

Research on Teaching Reform of Engineering Materials and Heat Treatment under the Background of Professional Accreditation of Engineering Education

Liangbin Chen*, Yu Ge, Yaohui Li, Yanpu Chao, Jingtao Jin

School of Electrical and Mechanical Engineering, Xuchang University, Xuchang, 461000, China

**Corresponding author*

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Abstract: Engineering Materials and Heat Treatment is a compulsory basic course for mechanical majors in our school, but some key problems still exist in the course. Aiming at these problems, this paper formulates reasonable teaching objectives, integrates teaching resources according to the standard of Professional Certification of Engineering Education, and puts forward specific teaching reform concepts from the aspects of teaching content, teaching methods and course evaluation system, so as to improve the teaching quality of the course, improve students' interest in learning and their ability to solve practical engineering problems.

1. Introduction

Professional Accreditation of Engineering Education is a professional accreditation body that organizes education experts and business experts to accredit the engineering professional education of higher education units, and its purpose is to provide preparatory education quality assurance for engineering and technical personnel who enter the industry.[1] Professional Accreditation of Engineering Education is an internationally accepted quality assurance system for engineering education, which is an important foundation for realizing international mutual recognition of engineering education and engineer qualification.[2,3] In 2012, the newly revised general standard for Professional Accreditation of Engineering Education made clear the basic concept that engineering education should be student-centered, ability-oriented and continuous improvement.[4] Different from the traditional teaching mode, the certification requirements of engineering education specialty are as follows: the curriculum system and quality assurance system should be set to be most beneficial for students to achieve their training objectives and graduation requirements; The objective of teaching implementation is to enable students to obtain ability training after experiencing the educational process; It is necessary to have a clear understanding of all aspects of the requirements of general standards and ways to obtain information, and to have clear and feasible improvement mechanisms and measures, which can track the improvement effect and collect information for continuous improvement.[5]

The major of mechanical design, manufacturing and automation in Xuchang University

(hereinafter referred to as "our school") has also participated in the Professional Accreditation of Engineering Education. Engineering Materials and Heat Treatment is a pretty important technical basic course for students majoring in mechanical engineering. It is a comprehensive course about the basic theory, basic knowledge and engineering application of mechanical engineering materials and their heat treatment technology. It plays an important role in constructing students' knowledge structure and improving students' ability to analyze and solve problems.[6] There are many knowledge points in the course of Engineering Materials and Heat Treatment. The traditional teaching mode is to adopt the mode of teacher lecturing and student listening, which usually ignores the practical engineering application value of the course. Especially under the background of Professional Accreditation of Engineering Education, the problems existing in the traditional teaching mode of Engineering Materials and Heat Treatment are more prominent, such as: the disconnection between theoretical teaching and practical teaching; Ignoring students' dominant position in the learning process; The imperfect assessment and feedback mechanism that greatly limits the cultivation and formation of students' innovative thinking and ability to solve practical problems, and fails to meet the standard requirements of Professional Accreditation of Engineering Education.[4,7,8] In view of the above-mentioned main problems in the traditional teaching process of Engineering Materials and Heat Treatment, this paper takes the teaching reform of Engineering Materials and Heat Treatment in our school as an example, makes full use of the rich teaching resources of the existing large-scale open network course platform (such as MOOC, iCourse, etc.), carefully builds our own online course, and displays the important knowledge points and related applications in textbooks in a more intuitive way of video and animation, so as to realize the mixed teaching mode that teachers' classroom teaching guidance and students' autonomous learning go hand in hand. Moreover, in view of the above-mentioned teaching mode, a new curriculum evaluation system should be scientifically constructed, which should not only pay attention to students' ability to master theoretical knowledge, but also pay more attention to students' autonomous learning ability and their ability to solve problems and innovate by using knowledge. Finally, a combination of quantitative and qualitative evaluation system is used to examine the students' achievement of the curriculum objectives, and continuous improvement of the next round of lectures is carried out based on the main issues fed back from the evaluation results.

2. Revision of Curriculum Objectives

According to the personnel training program of mechanical design, manufacture and automation specialty in our school and the standards of Professional Accreditation of Engineering Education, the curriculum objectives of this course are revised, and the final curriculum objectives should not only be consistent with the teaching philosophy under the background of engineering education certification, but also well support the corresponding index points in graduation requirements. Engineering Materials and Heat Treatment have 2 main objectives: Objective 1 is that students can master the relationship between composition, structure, process and properties of commonly used metal materials and their applications in mechanical design and manufacture, and understand the performance characteristics and applications of other nonmetallic engineering materials; Objective 2 is that students have the ability to select materials reasonably for mechanical parts, select heat treatment process correctly, and arrange process route properly. The above objectives 1 and 2 not only reflect the focus on the cultivation of students' abilities, but also support the graduation requirement index points 3.4 and 6.2 in the personnel training program for the mechanical design, manufacturing and automation majors of the University, respectively, and students can only meet the corresponding graduation requirements if they have completed the curriculum objectives of this course seriously.

3. Reform of Teaching Content

The reform of teaching content should simplify tedious formula derivation and dilute the explanation of profound theoretical knowledge, based on the personnel training program and guidance of training of engineering talents. The teaching content should be combined with the actual industrial production, should fully reflect the new development needs of related industries in China at present, and explain knowledge in easy-to-understand language and cases close to life, so that students can learn easily and are willing to learn. In order to adapt to the developments and changes of engineering materials in the new era, the teaching of new materials, new processes and new technologies related to high-tech or industry is specially added, which can not only make students keep up with the pace of scientific and technological development, but also be closer to modern industrial production and manufacturing. In addition, with the increasing use of polymer materials, ceramic materials and composite materials in engineering, the importance of these engineering materials is growing day by day, and this course also increases the lecture hours of such materials. In addition, the teaching content should highlight the key points and difficulties. Teachers should carefully organize the key points and difficulties in courses, and explain deeply and thoroughly to ensure students' mastery of basic theories.

4. Reform of Teaching Mode

The course of Engineering Materials and Heat Treatment includes the basic knowledge of materials and heat treatment methods. The learning content is not only much, but also abstract, which is very difficult for students majoring in machinery to understand and master.[1,9] The traditional classroom teaching mode is obviously not suitable for the teaching of this course, which is not conducive to mobilizing students' initiative and cultivating students' ability, and does not meet the requirements of "student-centered and ability-oriented" in the standard of Professional Accreditation of Engineering Education. Therefore, our school makes full use of the rich teaching resources of the existing large-scale open online course platforms (such as MOOC, iCourse, etc.) to create our own online courses, displaying the abstract knowledge points and related applications in textbooks by a more intuitive way of video and animation, thus realizing the mixed teaching mode in which teachers' classroom teaching and students' autonomous learning go hand in hand.

4.1. Utilization of Large-Scale Open Online Course Platforms

Large-scale open online courses are a new education and learning mode, which can provide students with higher quality, efficient and convenient educational resources and learning opportunities. First of all, learning is completed online, and students can arrange their own study time according to their own situation. They don't have to go to the classroom to study, and there is no time and space constraint. Secondly, all curriculum resources on the platform are open to the outside world, and anyone can freely choose courses to study.[10] When preparing the course of Engineering Materials and Heat Treatment, teachers can search the teaching resources of the course on platforms such as MOOC and iCourse, etc., classify them according to knowledge points, index them or download them, and provide them to the students for learning in the course of lectures.

4.2. Establishment of Online Open Courses

The establishment of online open courses mainly depends on the learning platform of Xuexi Tong. First of all, teachers should build courses in chapters on the learning platform, and upload corresponding PPT lesson plans, syllabus and training objectives. Second, teachers can prepare the

explanation and recording of course chapters in the recording room, edit them and subsequently upload them to the learning platform in chapters. Third, teachers can collect videos and animations related to the course, such as theoretical explanation, practical operation process, processing process, advanced engineering materials at home and abroad, and introduction of advanced processing technology, etc., which can be used after screening and classification, and uploaded to their own course platform for students to learn, so as to ensure that students are not out of touch with practical application. Fourth, carry out teaching activities on the platform to stimulate students' interest in learning according to the content of each chapter; Fifth, open an online display platform, so that students can collect or make materials related to courses by themselves, and then send them to the online course space for self-display after being reviewed by teachers.

4.3. Design of Mixed Teaching Mode

After the establishment of online open course, teachers will make full use of this resource to construct and organize courses, carry out a mixed teaching mode combining classroom teaching with students' autonomous learning after class, and carry out the design of teaching reform in the three modules of pre-course, in-course and post-course. [10] Before class, teachers can ask students to obtain online course resources through mobile phones and computers, use their time freely to preview, and ask questions and discuss through the platform. Teachers can summarize students' questions in the preview process and answer them in centralized time during classroom teaching. In class, teachers will focus on the important and difficult points of the course and the weak links of students' autonomous learning after class; Teachers can call up exercises in online open courses at any time according to their needs for in-class test exercises to deepen students' understanding of knowledge; When talking about some practical techniques, teachers can call up relevant videos and animations in online open courses in time for students to watch and learn, thus shortening the gap between theory and practical production. For example, when talking about common heat treatment processes such as quenching, normalizing, annealing and tempering, teachers can play videos related to practical operations to deepen students' learning. After class, teachers can arrange some difficult topics, so that students can review the knowledge explained in class with the help of online open courses; Teachers can answer questions online and expand after class, and share the latest developments and news related to this course with students in time for ideological and political education. In addition, when explaining some important course contents, students can be divided into several teams, and some open topics can be arranged for students to answer questions by learning online courses independently and consulting other materials. Then, students can report in teams by means of "flipping the classroom", thus improving students' autonomous learning ability and cooperation ability.

5. Reform of Curriculum Evaluation System

According to the concept of Professional Accreditation of Engineering Education, course evaluation is an important basis for evaluating graduates' ability, and it is also a reflection of the final effect of curriculum teaching. At present, the examination system of engineering materials series courses in most colleges and universities is still the traditional mode of "final examination +homework at ordinary times". Among them, the final exam scores account for 70% or 80%. These traditional curriculum assessment methods not only ignore the assessment and evaluation of students' learning process, but also fail to establish the connection among assessment methods, assessment contents and curriculum objectives. In the later stage, they can't analyze the achievement of curriculum objectives, and the assessment results don't give effective feedback to the teaching process, which is not conducive to the continuous improvement of curriculum teaching.

Therefore, our school adopts the system of quantitative evaluation and qualitative evaluation to evaluate the course of Engineering Materials and Heat Treatment.

5.1. Quantitative Evaluation

Quantitative evaluation is mainly to quantitatively examine the learning process and the acquisition of the final ability of students, analyze the achievement of each objective of this course, and feedback to the whole teaching process for continuous improvement. The assessment method and content of the course can not only examine students' mastery of theoretical knowledge, but also pay attention to students' engineering practice ability and autonomous learning ability. Therefore, on the basis of the original "final exam" and "homework after class", our school has added two examinations: "practical experiment" and "open project report", accounting for 60%, 20%, 10% and 10% respectively. Practical experiment is to let students master and verify the important knowledge points and laws in the course by learning practical courses. For example, what indexes can be used to characterize the mechanical properties of materials? And measure these related mechanical properties by utilizing uniaxial tensile test. Grasp the characteristics of phase diagram and equilibrium microstructure of iron-carbon alloy, and understand the relationship between alloy microstructure and composition through metallographic observation. And understand the relationship between microstructure and properties according to the test of hardness of materials. Through the assessment of practical experiment, the problem of poor engineering practice ability of students is effectively resolved, and the practical ability of students is remarkably improved, which paves the way for realizing the objective of training engineering talents. "Open topic report" is to arrange some open topics in the teaching process of the course, so that students in teams can learn independently by using our online courses to find answers and make reports. The assessment not only improves students' ability to utilize their knowledge to solve practical engineering problems, but also increases their sense of teamwork.

In order to meet the requirements of Professional Accreditation of Engineering Education, it is necessary to establish the corresponding relationship between detailed curriculum objectives, assessment methods, assessment contents and evaluation methods, to quantitatively evaluate the achievement of curriculum objectives. The calculation method of achieving curriculum objectives based on quantitative evaluation is as follows: According to the assessment link corresponding to each curriculum objective, different assessment methods and contents are given different weights. If the achievement degree of curriculum objective i is supported by N assessment points, supposing that the rated total score of the j ($1 \leq j \leq N$) assessment point be S_j , the average score of student assessment be A_j , and the weight of the j assessment point in curriculum objective i be W_j ,

($\sum_{j=1}^N W_j = 1$), then the achievement degree C_i of curriculum objective i can be calculated as:

$$C_i = \sum_{j=1}^N \frac{W_j A_j}{S_j} . [11]$$

For example, the curriculum objective 1 of Engineering Materials and Heat Treatment is supported by 60 points in the final exam (total score of 100 points), 50 points in the usual homework (total score of 100 points), 50 points in the practical experiment (total score of 100 points) and all the scores in the open project report (total score of 100 points). The scores of these four items used by student A to support curriculum objective 1 are 45 points, 40 points, 35 points and 85 points, and the corresponding weights of the four items are 60%, 20%, 10% and 10% respectively. Then the degree of achievement of curriculum objective 1 corresponding to student A

is: $C_1 = \frac{45}{60} \times 60\% + \frac{40}{50} \times 20\% + \frac{35}{50} \times 10\% + \frac{80}{100} \times 10\% = 0.76$, according to which the degree of

achievement of all students to curriculum objective 1 can be calculated. Finally, by summing the achievement degree of all students to the curriculum objective and dividing by the total number of students, we can get the average achievement degree of all students in the class to the curriculum objective 1.

5.2. Qualitative Evaluation

The qualitative evaluation is a calculation method that collects evaluation data by issuing questionnaires to all students studying this course and analyzes the achievement of curriculum objectives based on questionnaires. The achievement degree of curriculum objectives C can be written as:

$$C = \frac{\sum(S \times n)}{5 \times N} \quad (1)$$

Where S is the score of each score item in curriculum objectives, n is the number of students in each score item, and N is the total number of students.

The questionnaire mainly involves the evaluation of the achievement of the curriculum objectives. Each curriculum objective has five grades, which correspond to the distribution of the achievement of the curriculum objectives from low to high. Table 1 is the qualitative analysis results of the achievement degree of the curriculum objectives of Engineering Materials and Heat Treatment by the students of Class 1, Grade 21, majoring in mechanical design, manufacturing and automation in our school in the second semester of the 21-22 academic year.

Table 1: Example of Qualitative Analysis of Curriculum Objective Achievement Degree

Curriculum objectives	5 points	4 points	3 points	2 points	1 point	Achievement degree of Curriculum objectives
Objective 1	7 persons	15 persons	15 persons	3 persons	0 person	0.73
Objective 2	8 persons	16 persons	12 persons	4 persons	0 person	0.74

5.3. Curriculum Objectives Achievement Analysis and Continuous Improvement

The final achievement degree of curriculum objectives takes the minimum of quantitative analysis and qualitative analysis results. For example, the average achievement degree of curriculum objectives of all students in curriculum objectives 1 is 0.7 through quantitative analysis and 0.73 through qualitative analysis, so the final achievement degree of curriculum objectives 1 is 0.7. After obtaining the achievement degree of each curriculum objective in this course, it is necessary to make a reasonable analysis of the achievement degree of the curriculum objective. We can obtain the reasons for the high or low achievement degree of the curriculum objective by analyzing the corresponding examination contents and teaching methods, and then feed back to the teaching process to improve the next teaching process.

6. Conclusion

Engineering Materials and Heat Treatment is a basic course required for mechanical students, which plays an important role in constructing students' knowledge structure and improving students' ability to analyze and solve complex engineering problems in the field of mechanical design and manufacturing. Based on the background of Professional Accreditation of Engineering Education, this paper reformed the teaching of Engineering Materials and Heat Treatment course in

combination with the actual situation of teaching in our school. The reformed course not only meets the standards of Professional Accreditation of Engineering Education, but also significantly improves the teaching effect, stimulates students' interest in learning and improves students' engineering technical ability, and can achieve continuous improvement and obtain better teaching effect.

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References

- [1] Wu, S., Zhou, X. K., Fan, K. Q. (2020) Analysis on the Evaluation System of Engineering Materials Course under the Background of Engineering Education Professional Accreditation. *Henan Education (Higher Education)*, (11), 87-89.
- [2] Shi, X. T., Feng, L. B., Liu, Y. H., Wang, Y. P., (2017) Teaching Reform and Practice Exploration of Engineering Materials and Forming Technology Foundation under the Background of Engineering Education Professional Accreditation. *Teacher*, (32), 99-100.
- [3] Deng, K. L., Chen, G. L., Zhang, Y. F., Liu, H., Hua, Y. C., (2023) Safety Management of Electrical Laboratories in Colleges and Universities Based on Engineering Education Professional Accreditation. *China Modern Educational Equipment*, (01), 50-52.
- [4] Du, X. D., Li, H. Q., Zhang, X. B., (2014) Thinking on Teaching Reform of Engineering Materials Course Adapting to the Accreditation Standard of Engineering Education Specialty. *University Education*, (02): 117-118.
- [5] Wu, H. T., Tang, Y., Yan, J. N., Qian, F., Jiang, X. Y., Han Y. T., Lin S. Y., (2019) Food Chemistry Curriculum Reform Based on the Evaluation of the Achievement Degree of Engineering Education Professional Accreditation Curriculum. *Agricultural Engineering*, 9 (02), 85-89.
- [6] Zhang, L. Q., Liao, K., Chen, X., (2017) Discussion on the teaching experience of Mechanical Engineering Materials under the background of engineering education professional accreditation. *Times Agricultural Machinery*, 44 (12), 186-188.
- [7] Zhang, M., (2016) Teaching Reform of Materials Major Oriented by Engineering Education Professional Accreditation. *Survey of Education (First Half of the Month)*, 9 (5), 76-80.
- [8] Nie, X. W., Cai, M. D., (2021) Construction of Talent Training System for Material Forming and Control Engineering Major in Applied Universities under Professional Accreditation and New Engineering Construction. *Shanghai Journal of Educational Evaluation*, 10 (02), 56-61.
- [9] Li, H., Liu, A. H., Bai, X. M., (2021) Exploration of Online and Offline Teaching Practice of Engineering Materials and Forming Technology under the Background of Engineering Education Accreditation. *Modern Salt and Chemical Industry*, 48 (01), 145-146.
- [10] Yu, M., Yu, X. S., Gu, D. D., (2021) Research on the Reform of Online and Offline Mixed Teaching Mode Based on OBE Education Concept-Taking Civil Engineering Materials as an Example. *Cities and Towns Construction in Guangxi*, (11), 139-141.
- [11] Li, J., Hou, X. Q., (2023) Calculation of Achievement Degree of Curriculum Objectives and Graduation Requirements in Normal Professional Accreditation. *Journal of Higher Education*, 9 (03), 57-61.