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The Analysis and Strategies of Implementing "Dual Carbon" Education in Junior Middle School Physics Teaching under the New Curriculum Standard

Tingsong Fu[1,a], Wude Cai[1,b,*]

[1]*School of Physics and Electronic Information, Yunnan Normal University, Kunming, Yunnan, 650500, China*
[a]*2296313993@qq.com*, [b]*805737835@qq.com*
[*]*Corresponding author*

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Abstract: "Dual Carbon" Goal is a solemn commitment made by China to the world, aiming to build a community with a shared future for mankind. It is essential to adhere to the principle of national overall planning and actively implement the concept of "Dual Carbon" education in the field of physics education. This paper analyzes the necessity and feasibility of implementing "Dual Carbon" education in junior middle school physics teaching, sorts out the curriculum content requirements related to the work requirements of the "Dual Carbon" goal in the Compulsory Education Physics Curriculum Standard (2022 edition), and proposes teaching strategies based on specific examples.

1. Introduction

In September 2020, President the People's Republic of China stated to the world during the general debate of the 75th session of the United Nations General Assembly that China will strive to reach its peaking carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060 (hereinafter referred to as the "Dual Carbon" goal)[1]. Education is the foundation of a country, and education remains the key to low-carbon development[2]. In April 2022, Ministry of Education of the People's Republic of China issued the Compulsory Education Physics Curriculum Standard (2022 edition) (hereinafter referred to as New Curriculum Standard), which established the nature of compulsory education physics curriculum. This includes promoting the inheritance of human science and societal development, helping students understand nature and solve related practical problems from a physics perspective, guiding students to comprehend the relationship between science, technology, society, and environment, and enhancing their sense of social responsibility[3]. Guided by The Thought on Socialism with Chinese Characteristics for a New Era, based on the New Curriculum Standard, and aiming at the work requirements of the "Dule Carbon" goal, how to reflect the nature of the compulsory education physics curriculum in junior middle school physics teaching and help the realization of the "Dule Carbon" goal is an urgent problem to be solved.

2. The Necessity of Implementing "Dual Carbon" Education in Junior Middle School Physics Teaching under the New Curriculum Standard

2.1 The Necessity of Addressing the Climate Crisis

The climate crisis is imminent, and it is imperative to urgently promote the "Dual Carbon goals". According to the *Blue Book on Climate Change in China (2023)*, as a sensitive region with significant influence in global climate change dynamics, China has exhibited a higher rate of warming than the global average during the corresponding period[4]. Carbon dioxide emissions are primarily responsible for the greenhouse effect. Despite having relatively low per capita carbon dioxide emissions, China ranks first in total carbon dioxide emissions worldwide[5]. The "Dual Carbon" goal aims to achieve net-zero emissions of carbon dioxide. The promotion of the "Dual Carbon" goal not only demonstrates China's proactive role in building a community with a shared future for mankind, but also contributes to the realization of Chinese modernization in which humans and nature coexist in harmony.

The Centennial plan is education-oriented. Achieving the "Dual Carbon" goal requires collective efforts from all citizens to establish and practice the concept of green and low-carbon production and lifestyle, achieve carbon peaking through energy conservation and emission reduction, and attain carbon neutrality through afforestation. The nature of the compulsory education physics curriculum determines the necessity of implementing "Dule Carbon" education in physics teaching, and "Dule Carbon" education is the proper meaning of promoting the realization of the "Dule Carbon" goal.

2.2 The Necessity of Establishing a National Education System for Green and Low-Carbon Development

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), education plays a crucial role in combating global climate change[6]. In 2022, in order to achieve the "Dule Carbon" goal and make a unique contribution to the education industry, the Ministry of Education of the People's Republic of China successively issued the "Work Plan for Strengthening the Construction of a Higher Education Talent Training System for Carbon Peaking and Carbon Neutrality" and the "Implementation Plan for Constructing a National Education System for Green and Low-Carbon Development"[7][8]. These plans emphasize implementing the education of new development concepts and ecological civilization responsibility for all citizens, as well as promoting education on carbon peaking and carbon neutrality (hereinafter referred to as "Dual Carbon" education). At the same time, it is pointed out that basic concepts and knowledge about carbon peaking and carbon neutrality should be popularized in disciplines such as politics, biology, geography, physics, chemistry during basic education stage. The aim is to integrate green and low-carbon concepts into university, secondary school, and primary school systems by 2025 while achieving systematic cultivation and development of students' green lifestyle habits by 2030.

The basic education constitutes a vital component of the national education system, with the physics curriculum serving as a crucial instructional content during the basic education stage. Confucius said: "The conduct one develops from a young age is akin to innate qualities, while habitual actions resemble the workings of nature." Middle school serves as a crucial stage for fostering green and low-carbon behavioral habits, making it an optimal period for implementing "Dule Carbon" education[9]. Based on the concept of the New Curriculum Standard and focusing on the "Dual Carbon" goal, high-quality physics curriculum resources can be developed. On one hand, this will help achieve the goals of the physics curriculum. On the other hand, it will promote the construction of a national education system for green and low-carbon development and a talent

training system for higher education with carbon peaking and carbon neutrality.

3. The feasibility of Implementing "Dual Carbon" Education in Junior Middle School Physics Teaching under the New Curriculum Standard

In September 2021, the Opinions on Completely, Accurately, and Comprehensively Implementing the New Development Concept and Doing a Good Job in Carbon Peaking and Carbon Neutrality were issued by the Central Committee of the Communist Party of China (CPC) and the State Council[10]. The document primarily focuses on establishing a green, low-carbon, circular economic system as well as a clean, low-carbon, safe, and efficient energy system. Additionally, it outlines specific work requirements that must be achieved by 2025, 2030, and 2060.

The concept of carbon peaking and carbon neutrality has been organically integrated into the New Curriculum Standard, including curriculum objectives, curriculum content, and academic level Standard[11]. Furthermore, it has been fully permeated into the content requirements, teaching tips, and academic requirements of the curriculum content. Table 1 describes the curriculum content requirements in the New Curriculum Standard related to the work requirements of the "Dual Carbon" goal. The New Curriculum Standard serves as a direct basis for teaching physics in junior middle school, clarifying both "what to teach" and "how to teach" for implementing "Dual Carbon" education in Junior middle school physics teaching.

Table 1: The curriculum content requirements in the new curriculum standard related to the work requirements of the "Dual Carbon" goal

"Dual Carbon" goal	The curriculum content requirements in the New Curriculum Standard
Establish a green, low-carbon, circular economic system	1.1.2 Try expressing your own opinion on the issue of ambient temperature.
	2.4.5 Learn about the application of electromagnetic induction in production and life.
	3.4.7 Be aware of safe electricity usage and save electricity.
	5.1.3 Be able to use the knowledge learned to guide and standardize personal life, practice low-carbon life, and cultivate a sense of energy conservation and environmental protection.
Establish a clean, low-carbon, safe, and efficient energy system	3.1.1 Can describe the connection between different forms of energy and production, life.
	3.3.1 Understand the internal energy and heat, as well as comprehend the fuel's calorific value from the perspective of energy conversion.
	3.3.3 Understand the working principles of heat engines and recognize the significance of internal energy in the history of human social development.
	3.5.2 Recognize the efficiency from the perspective of energy conversion and transfer.
	3.5.3 Enumerate common examples where energy conversion and transfer occur in a specific direction.
	3.6.1 List common renewables and non-renewables.
	3.6.2 Understand the characteristics of nuclear energy and the potential issues associated with its utilization.
	3.6.3 Experience the significance of sustainable development from the perspective of energy development and utilization.
	5.3.1 Combining examples to analyze the impact of energy development and utilization on social development.

4. The Strategy of Implementing "Dual Carbon" Education in Junior Middle School Physics Teaching under the New Curriculum Standard

4.1 Based on Physics Textbooks, Explore the Convergence Point of "Dual Carbon" Education

Combined with the requirements of the curriculum content of the New Curriculum Standard and the work requirements of the "Dual Carbon" goal, taking the compulsory education physics textbook (2013 edition) published by the People's education press as an example, the content of the textbooks suitable for implementing "Dual Carbon" education is sorted out and teaching

suggestions are put forward, as shown in Table 2.

Table 2: The Contents and Teaching Suggestions Suitable for "Dual Carbon" Education in Physics Textbooks

Chapter	Section	Teaching Suggestions
The Change in the State of Matter	Temperature	Based on the situation and hazards of global warming, a new lesson is introduced: What is temperature? How do we measure temperature? Homework: Let students understand China's "Dual Carbon" goal in combating global warming. What efforts can we make to help achieve the "Dual Carbon" goal?
Internal Energy	Internal Energy	When explaining the three forms of heat transfer (heat conduction, heat convection and heat radiation), the greenhouse effect process is introduced: the sun transfers heat to the ground through heat radiation, and after the surface is heated, it releases heat to the outside through heat radiation. However, carbon dioxide gas in the air weakens this outward heat radiation from the surface, eventually leading to global warming.
Utilization of Internal Energy	Heat Engine	The development of heat engines has advanced human production and life, but their exhaust emissions have caused significant harm to the environment. Students were organized to hold a group debate competition on the topic of "Should the use of heat engines be banned?" with the aim of guiding them towards embracing the concept of harmonious coexistence between humans and nature.
	The Efficiency of the Heat Engine	Compare the calorific value and carbon emissions after combustion of natural gas, coal, oil, and other fuels. After class, students are guided to consult data from the "West-to-East Gas Transmission" project and collaborate on a group report, discussing the significance of this project in achieving the "Dual Carbon" goal.
	The Efficiency of the Heat Engine	From the perspective of energy conversion and transfer, students are guided to explore strategies for enhancing energy utilization efficiency, such as minimizing frictional heat generation in mechanical transmission systems, pulverizing coal into fine powder or converting it into gas for combustion, and harnessing waste heat from coal combustion through waste heat boilers for power generation.
	Transformation and Conservation of Energy	
Electricity and Magnetism	Magnetism Generates Electricity	Based on the power generation and ecological benefits of Baihetan Hydropower Station, students are guided to construct a physical model of the generator, and carry out scientific exploration using hand-cranked generators to reason about the principle of power generation. After class, students are guided to consult data from the "West-to-East Power Transmission" project and collaborate on a group report, discussing the significance of this project in achieving the "Dual Carbon" goal.
Energy and Sustainable Development	Energy	Guide students to list common renewables and non-renewables, understand the current global trends in energy development, and establish a concept of sustainable development. Organize students to discuss the impact of fossil fuels on the natural environment, compare the advantages and disadvantages of various types of renewable energy, and understand the proportion of non-fossil fuel consumption that the "Dual Carbon" goal aims to achieve by 2025, 2030, and 2060. Organize students to discuss how they can conserve resources and practice green and low-carbon concepts.
	Nuclear Energy	
	Solar energy	
	Energy and Sustainable Development	

4.2 Guided by Core Literacy, Achieve Mutual Promotion with "Dual Carbon" Education

Core literacy is not only the goal of the physics curriculum but also encompasses the correct values, necessary character traits, and key abilities that should be cultivated by "Dual Carbon" talents. "Dual Carbon" education serves as a necessary measure to develop students' core literacy. By focusing on the "Dual Carbon" goal, we can develop high-quality physics curriculum resources

to assist in junior middle school physics teaching, thereby achieving mutual promotion of core literacy and "Double Carbon" education. For instance, the Baihetan Hydropower Station is the second largest hydropower station globally and a significant national project for implementing "West-to-East Power Transmission", has an average annual power generation capacity of 62.443 billion kWh. This capacity can meet the annual electricity consumption needs of approximately 75 million people, save around 19.68 million tons of standard coal, and reduce carbon dioxide emissions by 51.6 million tons per year[12]. In the section on "Magnetism Generates Electricity", pictures or videos related to Baihetan Hydropower Station can be introduced to guide students in observing the structure of its generator set, abstracting the physical model of the generator, conducting scientific exploration with a hand-cranked generator, and summarizing and reasoning about the power generation principle. This will promote the development of students' literacy in physical concepts (movement and interaction), scientific thinking (model construction, scientific reasoning), and scientific inquiry. By guiding students to discuss the significance of the "West-to-East Power Transmission" project in achieving the "Double Carbon" goal, understanding the relationship between science, technology, society, and environment can be enhanced while fostering students' attitudes towards science and responsibility.

4.3 Implement Interdisciplinary Teaching with Physics as the Core

Achieving the "Dual Carbon" goal requires the active participation and cooperation of all sectors of society. From an educational point of view, it is imperative to implement interdisciplinary teaching. Teachers should build on physics knowledge and guide students to analyze and solve problems from a multidisciplinary perspective. This will enable students to develop a comprehensive understanding and application of knowledge, thereby contributing to the cultivation of "Dual Carbon" talents with innovative thinking and problem-solving abilities. The content that heat transfer can alter the internal energy of an object is utilized as a teaching case. First of all, it can be effectively combined with geographical knowledge of atmospheric heating processes and atmospheric motion to provide a detailed explanation. This enables students to gain a deep understanding of how the sun transfers heat to the ground through heat radiation and how carbon dioxide weakens heat radiation on the ground, thereby comprehensively grasping the underlying principles of the greenhouse effect. Secondly, carbon dioxide is collected using the "upward exhaust method" in chemistry, and the temperature change of two collection cylinders containing respectively carbon dioxide and air under sunlight is measured with a high-precision digital thermometer. This realizes the visualization of the greenhouse effect, enabling students to intuitively perceive the attenuating effect of carbon dioxide on thermal radiation. Furthermore, it can also be combined with the knowledge of photosynthesis in biology to help students understand the role of plants in reducing carbon dioxide levels in the atmosphere, comprehend the significance of afforestation in achieving the "Double Carbon" goal, and embrace the concept that lucid waters and lush mountains are invaluable assets.

5. Peroration

The realization of the "Double Carbon" goal needs to adhere to the principle of national overall planning, and students are the vital force to achieve the "Double Carbon" goal. As an important bridge between schools, families, and society, teachers should actively give play to the social nature of education. Teachers can guide students to carry out relevant after-school social practice activities around the work requirements of the "double carbon" goal, and pay attention to home-school cooperation, so that the "Double Carbon" education can take root and sprout from the school and flourish in the society, so as to promote the realization of the "Double Carbon" goal and the

establishment of a national education system for green and low-carbon development.

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References

[1] The State Council of the People's Republic of China. Remarks at the General Debate of the 75th Session of the United Nations General Assembly. https://www.gov.cn/gongbao/content/2020/content_5549875.htm.
[2] Zhao Zhongxiu. Developing low-carbon education will help achieve carbon-neutral target. China Sustainability Tribune, 2021, (09): 34-36.
[3] Ministry of Education of the People's Republic of China. Compulsory Education Physics Curriculum Standard (2022 edition). Beijing: Beijing Normal University Press, 2022, 4.
[4] Chao Qingcheng. Blue Book on Climate Change in China (2023). Beijing: Science Press, 2023,7
[5] Zhang Junyu, Song Meng, Liu Boen. Current Situation of Carbon Dioxide Emission and Suggestions for Emission Reduction in China. Natural Resource Economics of China, 2022, 35 (04): 38-44+50.
[6] UNESCO. Country progress on Climate Change Education, Training and Public Awareness. UNESCO, 2015: 3.
[7] Ministry of Education of the People's Republic of China. Notice of the Ministry of Education on Printing and Distributing the Work Plan for Strengthening the Construction of a Higher Education Talent Training System for Carbon Peaking and Carbon Neutrality. http://www.moe.gov.cn/srcsite/A08/s7056/202205/t20220506_625229.html.
[8] Ministry of Education of the People's Republic of China. Notice of the Ministry of Education on Printing and Distributing the Implementation Plan for the Construction of a National Education System for Green and Low-Carbon Development. http://www.moe.gov.cn/srcsite/A03/moe_1892/moe_630/202211/t20221108_979321.html.
[9] Cao Rui, Yang Yixin, Su Yingchun, et al. High School Geography Teaching Empowers "Dual Carbon" Goal. Education: Analysis and Strategies. Teaching Reference of Middle School Geography, 2023, (08): 4-10.
[10] The State Council of the People's Republic of China. The Opinions on Completely, Accurately, and Comprehensively Implementing the New Development Concept and Doing a Good Job in Carbon Peaking and Carbon Neutrality. https://www.gov.cn/zhengce/2021-10/24/content_5644613.htm.
[11] Jiang Shuang, He Chenggang. Paying attention to the integration and penetration of the concept of carbon peak and carbon neutrality in basic education curriculum. Basic Education Curriculum, 2023, (01): 8-13.
[12] Zhao Kun, Feng Congcong. Green power galloping on the banks of Jinsha River. China Electric Power News, 2023-11-16 (001).