognized system for ensuring the quality of engineering education [1,2]. In 2013, China became a provisional member of the Washington Accord, and in 2016, becoming a full member. Participating in the Washington Accord could gain the international recognition for the achievements in engineering education and accredited programs. Outcome-Based Education (OBE) is one of the three core principles implemented in the engineering education accreditation [3]. To satisfy the requirements of engineering education accreditation and emphasize the practical outcomes of talent development, the OBE philosophy has gradually become the mainstream trend in engineering education reform [4]. The OBE philosophy advocates that the instructional design and implementation should focus on the learning outcomes that students achieve after education. It emphasizes that the organizing, implementing and evaluating teaching activities should be based on the overall learning effectiveness or educational outcomes of students. Therefore, the OBE philosophy focuses more on building a complete knowledge framework rather than fragmented knowledge units in individual courses. Besides, it places greater emphasis on collaborative learning among students and

collaborative teaching among teachers. Compared to traditional education modes, the OBE philosophy has many advantages and breakthroughs. Consequently, establishing the OBE mode for cultivating talents in the new engineering disciplines has become a new approach for universities to enhance the quality of engineering education and talent development.

As known to all, students in the mechanical engineering will be the core force in the development of the industry. "Materials for Mechanical Engineering" is a mandatory foundational course for second-year students majoring in mechanical engineering in China. It serves as an introductory course that guides students into the field of mechanical engineering and lays the foundation for subsequent courses. The key objective of the course is to help students understand material properties, grasp the processing and shaping methods, acknowledge the technological processes of commonly used engineering materials, and be able to select appropriate materials and processing methods. The characteristics and current teaching status of the "Materials for Mechanical Engineering" course are shown in Figure 1. The course has a strong combination of theory and practicality. However, due to the theoretical nature of the teaching contents, teachers often emphasize the theoretical knowledge during the teaching process, neglecting the relevant internships and practical aspects of the course. The students' subjective initiative in learning is limited by their knowledge base, leading to a passive acceptance of knowledge. This ultimately results in the low student participation during the teaching process and making it difficult to establish effective teacher-student interaction. What's worse, it may also cause a dull class atmosphere and reduce students' learning efficiency. Additionally, the "Materials for Mechanical Engineering" course has abstract contents and lots of knowledge points. However, due to the limited total class hours and the requirements of the "New Engineering" curriculum construction, teachers cannot cover all the knowledge within the class time. Since the teaching mode is primarily instructor-led, it fails to reflect the student's active role, resulting in suboptimal learning outcomes for students. Therefore, there is a need to optimize and integrate the teaching content. Furthermore, the assessment of the course's teaching effectiveness is often limited to final exam scores. As a result, students' innovative and practical abilities are not adequately developed. Engineering education aims to produce professionals who will eventually contribute to society beyond the confines of academia. Only focusing on the theoretical knowledge learning and assessment is narrow and insufficient. How to integrate general education into specialized education, broaden students' overall knowledge base and enhance their adaptability and coordination abilities within the context of "specialized and profound" professional education is an urgent issue.

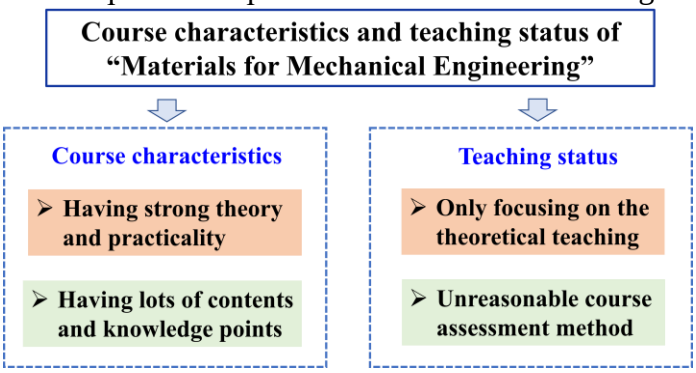

Figure 1: Course characteristics and teaching status of "Materials for Mechanical Engineering".

To further improve the teaching quality of the "Materials for Mechanical Engineering" course and align with the requirements of engineering professional accreditation, this work applies the OBE philosophy to the teaching of the "Materials for Mechanical Engineering" course. A teaching mode and an assessment method for "Materials for Mechanical Engineering" based on the OBE

philosophy are proposed. The main contents are structured as follows: the teaching reform of "Materials for Mechanical Engineering" is investigated in Section 2. Then, the study of course assessment method is introduced in Section 3. Finally, the main conclusions of this study are presented in Section 4.

2. Research on the Curriculum Teaching Reform

2.1. Enrich the Course Contents to Improve the Quality of Talent

Abstract and boring theoretical learning can reduce students' enthusiasm for learning, and enriching course contents is the key to improve the quality of engineering talent development. For example, in the teaching of the "Materials for Mechanical Engineering" course, emphasis on the practical application of theory is crucial. Inviting industry engineers to present reports, explaining heat treatment processes, addressing potential issues in the production process and introducing the latest heat treatment equipment can deepen students' understanding of the course contents. By incorporating 1-2 industry reports, students' interest and motivation for learning can be enhanced, achieving the teaching goal of cultivating advanced applied talents. The traditional knowledge acquired by students in class is often limited to conventional concepts, and traditional teaching hardly explores the discipline front innovative applications. As students' progress in their studies, they will gain a foundation in basic knowledge and theory in the field of materials. Teachers can integrate research topics with innovation and entrepreneurial projects to enhance students' creative abilities. The separation and independent nature between professional courses and research exploration are constraints in the construction of the "New Engineering" paradigm. Teachers should fully leverage their research capabilities, identify the knowledge points in research that relate to the course and foster students' interest in research. Furthermore, the foundation of universities lies in the ideological and political education. In the context of the "New Engineering" construction, it is essential to explore the ideological and political elements embedded in the curriculum. For instance, in the teaching of "Metal materials and heat treatment", fostering students' craftsmanship spirit can be emphasized. Telling them the determination to explore knowledge deeply and introducing the stories of famous scientists allow students to experience the charm of science.

2.2. Optimize the Teaching Mode to Cultivate Students' Abilities

The singular "spoon-feeding" teaching mode results in low student participation in the learning process. Enriching teaching methods and constructing diverse teaching modes are effective ways to cultivate students' abilities. Diverse teaching modes allow students to fully understand the knowledge points and solidify their knowledge foundation. For instance, teachers could use various combined teaching methods, such as utilizing online platforms (i.e., MOOCs). The multimedia technologies, such as animations, videos and modes, also could be applied for the practical case demonstrations. Additionally, incorporating practical operation videos through online resources can help students better understand the processes like heat treatment and enhance students' interest in learning. Utilizing online teaching software (i.e., Learning Hub) and incorporating interactive elements like brainstorming could also improve the class learning effectiveness. Furthermore, teachers can create temporary learning groups for the course, engaging in real-time online discussions with students to address questions and solve problems. This not only enhances the interactivity and interest of learning but also foster students' ability to think and solve problems. Such online interactions help teachers understand students' real-time learning psychology and thus pay attention to students' learning processes and motivations.

3. Research on the Course Assessment Method

3.1. Design of Course Assessment Components

Conducting formative assessments, including outcome-oriented course evaluations, is a significant aspect of professional accreditation. Course assessment involves the evaluation of the course content, teaching processes and overall teaching effectiveness. Traditional assessment methods tend to be overly simplistic and the final exam scores are regard as the sole evaluation criterion. In the context of "New Engineering" construction, there is a need for multi-dimensional assessments and evaluations of students. To achieve a more normalized and detailed assessment method, the proportion of final exam scores should be reduced in the overall grade and the weight of regular performance should be increased. A well-designed assessment system will cultivate students' enthusiasm for learning, encourage proactive learning and improve their problem-solving skills. The OBE philosophy focuses on learning outcomes, acknowledging individual differences among students and gradually guiding them to make progress through diverse learning opportunities. Simultaneously, the assessment system should emphasize self-comparison, adopt a diverse evaluation structure and highlight the individualized meaning of learning outcomes. Accurate assessments of specific learning states for students at different levels can guide teaching reforms and provide assurance for the sustainable development of teaching quality. Based on the OBE philosophy, the assessment can be organized into two levels: process assessment and final assessment, as shown in Table 1. The assessment components include class performance, homework assignment, mid-term exam, research report and the ultimate final exam score, with corresponding weights of 10%, 10%, 10%, 10% and 60%, respectively.

Table 1: Course assessment components and proportions.

Assessment components			
Process evaluation		Final evaluation	
Contents	Proportions	Contents	Proportions
Class performance	10%	Final exam	60%
Homework assignment	10%		
Mid-term exam	10%		
Research report	10%		

3.2. Development of Assessment and Evaluation Criteria

According to the assessment and evaluation methods based on the OBE philosophy proposed in Section 3.1, the assessment components for the "Materials for Mechanical Engineering" course include class performance, homework assignment, mid-term exam, research report and final exam. Each component is assessed on a percentage scale. The evaluation criteria for each assessment component are as follows:

(1) Class performance

Students should attend each class attentively, comprehend the course content, independently complete tests and actively participate in answering questions.

(2) Homework assignment

During the process of completing course assignments, students should independently complete the assignments, complete the steps for answering questions and provide accurate answers.

(3) Mid-term exam

The mid-term exam score is included in the total score with a rate of 10%, and the calculation method is based on the mid-term exam paper score × 10%.

(4) Research report

During the process of completing the research report, students should accurately conduct the literature review, independently complete the report and ensure the report content complete and accurate.

(5) Final exam

The final exam score is included in the total score with a rate of 60%, calculated based on the final exam paper score × 60%.

4. Conclusions

In this work, the teaching reform and assessment method of "Materials for Mechanical Engineering" inspired by the OBE are investigated. Enriching the course contents and optimizing the teaching mode are two effective ways to improve the teaching quality. In addition, an assessment method based on OBE is also developed. The assessment components and evaluation criteria of the proposed assessment method are defined. The results derived from this work can serve as references for improving the education quality of "Materials for Mechanical Engineering".

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