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Research On The Construction Of Ideological And Political Course Clusters For Engineering Majors With Comprehensive Practical Teaching

Zhao Li, Minglu Qu
(School Of Environment And Architecture, University Of Shanghai For Science And Technology, Shanghai, China, 200093)

Abstract:
The construction of ideological and political education (IPE) in curriculum has been explored since 2014 in China and has achieved significant results to date. The development direction of IPE in curriculum has evolved from the initial exploration and integration of ideological and political (IP) elements to the construction of a teaching system for IPE in courses. This study takes the course of Refrigeration Technology for Air Conditioning in the Building Environment and Energy Engineering (BEEE) major as an example, proposing a comprehensive practical teaching system for IPE in engineering courses. This system is centered on the dual-carbon goals as the core IP element, integrates different practical teaching modules, employs a blended virtual and reality teaching method, and adopts a personalized process based assessment method. The methods proposed in this study can be promoted in various courses in the major, thereby advancing the construction of IP course clusters and the IPE in specialized courses.
Key Words: *Comprehensive practical teaching; Ideological and political education (IPE); Course cluster; Blended virtual and reality; Process based assessment*

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I. Introduction

Curriculum-based ideological and political education (IPE) refers to a comprehensive educational concept aimed at constructing a pattern of educating individuals in an all-encompassing manner—covering all students, throughout the entire process, and across all courses. This approach aligns various courses with IP theory courses, creating a synergistic effect and establishing *fostering virtue through education* as the fundamental task of education. It is designed to thoroughly implement the integration of IPE throughout the education system, comprehensively advance the construction of curriculum-based IPE in universities, leverage the educational role of each course, and enhance the quality of students training in higher education. In 2014, Shanghai pioneered the practical exploration of curriculum-based IP construction. In December 2016, the National Conference on IP Work in Higher Education was held in Beijing, emphasizing that all other courses should also contribute their part and take responsibility, ensuring that various courses align and progress together with IP theory courses to form a synergistic effect. [1]

Since its inception, the IPE in curricula has undergone multiple developmental stages, including the initial germination phase from 2016 to April 2018. Although the concept of curriculum-based IPE was first piloted in Shanghai's universities, it was the speech at the National Conference on IP Work in Higher Education in December 2016 that truly set forth the requirements for IPE in universities to adapt to changing circumstances, advance with the times, and innovate according to trends. During this germination phase, research on curriculum-based IPE was limited, but it opened a new window for IP work in universities, providing positive value guidance and educational demonstration for exploring teaching reform practices nationwide. From May 2018 to April 2020, the preliminary development stage took place. On May 2, 2018, during a symposium with teachers and students in Beijing, it was emphasized that cultivating builders and successors for the socialist cause is the nation's educational policy and the common mission of schools at all levels and types in China. During this stage, professional teachers not originally engaged in IP work gradually joined the research on curriculum-based IPE, building on the foundation of teaching reform practices in specialized courses. After May 2020, the flourishing development stage began. In May 2020, the Ministry of Education identified the comprehensive advancement of curriculum-based IP construction as a strategic measure to fulfill the fundamental task of fostering virtue through education and an important task to improve the quality of talent cultivation comprehensively. This provided constructive guidance for the all-around flourishing development of curriculum-based IPE[2].

The development of curriculum-based IPE has reached a stage where, from a policy perspective, dynamic adjustments will continue to be necessary. Although a large number of policies on curriculum-based IPE has already been introduced, covering many aspects, the development conditions and environments of different universities vary, as do the nature of courses within universities. Therefore, universities need to formulate policies that align with the development of curriculum-based IPE at their institutions, promoting the construction of curriculum-based IPE in combination with the characteristics of different disciplines and majors [3]. From a content perspective, excavating IP elements within specialized courses is the most basic requirement of curriculum-based IPE. With the further development of curriculum-based IPE, universities are required to revise talent training programs in a targeted manner and construct a scientific and reasonable teaching system for curriculum-based IPE. This requirement entails integrating curriculum-based IPE into the entire process of course construction, including the initial excavation of IP elements, course teaching, course assessment, and course evaluation. However, for civil engineering majors, including the BEEE major, the further development of curriculum-based IPE mostly still suffers from issues such as single courses, single objectives, and single methods. For example, in a civil engineering major at a certain university, although the IP aspects of practical teaching sessions were considered and IPE was incorporated into the assessment process, the focus remains primarily on the integration of IP elements [4,5]. Some studies have approached the construction of curriculum-based IPE from the perspective of OBE (Outcome-Based Education), discussing it in conjunction with the requirements of engineering certification from the standpoint of the specialized course system, achieving top-level design [6,7]. However, current research still lacks discussion on specific practices for the construction of curriculum-based IPE within specialized course systems.

Therefore, this study will take the *Refrigeration Technology for Air Conditioning* course as an example to explore the IP teaching system for engineering professional courses from the perspectives of teaching modules, teaching methods, and assessment approaches. It aims to provide a reference for the construction of IPE throughout the entire course, covering comprehensive practical teaching methods.

II. The Concept Of Comprehensive Practical Teaching In IPE

The *Work Plan for Strengthening the Construction of a Higher Education Students Training System for Carbon Peak and Carbon Neutrality* issued by the Ministry of Education emphasizes the integration of green and low-carbon concepts into the education and teaching system. It calls for extensive green and low-carbon education, popular science, and research activities to enhance public awareness of green and low-carbon practices. The plan also accelerates the large-scale development of ultra-low energy, near-zero energy, and low-carbon buildings, and encourages universities to implement specialized interdisciplinary talent training programs for carbon neutrality. These programs focus on key carbon reduction technologies such as the green development and low-carbon utilization of fossil fuels, pollution reduction, and carbon capture, utilization, and storage (CCUS). Additionally, the plan promotes the rapid development of talent in energy storage and hydrogen energy fields [8].

Given this context, the BEEE major naturally possesses a rich foundation for curriculum-based IPE under the current dual-carbon target policy, making it highly suitable for exploring professional IP construction. The *Refrigeration Technology for Air Conditioning* course is a specialized course within this major, building on foundational courses such as *Engineering Thermodynamics* and *Heat Transfer*, and paving the way for advanced courses like *Air Conditioning Engineering* and final project of graduation design. Guided by the dual-carbon targets and policies such as the *Green and High-Efficiency Cooling Action Plan*, the course of *Refrigeration Technology for Air Conditioning* plays a crucial role in engineering education. The dual-carbon target policy and energy-saving and emission-reduction requirements form the core of the curriculum's IPE.

This study focuses on the course of *Refrigeration Technology for Air Conditioning*, incorporating IPE into the teaching system through practical teaching modules such as *Cognition Practice* and *Production Practice*. It adopts a blended virtual and reality practical teaching method and a process based assessment approach. The concept of comprehensive practical teaching in IPE is illustrated in Figure 1.

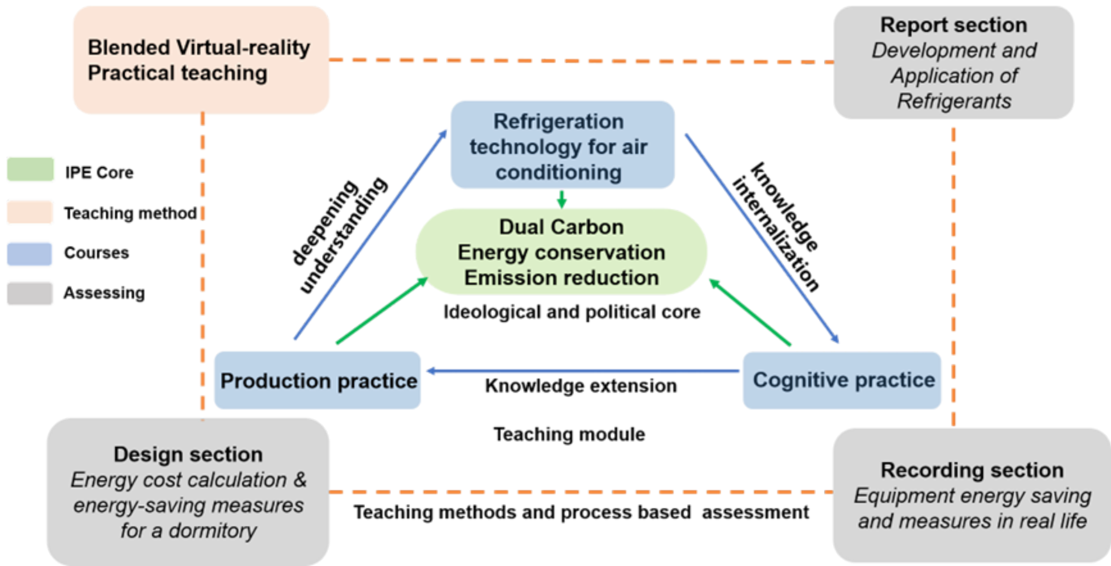

Figure 1 Comprehensive Practical Teaching in IPE for the course

III. Exploring IPE Cores And Elements

As a core course in the major of BEEE, *Refrigeration Technology for Air Conditioning* plays an important role in IPE. With the introduction of China's goals for carbon peaking and carbon neutrality, the emphasis on energy conservation and carbon reduction has been further strengthened. The goals of carbon peaking and carbon neutrality, as well as energy conservation and carbon reduction, naturally become the core elements of IPE in this major. All the courses in the training program of this major can be explored with this as the core of IPE.

This study takes the course of *Refrigeration Technology for Air Conditioning* as an example to illustrate specific construction methods and IPE approaches. The course explores the thermodynamic principles of refrigeration technology, enabling students to master the thermodynamic principles of the vapor-compression refrigeration cycle for air conditioning, understand the working principles of major refrigeration system components used in air conditioning, and perform relevant design calculations. It also clarifies the concepts of refrigeration systems, laying a solid foundation for students' future professional work and scientific research. Starting from three aspects—knowledge, ability, and value guidance, the course can integrate IP elements from three perspectives: policy guidance, environmental protection, and humanistic care [9].

In terms of policy guidance, the *Action Plan for Green and Efficient Refrigeration* jointly issued by the Chinese government in 2019 proposed energy efficiency improvement targets for 2022 and 2030, emphasizing tasks such as increasing the supply of green and efficient refrigeration products, promoting green and efficient refrigeration consumption, and advancing energy-saving renovations. On December 28, 2021, the State Council issued the *14th Five-Year Comprehensive Work Plan for Energy Conservation and Emission Reduction*, setting energy-saving and emission-reduction targets for 2025. On May 23, 2024, the State Council released the *2024-2025 Energy Conservation and Carbon Reduction Action Plan*, which outlined the overall requirements and key tasks for annual energy-saving and carbon-reduction efforts. Regarding environmental protection, the connection between the use of Freon refrigerants and ozone depletion is discussed to highlight the environmental responsibilities and considerations of refrigeration technology. Additionally, in 2023, the Ministry of Ecology and Environment issued the *2024 Hydrofluorocarbon (HFC) Quota Total Setting and Allocation Plan*, clarifying the total domestic production, import, and domestic use quotas for HFCs in 2024, as well as the quota allocation for enterprises. In terms of humanistic care, the development history of refrigeration technology in China can be used to inspire students' patriotic enthusiasm and guide them to establish a determination to devote for building an intelligent manufacturing country.

It is evident that the exploration of IP elements in various specialized courses of the BEEE major can be centered around the dual-carbon goals, with each course exploring its unique content within its own curriculum.

IV. Settings Of Teaching Modules

This study takes the course *Refrigeration Technology for Air Conditioning* as an example. In addition to the course itself, the teaching modules supporting this course include two separate practical training components: the *Cognition Practice* and *Production Practice*.

The *Cognition Practice* and the *Production Practice* are independent of each other and do not explicitly provide content-specific support for the *Refrigeration Technology for Air Conditioning course*. However, the teaching of these practical courses is centered around the primary equipment systems of the major, allowing students to engage with the practical aspects of their field. The Cognition Practice primarily focuses on equipment and systems, aiming to directly connect textbook knowledge with real engineering application. This process deepens students' understanding of the dual-carbon goals and energy-saving and carbon-reduction concepts. On the other hand, the *Production Practice* emphasizes interaction with the industry, enabling students to learn from a actual engineering perspective how leading enterprises are implementing the dual-carbon goals and energy-saving and carbon-reduction policies under the guidance of these targets. Therefore, during the *Cognition Practice*, students will visit and familiarize themselves with actual refrigeration rooms, refrigeration systems, and refrigeration equipment. In the *Production Practice*, students will be organized to learn at representative enterprises in the industry, such as Daikin and Climaveneta, which are prominent refrigeration equipment manufacturers.

Through the *Cognition Practice* component, the *Refrigeration Technology for Air Conditioning* course integrates theoretical knowledge with practical equipment systems, making it more accessible for students to internalize. Following this, the *Production Practice* further broadens students' knowledge and ultimately deepens their understanding of the fundamental principles of refrigeration technology. This process clarifies how these principles contribute to the achievement of dual-carbon goals within the actual industry development.

V. Teaching Method

Blended Virtual-Reality Practical Teaching

In the teaching of *Refrigeration Technology for Air Conditioning*, in addition to the traditional classroom instruction that combines offline and online methods, a blended virtual-reality practical teaching approach is also adopted. The best way to understand the role of refrigeration systems in the dual-carbon pathway is through the operation of actual systems. However, for the refrigeration systems of real buildings, there are numerous influencing factors, and the actual systems include many high-temperature, high-pressure, and high-speed rotating equipment, as well as a significant number of electrical devices with high voltage. Therefore, practical operations carry certain risks, and even if there are actual projects available for participation in operation and regulation, it is impossible to simulate annual climate changes within a short period of time [10]. Consequently, by utilizing the *Virtual Simulation Experiment Platform for Operation and Regulation of Central Air Conditioning Systems in Smart Buildings* and the modular scaled-down model experiment platform for central air conditioning, it is possible to achieve a blended virtual-reality practical training for the operation and regulation of refrigeration systems.

In this virtual simulation experiment platform, there is an experiment designed for adjusting the operating parameters of a refrigeration system. In this experiment, the evaporating temperature and condensing temperature of the refrigeration system are directly linked to actual influencing factors. For instance, the evaporating temperature is affected by the load, which is represented in the experiment by the number of indoor occupants to signify the indoor load. By altering the number of indoor occupants, students can observe the changes in evaporating temperature and the consequent variations in the operating parameters of the entire refrigeration system. Similarly, the condensing temperature is directly associated with outdoor meteorological conditions. By modifying the outdoor temperature and humidity parameters, students can simultaneously observe the corresponding changes in the operating parameters and energy efficiency of the refrigeration system within the virtual simulation experiment system. This enables students to independently deduce the impact of refrigeration system parameter changes on system energy efficiency and the theoretical directions for enhancing the energy efficiency of refrigeration systems.

The fundamental knowledge about the operating parameters and energy efficiency of refrigeration systems that students acquire on the virtual simulation experiment platform can be further validated on the modular scaled-down model experiment platform for central air conditioning. This scaled-down experiment platform is modularly configured, including a heat source refrigeration system module, a cooling tower module, a fluid distribution network module, and an terminal module. Among these, the heat source refrigeration system module employs a water-source heat pump system. Students can alter the condensing and evaporating temperatures by changing the heat output of the heater, and then, through the measurement of system operating parameters, they can calculate the system's energy efficiency on their own. This allows for a mutual corroboration with the patterns of energy efficiency changes in the refrigeration system obtained from the virtual simulation experiment platform.

This blended virtual-reality teaching method enables students to observe system parameters, grasp the components and principles of the system, and engage in hands-on adjustments. By actively setting different outdoor conditions and indoor loads, students achieve the goal of system regulation and operation, ultimately summarizing the inherent patterns and mastering the operational adjustment laws of refrigeration systems [11]. Through this blended virtual-reality practical teaching approach, students can effectively deepen their understanding of the significant impact of refrigeration technology on the dual-carbon pathway. From a practical perspective, this method allows students to actively implement the policies of the dual-carbon goals.

Process based assessing

In the IP construction of the *Refrigeration Technology for Air Conditioning* course, the design of assessment methods fully takes into account IPE. In the course teaching, based on the refinement of course objectives and graduation requirements, the basic components of the course are determined. The course assessment components are also arranged around the teaching components, covering the course objectives and supporting the corresponding graduation requirements [12]. In the teaching modules of this study, for the refrigeration technology for air conditioning module and the introductory/Production Practice modules, practical IP elements are also incorporated into the design of the process-oriented assessment methods.

According to the course nature and syllabus of *Refrigeration Technology for Air Conditioning*, the course assessment methods, in addition to the final examination, include at least three components for regular grades, among which are the traditional class performance and routine assignments. Moreover, two unique assessment components are established to integrate IP elements into the evaluation process: the report component and the design component. In the report component, students are required to write reports on the following given topics: **1.** The development and application of air-source heat pumps in the process of *replacing coal with electricity*; **2.** The application and phase-out of refrigerants and the development of new refrigerants. Students are expected to search for information on their own based on the given topics and complete the reports. During the information search process, students can fully understand the policy-leading aspects of replacing coal with electricity, the dual-carbon goals, and the refrigerant phase-out policies, thereby integrating IPE into their self-learning process. This also cultivates students' lifelong learning abilities, aligning with the graduation requirements set by engineering accreditation. In the design component, students are given a specific task: to estimate the electricity cost of their dormitory’s air conditioner over the past year and propose methods to save on electricity costs. The task is subjective and somewhat comprehensive, thus it can fully tap into the students' potential for self-directed learning.

In the assessment of the *Cognition / production Practice* courses, in addition to the final report, a personalized process based assessment component has been added: students are required to document no fewer than three types of professional equipment and systems they encounter in their daily lives through photos, videos, and other forms of media. They must also research and explain how these equipment and systems can play a role in the dual-carbon pathway. The inclusion of this assessment component is designed to foster students' professional awareness and sensitivity as engineers, encouraging them to pay attention to the specific manifestations of the dual-carbon goals in daily life.

Through the implementation of blended virtual-reality practical teaching and personalized process based assessments, students are encouraged to analyze cases from their own surroundings. This approach allows them to start from their personal experiences, understand the connection between individuals and the dual-carbon goals, and, through tangible representations such as energy costs, genuinely begin to practice energy-saving and carbon-reduction measures.

VI. Methodology Application

In summary, for engineering-related courses, IPE can be comprehensively covered through all-encompassing practical teaching. Within this methodological framework, the first step is to explore IP elements centered around the dual-carbon goals for the core course, *Refrigeration Technology for Air Conditioning*. Subsequently, the practical teaching modules and components related to this course within the training program are incorporated into the IPE segments. Therefore, the *Cognition and Production Practice* courses can also be included in the IP teaching segments of this course. Finally, by utilizing blended virtual-reality practical teaching methods, supplemented by personalized process based assessment components, a closed-loop of IPE in the course is achieved. This methodological system is applicable to various engineering disciplines and courses.

For the BEEE major, aside from refrigeration technology, there are also fundamental and specialized courses such as *Engineering Thermodynamics*, *Fluid Mechanics*, *Heat Transfer*, and *Air Conditioning Engineering*. By leveraging the inter-supportive relationships among various modules and courses within the professional training program, the *Refrigeration Technology for Air Conditioning* course depicted in Figure 1 can be substituted with other fundamental and specialized courses. Starting from the course objectives, characteristics, and assessment methods, teaching methods and personalized process based assessment approaches that align with the course can be designed, thereby establishing an IP teaching system for the course.

VII. Conclusion

This study takes the *Refrigeration Technology for Air Conditioning* course as an example and proposes a methodological system for IPE in engineering courses that integrates comprehensive practical teaching. According to the nature and characteristics of the course, and in conjunction with practical teaching modules such as the *Cognition and Production practice*, the study focuses on the dual-carbon goals as the core IP element. It employs a blended virtual-reality practical teaching approach and incorporates personalized process based assessment methods that are closely integrated with IP elements, thereby completing the closed-loop of IPE for the *Refrigeration Technology for Air Conditioning* course. By extending this method to other specialized courses, it is possible to gradually form a cluster of IP courses for engineering disciplines, ultimately achieving IPE across the major.

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