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Reform of Mechanical Design Course in the Era of "Emerging Engineering Education"

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Abstract: With the deepening of the construction of 'Emerging Engineering Education', the traditional teaching of Mechanical Design course has exposed many shortcomings: one is the lack of practical engineering problems in the teaching process, which causes the disconnection between students' theory and practice, the other is the single teaching evaluation index, which makes it difficult to measure the comprehensive quality of students. Addressing these issues, the reform plan outlined in this paper emphasizes three core aspects: emphasizing the development of practical skills, fostering curriculum integration and interdisciplinary cooperation, and integrating ideological and political education into instruction. The objective of this plan is to comprehensively elevate the teaching quality and educational impact of Mechanical Design courses, thus aligning with the requirements for mechanical engineering professionals within the context of 'Emerging Engineering Education'.

1. Introduction

In recent years, in order to occupy the strategic commanding heights in the new round of scientific and technological revolution, China has put forward strategies such as 'China Intelligent manufacturing', 'Emerging Engineering Education' and "Innovation-driven Development". Accordingly, the education system has entered the 'Emerging Engineering Education' period to meet the development needs of the new era[1]. Compared with the traditional engineering model, the 'Emerging Engineering Education' concept puts forward higher requirements for engineering talents, emphasizing not only the professional cultivation of a single discipline, but also the cultivation of interdisciplinary knowledge, innovation ability, practical experience and comprehensive quality. This aims to enable graduates not only to effectively apply existing knowledge to solve practical problems, but also to continuously learn and master new technologies to meet the challenges of future development and play a leading role in new technologies and industries.

As a compulsory basic professional course for mechanical students, Mechanical Design course aims to enable students to understand and master the working principles, structural characteristics,

design theories and methods of commonly used mechanisms and general parts and other common problems of machines and institutions, and to cultivate Mechanical Design thinking and methods, which are both theoretical and practical in engineering[2]. It plays an important role in the construction of learning knowledge body of engineering related majors: it is not only the comprehensive application of basic courses such as mathematics, mechanics and graphics learned in the early stage, but also the theoretical basis of later professional courses[3].

In order to meet the new trend of the cultivation of ‘Emerging Engineering Education’ talents, it is urgent to carry out systematic innovation and exploration in the aspects of course content and evaluation form, so as to cultivate high-quality composite ‘Emerging Engineering Education’ talents who can apply what they have learned.

2. Problems in the traditional teaching of Mechanical Design course

2.1 Lack of practical engineering problems in the course content

In the traditional teaching mode of Mechanical Design course, there exists a significant problem of insufficient connection between the course content and the actual project. When facing more complex and lengthy practical engineering problems, some students often reflect that they "can’t understand", which fundamentally requires strengthening the depth and breadth of case teaching.

From the perspective of teaching practice, the arrangement of traditional Mechanical Design course contents tends to the construction of theoretical knowledge system, and the integration of practical engineering cases is not sufficient and systematic. In the teaching process, teachers focus on the explanation and derivation of basic concepts, principles, formulas and other theoretical contents of Mechanical Design, and lack the deep integration and transformation of these theoretical knowledge with practical engineering situations. When students are exposed to a problem containing a large amount of practical engineering background information and a certain complexity, due to the lack of knowledge foundation and thinking guidance in the early stage, it is difficult to quickly and accurately extract key information from the problem, identify the Mechanical Design knowledge involved, and thus make it difficult to understand the whole problem.

From the perspective of students’ learning situation, they have been in an environment dominated by theoretical knowledge learning for a long time, and are accustomed to memorizing and simply applying abstract concepts and formulas, and lack intuitive feeling and practical experience in the real scenes of practical engineering problems. When contacted with practical engineering problems, it is difficult to establish an effective connection between the description of the problem and the theoretical knowledge learned, and the ability to analyze practical engineering problems and design solutions is lacking. Most of the traditional Mechanical Design courses are exam-oriented, focusing on theoretical knowledge memorization and simple calculation. The given conditions of examination questions are clear and simplified, and students can answer according to formula calculation. In actual engineering practice, Mechanical Design needs to comprehensively consider design requirements, working conditions, material characteristics and other factors, and accurately screen appropriate parameters from the Mechanical Design manual. Because the exam-taking assessment does not focus on training students’ ability to solve practical problems by using the manual, it is difficult for students to obtain accurate parameters and calculate flexibly in complex practical situations when facing real engineering tasks, even if they are familiar with theoretical formulas, and they cannot adapt to the requirements of ‘Integration of enterprises with vocational schools and universities’ under the background of ‘Emerging Engineering Education’.

2.2 Single teaching evaluation index

In the traditional teaching evaluation system of Mechanical Design course, the final written test score plays a dominant role, which tends to test students' mastery of theoretical knowledge, such as the memory of theorems and formulas, and the familiarity with the design standards of mechanical parts. However, such an evaluation method has obvious shortcomings.

From the perspective of examining students' comprehensive literacy, as the pre-mechanical courses such as mechanics of materials and theoretical mechanics have laid a certain foundation for the Mechanical Design course, this course is highly comprehensive and practical, and emphasizes the integration and application of multiple knowledge fields. However, there are obvious limitations in traditional evaluation indicators, which cannot examine the practical ability, problem solving ability and innovative thinking demonstrated by students in practice. How to transform theoretical knowledge into practical operation and innovative practice ability is the source power to promote the development of the mechanical field. The traditional teaching evaluation index is not conducive to fully understanding the students' knowledge mastery level, but also deviates from the requirements for talents under the background of 'Emerging Engineering Education'.

In modern mechanical engineering projects, communication and division of labor among members are crucial. How to achieve efficient teamwork and innovation in practice, and how to motivate team members to give full play to their innovative ability through strategies, is an important topic for cultivating students' ability[4]. However, teamwork ability, a critical quality in the field of modern engineering, is often ignored by traditional evaluation indicators: traditional teaching evaluation fails to pay due attention to and quantify the performance of students in group projects and team work, leading to the neglect of this important quality, which is not conducive to the growth and development of students in team cooperation. How to achieve efficient teamwork and innovation in practice, and how to motivate team members to actively play their innovative ability through strategies, still need to be further studied.

Moreover, the singleness of traditional evaluation index is also reflected in the one-sided cognition of students' autonomous learning ability and learning attitude. Only through the closed book examination, it is impossible to determine whether the students independently explore the frontier knowledge and technology in the field of machinery outside the classroom to achieve self-improvement. The courses of mechanical major are continuous, and the traditional evaluation index is very easy to make students carry out short-term and mechanical learning just to cope with the exam, which is not conducive to students' long-term grasp of knowledge and all-round improvement of comprehensive quality, and can not meet the demand for the diversified ability of Mechanical Design talents under the background of 'Emerging Engineering Education'. Therefore, it is urgent to reform the traditional teaching evaluation index.

3. Mechanical Design course reform programme

Aiming at the goal of cultivating the mechanical professionals in the era of 'Emerging Engineering Education' shown in Fig.1, the following Mechanical Design course reform programme is formulated.

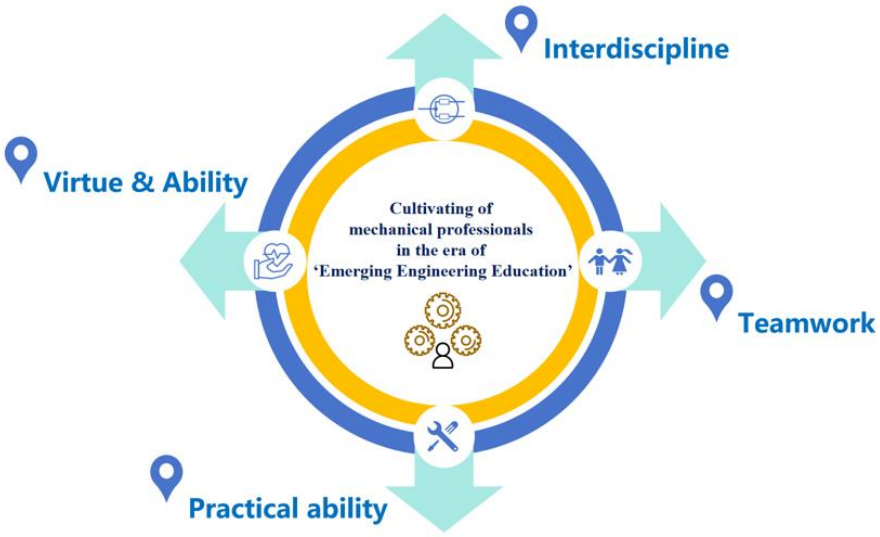

Figure 1: Goal of cultivation.

3.1 Highlighting the cultivation of practical ability

With the booming development of 'Emerging Engineering Education', the course of Mechanical Design is at a key transition point, and it is urgent to move from traditional teaching mode to innovative teaching mode. The traditional teaching of Mechanical Design focuses on the teaching of theoretical principles and ignores practice, often falling into the one-way transmission of theoretical knowledge, and students lack enough opportunities to apply what they have learned in practical operation, resulting in a disconnect between theory and practice. Based on this, curriculum reform is imperative, we should abandon the traditional 'cramming' teaching, and help students to complete the leap from theoretical cognition to practical application. Efforts should be made to readjust the proportion between theory and practice teaching, significantly increase the proportion of practice, build a bridge between theory and practice, actively introduce a new project-driven learning model, and fully stimulate the potential of students to actively explore and independently solve practical problems. Thus, students are encouraged to realize the key breakthrough from '0' to '1' and from scratch when dealing with practical design problems earlier, and gradually grow into Mechanical Design professionals who meet the needs of the new era.

Given practical application scenarios, students are encouraged to make full use of the knowledge of mechanical principles, basic theories and design principles of Mechanical Design in the form of groups to conceive a variety of innovative design concepts. Through project practice, organic integration of traditional design methods and modern design methods, so that students fully experience the whole process of mechanical parts design. Students are guided to dig out the potential problems of the design scheme, and carry out in-depth discussion and analysis for the feasibility. In addition, I completed the optimization of the project according to the sequence of the chapters on the strength, connection and mechanical transmission of mechanical parts, made a team report and defense, elaborated the design and verification results, thus accumulating experience in practice and improving my practical ability and engineering expression ability. Each group presented and reported the plan in front of the whole class, and further improved the plan through teachers and students' questions and evaluations.

Through teamwork mode, students are encouraged to form joint efforts to explore together. In a team, students make reasonable division of labor according to their respective expertise and advantages to maximize efficiency. Moreover, teacher should encourage students to self-recognize

and improve, so as to give full play to their strengths and make up for their shortcomings in the process of learning and practice. It can not only significantly enhance students' learning confidence and interest, but also effectively exercise students' teamwork, independent research and problem-solving abilities. In this way, when students enter the workplace, they will have the ability to adapt to the team-centered working environment, collaborate efficiently with colleagues. The combination of industry and learning is the backbone of innovation and project advancement in the field of machinery.

In addition, in peacetime, students are guided to actively explore the cutting-edge technology trends in the field of Mechanical Design by consulting relevant literature materials in the past three years. At present, the course selects 'Mechanical Design (10th Edition)' compiled by the Teaching and Research Department of Mechanical Principles and Mechanical Parts of Northwestern Polytechnical University as the teaching material. In recent years, the field of machinery has shown a rapid development trend, and many cutting-edge technologies have been emerging. In the learning process, students should not be limited to textbook knowledge, but should accurately understand the significant differences between cutting-edge technology and traditional technology through literature research, encourage students to integrate these cutting-edge technology achievements into project practice, and optimize and improve the original practice plan.

Practical conditions are the material basis of practical ability cultivation. Schools should also increase resource investment, carefully build training bases and experimental platforms that are closely aligned with the curriculum system and can highly simulate the real industrial environment, so as to create a practice space that is close to the real work scene for students.

Through the above measures, the aim is to train Mechanical Design professionals who can adapt to team cooperation, have innovation and practical force, and adapt to the talent training wind of the 'Emerging Engineering Education' background, so that it will become a key force to promote the development of the mechanical field in the new era.

3.2 Multi-curriculum integration and multi-disciplinary crossover

The traditional curriculum content has limitations in the dimension of discipline integration and practical application, which is difficult to meet the demand for compound talents in modern engineering field under the background of 'Emerging Engineering Education' construction. Therefore, breaking the discipline barrier and promoting multi-course integration and cross-disciplinarity has become the core task of the curriculum reform of mechanical majors.

The courses of mechanical majors in each semester are both continuous and progressive, which creates favorable conditions for the integration of multiple courses and helps graduates to form various abilities and qualities. However, the curriculum setting is based on ideal presets, and it is difficult to ensure that students can effectively integrate past knowledge into the course practice of Mechanical Design. It is necessary to actively break through discipline barriers, introduce interdisciplinary knowledge such as material science and computer science learned in the first and second years, build a more comprehensive and diversified knowledge system, consolidate and strengthen students' knowledge foundation in subject basic courses, and further form a perfect and systematic knowledge network structure. Students should be guided to comprehend the methodologies of Mechanical Design from a holistic perspective, enabling them to not only proficiently apply the foundational knowledge from basic courses when tackling practical issues but also adeptly utilize advanced design tools to significantly enhance their ability to solve intricate problems comprehensively. This will better equip them to adapt to the evolving demands and challenges within the field of modern mechanical engineering.

In the process of project practice, students are actively encouraged to make full use of the

computer-aided design (CAD) and computer-aided engineering (CAE) knowledge learned in this semester. With the help of MATLAB, AUTOCAD, Visual Studio Code, ANSYS and other software, parametric optimization design and simulation analysis of mechanical parts were carried out, and relevant results were presented in detail in the team report. This initiative aims to strengthen students' understanding of the structure and performance of mechanical parts, move from given cases to independent innovation, and master the use of various tools. While comprehensively improving students' comprehensive mastery of professional courses and professional skills, it also enables students to have a more direct understanding and perception of the application of modern Mechanical Design methods in practical engineering, laying a solid foundation for dealing with complex engineering tasks and challenges in the future.

In the Mechanical Design course, students encounter extensive use of formulas and charts, necessitating precise selection of formulas and parameters. To reinforce their understanding and enhance their overall abilities, they are urged to embrace programming. By building on their textbook knowledge, students are actively encouraged to utilize programming languages like Python, MATLAB, and VB to accomplish various tasks, including mechanical part strength assessments, limit stress diagram creation, and the design procedures for thread connections, belt drives, chain drives, and gear drives, as illustrated in Figure 2. This will not only help students deepen their understanding and mastery of knowledge, but also effectively improve their ability to solve practical problems in Mechanical Design using computer technology, and lay a solid foundation for training innovative Mechanical Design talents to meet the requirements of 'Emerging Engineering Education'.

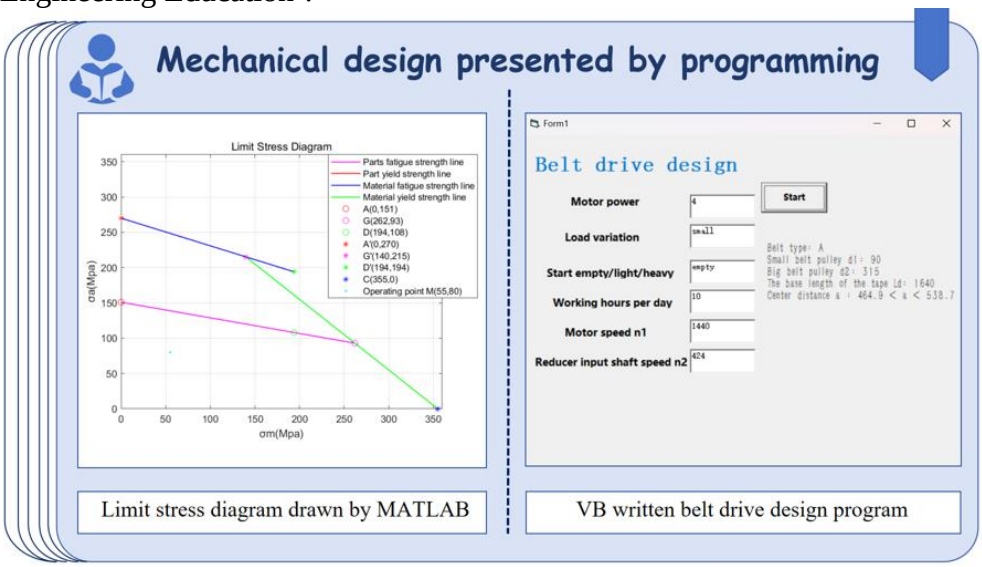

Figure 2: Mechanical Design presented by programming.

In order to further deepen the integration effect of multi-disciplinary knowledge and fully stimulate the intrinsic enthusiasm of students in independent learning, topics with distinct cross-disciplinary and multi-domain knowledge integration characteristics such as lightweight manufacturing, additive manufacturing, green manufacturing and intelligent mechanical system integration are given as expanded content. Students are encouraged to set up a topic for discussion and brainstorm ideas on the 'Tron Class' online learning platform of our school after consulting the information on their own. Expanding students' knowledge horizons is effective in guiding them to delve deeper into their studies, fostering a deeper understanding of the interconnectedness of knowledge across different disciplines. Additionally, it offers fresh perspectives for analyzing and addressing challenges in the future design process.

To sum up, the curriculum reform path of multi-course integration and multi-discipline intersection can not only comprehensively optimize students' knowledge structure, but also provide solid comprehensive practical ability support for them to cope with complex engineering problems. It is the only way for mechanical majors to adapt to the needs of the 'Emerging Engineering Education' era and cultivate high-quality composite talents.

3.3 Integration of Civic and Political Education into Teaching

Under the background of 'Emerging Engineering Education', higher requirements are put forward for talents' knowledge structure, innovation ability and comprehensive quality. The policy emphasized that 'We must persist in taking moral education and educating people as the central link, run ideological and political work through the whole process of education and teaching, achieve full and all-round education, and strive to open up a new situation in the development of the cause of higher education in our country.' Colleges and universities should take moral cultivation as the core and build a system of 'Three All-Round Education'. Accurate and efficient implementation of curriculum ideology and politics in the teaching process is not only a key path to achieve the goal of 'Three All-Round Education', it is an inevitable requirement to adhere to the 'responsibility post' of education and teaching, but also a solid cornerstone to mold students' noble moral quality and professional literacy, and help students establish a correct world outlook, outlook on life and values while mastering professional knowledge and skills. Students can grow into a new era of talents with both virtue and ability, all-round development, and contribute to the modernization of the country and the great cause of national rejuvenation in the near future.

On the official website of the School of Mechanical Engineering of our university, many research achievements in the field of mechanical engineering of our university are systematically displayed. Through the 'Tron Class' network teaching platform of our school, we provide rich and systematic graphic and video data, and build up a multi-dimensional knowledge resource base. Students who are interested can view these videos by themselves to gain an in-depth understanding of the cutting-edge developments in the field of mechanical engineering. At the same time, a series of targeted and inspiring topics focusing on the research direction and research status are set up in the platform discussion area, and students are actively encouraged to independently explore the research direction they are interested in, and have a deep understanding of the outstanding influential figures in the corresponding field and their achievements and spirit. It not only fully stimulates students' learning enthusiasm and internal motivation but also enables them to profoundly understand the crucial role of all facets of Mechanical Design in product quality and user safety. Consequently, it effectively enhances their sense of responsibility and emphasizes fostering their spirit of accountability when confronted with intricate engineering challenges.

The road to scientific research is long, and the achievement needs to be closely coordinated and relays by generations of researchers like precision gears, and the wisdom crystallization of former people is the cornerstone and the spirit of unremitting exploration is the guide beacon. In the field of mechanical engineering, any slight deviation may lead to the imbalance of the entire system, and the 'inferior parts' of academic fraud must not be allowed to mix into the scientific research system. Especially in today's era of frequent interaction between mass media and scientists, academic misconduct is of great harm to misleading public cognition, which may cause the public to misunderstand scientific research progress and application of achievements in the field of mechanical engineering, and thus affect the investment of scientific research resources and social support. Therefore, in the process of cultivating students' scientific research spirit and professional quality, it is necessary to consistently adhere to the bottom line of integrity, inherit the excellent learning style of rigor, innovation and collaboration in the field of mechanical engineering, guide

students to establish correct scientific research values, lay a solid ideological foundation for their long-term development in the vast field of mechanical engineering, and enable them to accurately calibrate their scientific research course. To contribute to the development of mechanical engineering.

The integration of ideological and political education into the classroom is a solid foundation for shaping students' good moral quality and professional accomplishment. It promotes their growth into outstanding talents in the new era with both virtue and ability, as well as ideal and responsibility. This integration injects strong impetus into the modernization of the country and the great cause of national rejuvenation, playing the forging melody of talent and power in the new era.

4. Conclusion

Through the above multi-dimensional initiatives, it is expected to systematically optimize the teaching system of Mechanical Design courses, and cultivate mechanical engineering professionals with solid professional skills, innovative thinking and good moral qualities for the society. It is expected to meet the needs of the times in depth, promote the adaptive development and teaching level of Mechanical Design courses in the wave of 'Emerging Engineering Education', and provide a solid guarantee and source of vitality for the cultivation of talents in the field of mechanical engineering. Fig.3 systematically summarizes the content proposed in this paper in the form of a mind map.

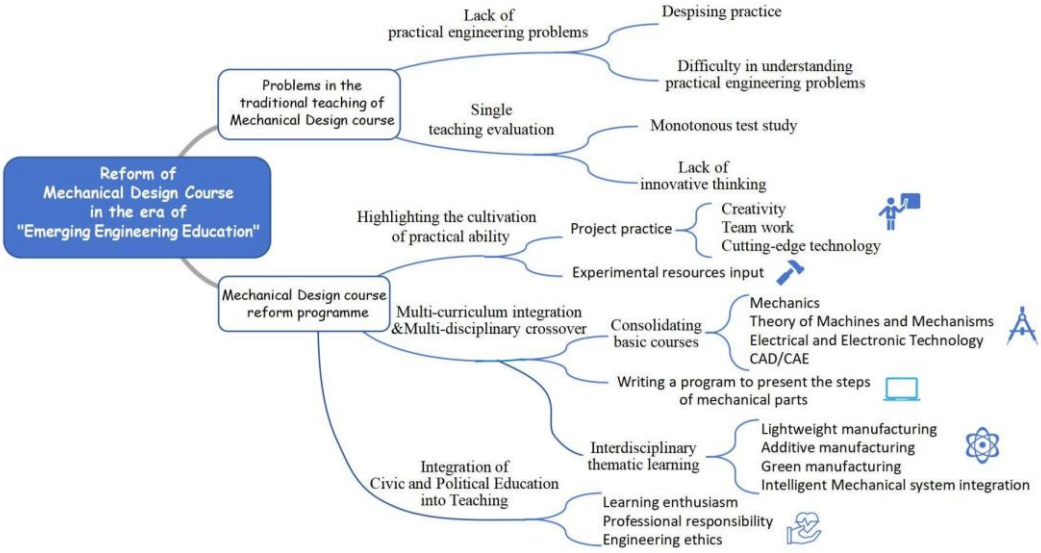

Figure 3: Summary mind map.

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