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Teaching Reform of Materials Science and Engineering Foundation under the Background of "Carbon Peak and Carbon Neutral"

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Abstract: ***Universities have always been pioneers, advocates and leaders of economic and social reform, and should play a key role in this systematic change. In July 2021, the Ministry of Education issued the Action Plan for Carbon-neutral Scientific and Technological Innovation in Institutions of Higher Learning, which clarified the major tasks for universities to provide scientific and technological support and talent support for the dual-carbon target. The first to realize the campus carbon neutral, and promote the carbon neutral scientific and technological innovation and the training of high-quality talents with the construction of campus environment, is a positive response to the national strategy and the action plan of the Ministry of Education. In the Work Plan for Strengthening the Construction of the Training System for Higher Education issued in May 2022, the Ministry of Education particularly stressed that universities should strengthen green and low-carbon education, strengthen the construction of teaching resources in the field of "dual-carbon", and promote the high-quality training of "dual-carbon" related professionals. The key to controlling dual carbon lies in material technology. Therefore, it is particularly important to cultivate materials professionals with dual carbon concepts and related technologies. Based on this, the members of our teaching group have carried out a series of teaching reforms for the course "Fundamentals of Materials Science and Engineering" based on years of frontline teaching experience. They have combined theoretical teaching and practical teaching, providing strong guarantees for cultivating competitive talents in the field of dual carbon control.***

Keywords: Carbon neutrality, Educational innovation, Materials Engineering.

1. Introduction

The "carbon" in the "carbon neutral" refers to the CO_2, Sometimes also refers to all the "greenhouse effect" gases, such as methane, nitrogen oxides, etc. Due to CO_2 in greenhouse gasesThe absolute majority, therefore is the focus of control [1]. During the NPC and CPPCC sessions in 2021, the "carbon peak" and "carbon neutral" mentioned in the Chinese government report became hot words, and more and more enterprises and institutions began to pay attention to carbon emissions in industry and daily life. "Carbon peak" is to control the CO_2 Total emissions peak at some time and then gradually fall back; "carbon neutral" means the additional CO_2 produced by humans each year All through plant absorption or industrial adsorption and other means of removal, to achieve not affecting the original CO_2 in nature Balbalanced target [2,3]. The development of human civilization and the improvement of productivity are accompanied by a large amount of energy consumption, and the use of energy is accompanied by a large amount of carbon emissions. While human beings have created an unprecedented civilization, they have also caused huge environmental and ecological hidden dangers. Human carbon emissions in 2020 are nearly 1,000 times that of those in 1,800, corresponding to CO_2 in the atmosphere. The concentration has also increased from 280ppm before the Industrial Revolution to 410ppm, far beyond the safety level of [4,5]. CO_2 in the atmosphereThe increase of concentration will cause the accumulation of surface heat, accompanied by the melting of ice snow, rising sea level, precipitation migration, frequent extreme weather and other phenomena, which directly pose a serious threat to the sustainable development of the global natural ecosystem and the whole human society.

To achieve the goal of "double carbon", cultivating high-quality "double carbon" talents with innovation and practical ability is the foundation. Once launched, carbon neutrality quickly became an action target and evolved into a "net zero emissions" race. The Ministry of Education has formulated the Action Plan for Carbon-neutral Scientific and Technological Innovation in Higher Education Institutions, [5], which provides a program for providing scientific and technological support and talent guarantee for the carbon-neutral strategy. The plan requires universities to play the role of the main force of basic research and the source of major scientific and technological innovation, promote the construction of carbon neutral future technical colleges and demonstration energy colleges, build a number of state-level carbon neutral and related first-class undergraduate programs, and encourage universities to open carbon neutral general courses [6,7].

Therefore, in the context of "double carbon", we will gather a group of high-level innovation teams to constantly adjust and optimize the construction of carbon neutral related majors and disciplines, promote the continuous improvement of the quality of talent training, and achieve new breakthroughs in basic theoretical research and key generic technologies in the field of carbon neutrality. As university teachers, they should take the initiative to carry out teaching exploration, promote talent training, and reserve a large number of relevant professional quality talents [8-10] for the development of new clean energy and the construction of a "beautiful China". Need to make the contemporary college students in the teaching process to realize the current energy shortage and the seriousness and urgency, stimulate the contemporary college students' energy and environmental ecological crisis consciousness, enhance their construction of ecological civilization construction of responsibility and mission, inspire students to improve the related theory of cognitive height at

the same time, strengthen the undergraduate practice ability, strengthen their independent thinking and innovation ability.

Materials Science and Engineering Foundation is a comprehensive course focusing on new materials, new methods, new technologies and their application fields and development trends. Through the study of this course, students can help them to establish the basic knowledge structure of material science, clarify the training objectives of related majors, learn the latest development trends of various emerging materials, and lay a foundation for the subsequent study of professional courses. After years of teaching practice, the course content has been continuously supplemented and improved, especially with the addition of functional composite materials, energy materials, advanced processing of polymer materials and other related contents, and has achieved good teaching results. However, with the rapid development of the national "double carbon" strategy and the adjustment of industry layout upgrade, the material science and engineering foundation needs to add "double carbon" related materials and carbon reduction theory new technology system course content, to meet the growing cultivation of interdisciplinary, with "double carbon" engineering application thinking of the urgent needs of new engineering talents.

2. The Importance of Teaching Basic Theory of Engineering Science under the Background of Double Carbon

As a core course of materials science and engineering, Materials Science and Engineering involves the knowledge of materials, chemistry, energy, environment and other fields, and has the characteristics of multi-disciplinary. In view of the shortage of "dual carbon" teaching content and single teaching mode, the course design needs to face the research frontier of materials under the background of "dual carbon", enrich the course content, more systematically introduce new clean energy materials, environment-friendly materials, carbon capture, utilization and storage technology and other related content; improve the course teaching mode, integrate the concept of green low carbon and sustainable development into teaching, add the scene teaching, and lay a solid foundation for cultivating "dual carbon" talents that conform to the development of The Times. It aims to cultivate students' scientific thinking and innovation ability, as well as the ability to analyze and solve problems, so as to lay a good foundation for the later study of relevant professional courses. It plays an important role of "connecting the past and the next" in cultivating urgently needed talents. The importance of the course is self-evident.

3. Teaching Characteristics and Current Situation of the Course of Materials Science and Engineering

"Materials Science and Engineering Foundation" is one of the required professional basic courses of materials majors, and it is also a postgraduate entrance examination course, which plays a very important role in the teaching system. "Material science and engineering foundation" to the composition of materials, structure, performance and application and the preparation process as the main line, the introduction of metal materials and inorganic nonmetallic materials atomic structure and bonding type, crystal structure and structural defects, atomic diffusion, phase diagram, solidification process and plastic deformation and other basic knowledge. Let students fully understand the basic properties of materials and the basic knowledge required for the reasonable development of the process, so as to cultivate applied talents who master the basic principles of materials, but also proficient in the preparation, processing and application of materials. "Material Science and Engineering Foundation" is a strong theoretical course, with the characteristics of various knowledge points, strong concept, abstract content, etc. If students do not take the initiative to preview before class and review after class, it is difficult to understand and master. In addition, "Materials Science and Engineering Foundation" focuses on the introduction of the basic principles related to material structure, performance and application. The current teaching method focuses on teaching theoretical knowledge and principles, and pays less attention to and guides students to analyze and solve practical problems.

With the rapid development of the field of materials, new theories, new technologies and new materials are constantly emerging. In order to make students keep up with the development of the material field, the front-line teachers should start from the depth and breadth of knowledge, constantly update the curriculum teaching content, teaching means, practical teaching, curriculum assessment form, reform and explore the curriculum, and constantly seek a better teaching mode.

4. Exploration and Reform of Teaching Methods of Material Science and Engineering under the Background of Double Carbon

The core of carbon neutrality is to control carbon emission and absorption, and the specific implementation depends on the reasonable and controllable transformation of carbon-based materials. Therefore, the science and engineering talents represented by the material discipline will become the new force of carbon neutral strategy, which will directly affect the implementation quality of carbon neutral strategy. Science and technology students now and in the coming decades will also be the implementation of carbon neutral policies. The carbon neutral strategy will also be the historical mission of this and future generations of talents in the science and technology industry. It is very important to explore the establishment of a new engineering education and teaching system for science and engineering personnel training to meet the strategic needs of carbon neutrality. It should not only lay out in advance, but also take immediate action. Material is the cornerstone of the development of modern society, but also the key to achieve the goal of "double carbon". As one of the important disciplines in China, materials science and engineering shoulder the responsibility of cultivating high-quality innovative talents in materials. This team combines the teaching practice of teaching this course for many years, analyzes the current situation of the course, considers the reform measures of course content and teaching mode under the background of "double-carbon", and

discusses the innovative training mode of the new generation of compound "double-carbon" talents by means of knowledge guidance, multi-disciplinary collaboration, industry-university-research integration.

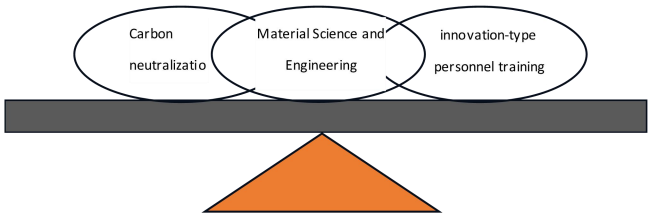

Figure 1: Objectives of teaching reform

As a core course of materials science and engineering, Materials Science and Engineering involves the knowledge of materials, chemistry, energy, environment and other fields, and has the characteristics of multi-disciplinary. In view of the above problems of insufficient "two-carbon" teaching content and single teaching mode in the current curriculum, The course design should be oriented to the research frontier of materials in the context of "double carbon", Enrich the course content, More systematic introduction of new clean energy materials, environmentally friendly materials, carbon capture, utilization and storage technology and other related content; Improving the course teaching mode, Integrate the concept of green, low-carbon and sustainable development into the teaching, On the basis of traditional teaching, add situational teaching, independent learning, application practice and other links, To lay a solid foundation for the country to cultivate "double-carbon" talents that adapt to the development of The Times, Specific thinking and suggestions are as follows.

4.1 Closely Combine the "Double-carbon" Materials and Technology Research Frontier, Enrich and Optimize the Course Content

Carbon neutrality is a huge industrial chain. Developing green and clean energy at the source, practicing energy conservation and emission reduction in the process, and realizing efficient resource recycling at the back end are the key to achieve the strategic goal of "double carbon". Each link involves the innovation and application of materials and technologies. Therefore, in combination with the concept of carbon neutrality, the course of Materials Science and Engineering suggests to add and systematically introduce the following contents.

4.1.1 Clean energy Materials and Technologies:

Developing clean energy, promoting the green transformation of China's energy economy, and reducing the dependence on fossil energy are one of the fundamental ways to reduce carbon emissions from the source [4,5]. At present, China's energy structure is shifting from fossil energy to chemical power supply, nuclear power, biomass energy, geothermal energy, wind energy, ocean energy, solar heat energy / battery, clean coal and other clean energy sources, which has also led to the large-scale development and utilization of clean energy materials and technologies. This part of the teaching content helps students to understand the latest technological progress of new energy materials and devices, and build a new energy technology knowledge system.

4.1.2 Environment-friendly materials and their high-value and efficient recycling technology:

With carbon fiber polymer composite material recycling, for example, as in recent years, civil aircraft, hydrogen storage cylinders, rapid development in the field of wind power, the application of carbon fiber composite material increasing, the corresponding carbon fiber composite products discarded after the recycling pressure is increasing, how to realize the high value of carbon fiber composite recycling has become the current research hotspot. In addition, under the background of "two-carbon", the recycling and utilization of traditional polymer composites such as rubber composites, lightweight polymer composites for automobiles and packaging composites has also attracted wide attention. In order to achieve the goal of "double carbon", not only from the high value of traditional composite resource utilization research, more attention to the development of sustainable composite materials, such as cellulose, lignin, starch represented by natural biological polymer materials and polylactic acid, polyvinyl alcohol, polyterephthalic acid-adipic acid biodegradable synthetic polymer materials, etc. In addition, the development of new materials such as wood-plastic composite materials and dandelion rubber composite materials has also played an important role in realizing energy conservation and emission reduction, green and low-carbon development.

4.1.3 Carbon fixation materials and carbon capture technology:

Carbon capture, utilization and storage technology directly separates carbon dioxide from the emission source, which is an important means to effectively reduce carbon emissions at the back end. Carbon capture and energy utilization, carbon capture and resource utilization are two important directions of carbon fixation technology development. The former uses the excellent fluidity and heat conductivity as fuel-drive heat engine; the latter replaces carbon dioxide with petroleum as chemical raw materials, producing new potential materials such as building materials, chemicals, plastics, carbon fiber and carbon materials.

4.2 Improve Teaching Methods and Practice the Reform of Diversified "Two-carbon" Teaching Mode

4.2.1 Scenario teaching, interactive learning:

The method of "situational teaching" is adopted to visualized the abstract theoretical knowledge, so that students can feel the internal connection and mechanism between the development and design of new materials and the "two-carbon" goal, so as to stimulate students' interest and deepen their understanding and cognition. For example, when introducing clean energy materials and key technologies, relevant experimental videos are presented, so that students can intuitively understand the preparation process of materials and their practical application in relevant energy storage systems. Using "heuristic", teaching mode, combined with "group discussion", such as in the waste polymer materials recycling, can guide students to think and discuss "white pollution management strategy", active classroom atmosphere, promote the teaching interaction, increase the students

'participation, mobilize students' learning initiative, improve the teaching quality.

4.2.2 project guidance, application practice: relying on scientific research projects, guide students to participate in experimental research, avoid the traditional classroom teachers instill boring prompted students to the material science and engineering theory course of abstract knowledge into application practice, cultivate students flexible application theory knowledge, the ability to solve the problem of practical engineering, improve students' comprehensive quality. For example, by participating in the 3D printing project of functional devices related to energy, students can have a deep understanding of the principle of 3D printing technology and the construction mechanism of the multi-level structure of devices, so as to enhance students' understanding of material processing characteristics, device structure design and structure-effect relationship. Students are encouraged to participate in "Internet +", "Challenge Cup" and other practical and academic science and technology competitions, and guide students to practice practically, so as to achieve the effect of promoting learning and teaching through competition, cultivate students 'good innovation consciousness and scientific literacy, and improve students' scientific and technological innovation and engineering practice ability.

4.2.3 Topic orientation and independent learning:

After students fully understand the basic theoretical knowledge of Materials Science and Engineering, they can carry out thematic discussions, connect the key points of knowledge they have learned, and achieve mastery through mutual verification of different knowledge points, help students to form a systematic knowledge system and deepen their understanding and mastery of the course content., For example, open "the development of biodegradable polymer materials to solve the feasibility of global white pollution" panel, guide students to consult, review the existing biodegradable polymer material types, structure and performance, processing characteristics, the source of white pollution, material degradation mechanism and the impact on the environment, deepen students' understanding of biodegradable materials power to achieve the goal of "double carbon", set up the sustainable development of science.

4.2.4 Tracking the frontiers and advancing with The Times:

The specialty and discipline construction of carbon neutral has distinct characteristics of crossover, application and transformative. Teaching content should not be limited to the existing teaching materials, should pay more attention to dynamic and hot spots, the latest academic achievements in time to the teaching, broaden the students 'knowledge, strengthen students' understanding of this field, encourage students to master frontier and innovative knowledge, which in turn can enhance students' interest in learning courses. By inviting well-known scholars and industry experts in the field to give online or offline lectures, students are encouraged to attend more "double-carbon" knowledge network lectures, feedback problems they do not understand and carry out classroom discussions, so as to create a good academic atmosphere, stimulate students' enthusiasm for scientific research, and cultivate the consciousness of "double-carbon" innovation.

In addition to the above measures, we can also strengthen the reform of practical teaching links, such as setting up relevant innovation experiments. Students are encouraged to participate in teachers 'scientific research projects, encourage students to apply for innovation and entrepreneurship training programs and various discipline competitions, and cultivate students' innovation consciousness, practical ability and ability to solve practical problems; the school can cooperate with surrounding enterprises to establish internship bases and practice base, organize students to go out of the classroom, laboratory and into the enterprise, understand the production status of enterprises, and complete the problems to be solved as experimental projects. In this way, we not only complete the teaching tasks of internship and internship, but also cultivate students' ability to combine theory with practice, analyze and solve practical problems.

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Author Profile

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