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Teaching Reform of Mechanical Manufacturing Technique under the Background of Engineering Education Professional Certification

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Abstract: In the context of new engineering education, based on the engineering education certification standards, and referring to the talent cultivate plan for mechanical design, manufacturing and automation majors, this teaching status of the course “mechanical manufacturing technique” was analysed. As a result, the following questions were found in this course: outdated teaching content, detachment between theory and practice, and single teaching methods and assessment mechanisms. This paper explores the teaching reform measures from three aspects: teaching content, teaching methods, teaching evaluation, based on the principle of student-centred and outcome-oriented, in order to achieve teaching objectives, improve teaching ability, mobilize students’ learning enthusiasm, develop teaching effectiveness, and ultimately meet the needs of new engineering education and the professional certification standards of engineering education.

1. Introduction

In 2016, China officially joined the Washington Accord, marking the beginning of the internationalization of China’s engineering education professional certification system[1]. In 2017, the Ministry of Education actively promoted the construction of new engineering disciplines, making every effort to explore and form a Chinese model and experience that leads the world in engineering education, and to help build a strong country in higher education. Under the background of engineering education professional certification and new engineering disciplines, this paper adheres to the engineering education philosophy of “student-centred, outcomes-oriented, and continuous improvement”, and carries out teaching reform focuses on core basic courses such as “mechanical manufacturing technique”. The aim is to cultivate composite engineering and technical talents, meeting the needs of social development, have a solid natural science foundation, broad mechanical professional knowledge, and strong practical abilities.

“Mechanical manufacturing technique” is a compulsory core course for students majoring in mechanical design, manufacturing, and automation to learn machining and assembly processes of mechanical parts. By studying this course, students need to develop the following abilities: Master the basic theories and knowledge required for typical part processing and assembly process formulation, and can independently formulate part processing process regulations and design related fixtures; When formulating mechanical processing technology regulations, full consideration can be given to the impact of social, economic, environmental, health, safety, legal, sustainable development, and cultural factors, and corresponding responsibilities can be assumed; Cultivate the strong ability to transform innovative design works into products and shape the spirit of craftsmanship. However, there are several shortcomings in the current teaching of "mechanical manufacturing technique": The teacher-centred teaching mode cannot stimulate students' motivation for self-directed learning[2-3]; More emphasis is placed on imparting theoretical knowledge while neglecting practice, and the connection between theory and practice is not close enough[4-5]; The evaluation mechanism is unreasonable and cannot comprehensively assess the students' learning process[6]. Therefore, based on engineering education certification and new engineering disciplines, the article explores the education of "mechanical manufacturing technique" course, proposes teaching reform measures, and lays the foundation for cultivating composite talents who combine theory and practice.

2. The problems existing in the original curriculum teaching

2.1. Outdated teaching content, unable to keep up with technological development

"Mechanical manufacturing technique" is the most flexible and ever-changing content in the mechanical manufacturing process. With the continuous development and progress of manufacturing modes, scientific theories, advanced manufacturing technologies, tool materials, advanced machine tools, etc., the manufacturing process of the same part will be greatly different. However, the textbook cannot keep up with the development and progress of science, and cannot update the content in real time, resulting in slightly outdated teaching content. They cannot keep up with the forefront development and trends of manufacturing technology in their major, and still only focus on traditional processing methods and processes, almost not involving new technologies, new equipment, and new materials. For example, when evaluating the machinability of part structures, from the perspective of traditional machining techniques, some structures have very poor machinability and are very difficult to process, such as deep holes, narrow slits, square holes, etc. However, if advanced processing techniques such as gun drilling, laser cutting, and electrical discharge technology are used, they can still be effectively and greenly processed. However, the teaching content is still limited to traditional mechanical processing techniques, which cannot broaden students' horizons, stimulate their learning enthusiasm, and cultivate their self-learning ability.

2.2. Lack of extracurricular practical activities, theoretical knowledge cannot be applied in practical processing

This course is a core professional course with rich content, dense knowledge points, and strong comprehensiveness. It requires rich processing experience to understand and absorb theoretical knowledge. However, this course has a total of 48 class hours, including 46 teaching hours and 2 are experimental hours. The theoretical teaching time accounts for too much, while the practical time is too little. On the one hand, at the beginning of learning, students lack experience in mechanical processing, and on the other hand, during the teaching process, students still have very little practical time, ultimately leading to insufficient practical experience and inability to digest and absorb theoretical knowledge. During offline teaching, students are often distracted by the teacher's abstract theoretical lectures. They often feel bored and unable to concentrate, resulting in low learning efficiency and poor teaching effectiveness. On the one hand, before teaching, students lack experience in mechanical processing and practical foundation; On the other hand, during teaching, students still have very little time for practical experience and have not developed their processing skills. For instance, when studying the design of clamping mechanisms, students look at slides and listen to the teacher's explanation, feeling very confused and completely unable to imagine what an clamping device with an eccentric mechanism looks like. They cannot understand the specific impact of the magnitude and action position of clamping force on machining. When introducing the location principle, students cannot understand the consequences of redundant location using rough location datum, and why it is necessary to limit the use of redundant location at this time. In summary, currently this course has not established a good feedback mechanism for theoretical output and practical absorption, mainly manifested as a lack of course teaching driven by engineering practice projects; Lack of exemplary teaching; Lack of experimental teaching projects related to practical engineering. Therefore, how to carry out comprehensive extracurricular practical activities is the key for students to master theoretical knowledge and ensure teaching quality.

2.3. Single teaching methods and traditional teaching modes

The "mechanical manufacturing technique" course mainly adopts offline teaching and multimedia methods such as PPT for teaching. Face to face communication between teachers and students helps to create a good learning atmosphere, and teachers can also have real-time insights into students' learning status. However, this teaching method overly focuses on imparting theoretical knowledge and requires teachers to transfer a large amount of knowledge and information to students within a limited time, while students are mostly passive listeners. So, this teaching method not only does not attach enough importance to the cultivation of students' application abilities, but also has low enthusiasm and participation in learning, making it difficult to achieve deep level interaction. This teaching method does not emphasize the cultivation of students' comprehensive abilities, and students have low enthusiasm and participation in learning, making it difficult to achieve deep level interaction between teachers and students. At present, many teachers are also trying to use multimedia to initially integrate theory with practice by adding pictures and videos. However, students generally reflect that the course content is relatively abstract and difficult to digest, and their understanding of knowledge is superficial and their impression is not deep. Their ability to analyse and solve problems cannot be improved. Hence, there is an urgent need to reform teaching methods, expand teaching modes, and improve teaching abilities. It is very important to gradually transform the traditional teacher-cantered teaching model towards a student-centred education model. Ultimately, teachers should pay attention to cultivating students' learning initiative and innovation abilities, and enabling them to possess good engineering qualities.

3. Measures for curriculum and teaching reform

3.1. Reasonably optimize course content and timely update advanced manufacturing processes

(1) Reasonably arrange the content of the textbook and discard content that is not suitable for students in our school

The textbooks used in our major are generally from top domestic universities such as Tsinghua University and Harbin Institute of Technology. The content of the textbooks is more theoretical for most of our students, and some of the content is difficult to learn and use. When introducing machine tool errors, the textbook not only provides a graphical explanation of the impact of errors on machining accuracy, but also introduces error theory analysis methods to quantitatively calculate the impact of errors on machining accuracy. This part is relatively difficult for our students, so we can simplify or delete it appropriately during teaching. When introducing the process dimension chain, the flat dimension chain section was deleted and the straight dimension chain content was retained. In summary, it is necessary to teach students according to their aptitude, and arrange teaching content that is suitable for our students.

(2) Timely update advanced manufacturing processes and supplement the shortcomings of textbook content

The course objectives require that this course should highlight key points, be easy to learn, and closely follow the direction of professional development. However, textbooks generally have timeliness and generally lag behind the development of new methods, technologies, and processes. Therefore, it is particularly important to update the latest technologies and research results in the field of "mechanical manufacturing technique" in a timely manner according to the course content. For example, when introducing the selection of blanks, traditional textbooks are limited to ordinary casting, forging, welding and other methods of manufacturing blanks, but advanced manufacturing processes such as precision casting and precision forging have already been applied in industrial manufacturing. In order to broaden the students' horizons and knowledge, it is necessary to supplement this section in time. Mechanical manufacturing technique is the most flexible of mechanical manufacturing, deeply influenced by advanced manufacturing technology, theory, equipment, tools, etc. Hence, it is necessary and important to timely supplement advanced manufacturing processes on the basis of traditional mechanical manufacturing processes.

3.2. Close integration of practical teaching and theoretical teaching, introducing various evaluation methods

(1) Design experimental courses and introduce engineering examples

This strategy is outcome oriented, focusing on examining students' ability to apply theoretical knowledge and cultivating their practical experience. In this course, experiments closely related to engineering practice can be selected, such as the "statistical analysis of processing errors" experiment. When introducing statistical analysis of machining errors, we discussed the distributing chart method and the point chart analysis method, and theoretically introduced the advantages and disadvantages of the two methods. In order to deepen the understanding of students, error analysis experiments can be conducted to actually process a batch of parts, understand the changes in size of parts during the processing process, analyse the reasons for errors, master the basic principles and methods of statistical analysis of processing errors, and learn to combine engineering theory with practical engineering applications. In addition to designing experiments, engineering examples are constantly introduced during the teaching process. Using actual engineering cases as part of teaching content makes it more "engineering oriented", integrating knowledge transmission and ability cultivation, achieving "learning by doing" and "doing while learning", truly achieving learning through engineering practice.

(2) Step out of the classroom and conduct on-site teaching

It is the responsibility of every school and every teacher to cultivate students' ability to discover, solve, and verify problems, and practical teaching is the most effective means. At present, most metalworking practices in various universities are offered in the first year of college, but at this time, students have not mastered a lot of professional knowledge, and the theoretical teaching and practical teaching have been separated. Practice has shown that this teaching system is neither in line with the current reality that our students lack modern mechanical processing experience, nor does it conform to the basic laws of understanding, leading to practical teaching falling into the dilemma of difficult teaching for teachers and difficult learning for students. Compared with other courses, practical teaching plays a more significant and important role in “mechanical manufacturing technique”. When teaching, if the teacher feels that the students cannot understand the content being taught, they can lead the students directly to the internship industry to demonstrate the theoretical knowledge taught with physical objects, compare the actual objects with the content being taught, in order to have a profound understanding and a clear impression. For example, when explaining the processing of shafts, introduce the relevant theories of shaft parts (such as structure, types, technical requirements, process analysis, processing of slender shafts, etc.) in the classroom, and then lead students to the factory to see what the functions of machine tools and devices such as lathes, three- jaw chucks, tops, centre frames, and tool holders are, and how they work. Let students observe what shape errors are prone to occur during the turning process of slender shafts, and guide them to think about how to reduce machining errors. Through the combination of theory and practice, students are bound to have a deeper understanding.

(3) Carry out group design to cultivate students’ comprehensive application ability and team spirit

Form a small group of 3-5 people to design the course. This course is highly comprehensive. After absorbing rich theoretical knowledge in the classroom, students can design products that they are interested in, integrate knowledge of location, clamping devices, machining process planning, etc., and achieve an effective combination of theory and practice. Through regular reports, teachers can also timely understand the weak links of students in order to provide targeted teaching.

3.3. Reform teaching methods to enhance the attractiveness of courses.

(1) Use engineering examples and teaching aids more frequently

An abstract theory will become simple and easy to understand due to an appropriate metaphor, while a boring course will become interesting due to vivid examples. Therefore, it is very important for students to make knowledge points from difficult to easy and from abstract to vivid. In order to help students better understand the content they are learning, and teachers should use engineering examples and teaching aids at appropriate times. In this course, there are some difficult to understand theoretical rules, such as the principle of selecting rough locating datum. This principle is described as “coarse datum cannot be reused as primary positioning datums, but can be reused as secondary datum.” The textbook does not provide a detailed explanation of this principle. If the teacher only uses traditional methods to teach, it is difficult for students to fully understand this principle. Teachers can use cylinders with uneven surfaces to show students why rough datum cannot be used repeatedly as primary datums. At the same time, demonstrate to students why rough datum can be reused as secondary datums.

(2) Increase multimedia and utilize online platforms for teaching

New multimedia mainly refers to “micro videos” and “micro courses”, which can integrate education with entertainment and attract students to learn. In class, students can learn about the international development trends and research hotspots in the field of “mechanical manufacturing technique” by playing micro videos such as automotive wheel hub machining and precision CNC machining. “Micro courses” can be video courses created by teachers themselves for a certain knowledge point, or students can be recommended to watch imported online video courses on online teaching platforms. This course’s knowledge points, such as location principles, assembly processes, etc., can be learned through corresponding micro courses on the Chaoxing platform. Through micro course learning, students not only increase their interest and self-learning ability, but also contribute to achieving course objectives.

3.4. Enrich the curriculum evaluation mechanism, comprehensively evaluate student abilities.

On the basis of the three commonly used assessment mechanisms of attendance, homework, and final exams, diversified expansion is carried out to supervise students' learning and comprehensively evaluate their abilities. Under the background of engineering education professional certification, the assessment mechanism of this course focuses on process assessment, which mainly includes two parts: daily performance (40%) and final exam (60%). The daily performance (40%) includes learning performance (10%), experiments (10%), and in-class design (20%). The diversified expansion of assessment mechanisms can comprehensively and accurately reflect the learning effectiveness of students.

The daily performance mainly includes three parts: learning performance, in class experiments, and in-class design. (1) The learning performance mainly assesses students' participation in classroom and online learning, including attendance, homework, and test scores. The average score of each part is calculated as 10% of the total grade. (2) There are two experiments in this course. Experiment 1 aims to help students understand the quality of mechanical processing, and Experiment 2 is to enhance students' understanding of mechanical processing machine tools and fixtures. Finally, the experimental score accounts for 10% of the total score. (3) In-class design requires students to divide into small groups and work together to complete the structural design and manufacturing process of a mechanical product. In-class design mainly assesses whether students have mastered basic theories and design methods, and as well as their ability to apply relevant knowledge to formulate mechanical manufacturing process regulations considering actual production conditions, economic analysis, social and environmental factors. In-class design accounts for 20% of the total score. The evaluation of in-class design includes three parts: 1) design of product; 2) Machining process technique regulations of parts; 3) PPT production, presentation, and Q&A.

The final exam is closed book, which mainly assesses basic knowledge and related design and analysis methods. The types of exam questions include choice questions, fills-up topic, calculation questions, and comprehensive analysis and design questions. Among them, the basic concept questions account for 20%, the basic calculation and analysis questions account for about 40%, and the assessment of machining process analysis and calculation questions, the comprehensive process design questions account for about 40%. The exam score accounts for 60% of the total score.

4. Conclusions

This paper investigates the current teaching status of the "mechanical manufacturing technique" course based on the certification standards for engineering education and the requirements of new engineering disciplines, and deeply analyses the problems existing in the current teaching process, such as outdated teaching content which is unable to keep up with technological development; outdated teaching content and inability to keep up with the development of technology; Lack of extracurricular practical activities, theoretical knowledge cannot be applied in practical processing; Single teaching methods and traditional teaching modes, etc.. In order to solve these problems and meet the requirements of engineering education professional certification, this paper proposed some measures from the aspects of teaching content, teaching methods, teaching evaluation, etc., as follows:

(1) The course content needs to be optimized and advanced manufacturing processes must be updated in time. There are two ways to implement this plan. The first one is to rearrange the content of the textbook and discard content that is not suitable for students in our school. The second one is to update advanced manufacturing processes and supplement the shortcomings of textbook content in time.

(2) Close integration of practical teaching and theoretical teaching, introducing various evaluation methods. There are three ways to realize the measure. Firstly, teachers should design experimental courses reasonably and introduce as many engineering examples as possible. Secondly, let students step out of the classroom and experiment on-site teaching. Finally, carry out group in order to cultivate students' comprehensive application ability and team spirit, teachers should arrange group design during course appropriately.

(3) In order to enhance the attractiveness of the curriculum, various teaching methods should be applied to this course. We can use engineering examples and teaching aids more frequently when introduce the abstract theory. We should use multimedia and online platforms during teaching to activate the classroom atmosphere and deepen teacher-student interaction.

(4) There is an urgent need to enrich the curriculum evaluation mechanism in order to comprehensively evaluate students' abilities. Based on the three commonly used assessment mechanisms of attendance, homework, and final exams, diversified expansion is carried out to supervise students' learning and comprehensively evaluate their abilities.

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