Reform of the Teaching of the Ventilation and Air Conditioning Engineering (VACE) Course: Content Updating and Exploration of Teaching Methods

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Abstract: This paper provides an in-depth discussion on the research and practice of the educational model of science-practice integration in the course of Ventilation and Air Conditioning Engineering. This educational model integrates multi-channel teaching content and methods such as interactive practical teaching platform construction, dynamic optimization of course content, project-based learning, etc., aiming to enhance students' practical operation, analytical ability and learning motivation. Through the practice platform, students combine theory and operation in practical training equipment to deepen their understanding of system operation; content optimization adds energy-saving control and case study to enhance students' mastery of efficient operation and management; project-based learning guides students to identify problems and design energy-saving solutions, simulate actual engineering processes, and master energy-saving assessment and intelligent control technology.

***Keywords*:** ventilation and air conditioning;building equipment engineering; practical teaching platform; project-based; energy-saving control

1. Introduction

With the advancement of “peak carbon” and “carbon neutral” goals, the problem of building energy consumption needs to be solved by more advanced energy-saving technologies, which puts forward higher energy-saving requirements for the construction industry [1]. For higher vocational education, unlike undergraduate education that favors technology development, higher vocational students are more focused on practical operation and maintenance skills. Despite significant progress in the control and management of ventilation and air conditioning (VAC) systems in new buildings, the operation of VAC is still largely neglected in many retrofit projects [2]. This phenomenon highlights the challenges and opportunities of the traditional ventilation and air conditioning industry in the process of modernization and transformation. Therefore, how to effectively cultivate students' practical operation ability and operation and maintenance management skills in the field of ventilation and air conditioning engineering in higher vocational education has become the focus of current teaching reform [3].

Ventilation and Air Conditioning Engineering is not only a core course for construction equipment engineering majors in higher vocational colleges and universities, but also a key way to help higher vocational students master the operation and control of air conditioning systems, and the quality of its teaching has a direct impact on the vocational ability of the students and their employment prospects [4]. The traditional mode of separation of theoretical and practical teaching has been difficult to adapt to the needs of the rapid development of modern air conditioning engineering technology, how to combine theoretical teaching and practical operation, to help students master the basic theories and at the same time have the ability to solve real-world problems, which has become the core task of the reform of higher vocational education [5]. Therefore, this study proposes to carry out teaching reform from the following three aspects: first, effectively combining theory and practice through the construction of an interactive practical teaching platform, so that students can understand the application of theory in real situations; second, dynamically optimizing the curriculum system and content, increasing the cutting-edge content such as energy-saving control, in order to closely match the development needs of the industry; and third, widely applying project-based learning, designing specific project tasks, and comprehensively improving the students' comprehensive practical ability [6].

Through the above multifaceted reform initiatives, this study is committed to constructing a more effective and targeted teaching system, so that students can comprehensively improve their professional competitiveness in the process of strengthening practical ability and logical thinking. At the same time, these teaching innovations not only help students better integrate into the industry demand, but also make the course more in line with the national energy saving and emission

reduction policy guidelines, laying a solid foundation for the future development of students in the field of energy saving renovation and operation and maintenance management.

2. Construction of an interactive practical teaching platform

2.1 Background and Necessity

The traditional teaching of ventilation and air-conditioning engineering usually adopts the separation of theoretical lectures and classroom practical training, which is difficult to stimulate students' enthusiasm for learning, especially for the higher vocational students with weak foundation, who may find it more difficult to understand the operation process and control principles of the air-conditioning system. In addition, single classroom learning is often ineffective in actual teaching. In order to solve these problems, it is especially important to build an interactive practical teaching platform, through which students can directly apply the theories they have learned to actual equipment operation and problem solving in a real system environment.

2.2 Design of the interactive practical teaching platform

The design of the platform is based on students' needs and teaching objectives, and closely combines theoretical knowledge and practical operation. The platform is based on the air-handling units in the training room and the centralized air-conditioning system in the library, equipped with corresponding sensors and data monitoring systems to realize real-time data feedback and operation guidance. The following is the main module design of the platform:

(1) System Status Monitoring Module: This module provides real-time monitoring of the temperature, humidity, airflow and energy consumption of the air-handling units through sensors. Students can observe the changes in the response of the air-conditioning system under different operating conditions through the data monitoring platform, thus deepening their understanding of the system operation process.

(2) Operation Simulation Module: In this module, students can operate the simulator to adjust the parameters of the air-handling unit, such as air speed, humidity control and temperature adjustment, etc., and observe and record the changes of key parameters under different working conditions after changing the control strategy.

(3) Fault Diagnosis and Troubleshooting Module: A series of simulated fault scenarios are formulated according to the teaching content to stimulate students to realize diagnosis through fault analysis, so as to master the identification and troubleshooting methods of common faults. This not only enhances students' problem solving ability, but also brings them closer to the actual operation and maintenance situation.

2.3 Instructional Process and Implementation Effectiveness

By building this interactive practical teaching platform with the help of the air-conditioning system in the school library, it not only achieves easier understanding of the relevant theoretical knowledge by students, but also optimizes the teaching process of teachers. In the whole course arrangement, teachers can first let students have a basic concept through a short theoretical course, and then move the teaching site to the practical teaching platform for students to carry out simple simulation operation and then carry out further theory, and continuously iterative. Through the application of the interactive platform, the higher vocational students can complete the systematic learning experience in the process of operation and observation, which not only enhances their enthusiasm for learning, but also allows them to gain solid practical experience through the scenarios of troubleshooting, parameter adjustment and energy-saving operation. After a complete cycle of platform application, it is obviously found that students' participation is significantly increased, and at the same time, the practical skills of operation and maintenance are also well developed.

3. Dynamic optimization of the curriculum system and content

3.1 Background of curriculum optimization

With the continuous development of the building energy efficiency industry, although there have been many projects that have conducted a lot of research on the energy-saving operation of ventilation and air-conditioning systems, there are still many buildings that have problems of sloppy management in the operation of the system. Therefore, energy-saving control of ventilation and air-conditioning systems should be the focus of current programs. However, many ventilation and air conditioning courses still focus on basic theories and fail to comprehensively cover the cutting-edge technologies and applications of energy-saving control. In order to adapt to the modern industry demand, the senior “Ventilation and Air Conditioning Engineering” course urgently needs to optimize the system, incorporate the energy-saving control into the core teaching content, and help students master the knowledge and skills that are more in line with the market demand by

dynamically updating the curriculum.

3.2 Directions for updating course content

In response to the characteristics of the building equipment engineering program, this course is optimized to focus on the following areas to enhance students' understanding of the operation and control of modern air conditioning systems:

(1) The introduction of energy-saving control technology: the introduction of energy-saving control technology into the course content is one of the keys to the optimization of current teaching. Specific content includes heat and humidity sub-control technology, heat pump technology, the application of frequency conversion technology, as well as the operation and regulation of cooling water and chilled water system. Based on the basic principle of improving the energy efficiency of chiller units by raising the evaporating temperature and lowering the condensing temperature, various types of energy-saving control technologies are analyzed to help students comprehensively understand the principle of energy saving from the local to the overall, and master the efficient operation of modern air conditioning systems.

(2) Practical case study: On the basis of theoretical teaching, the course sets up several case studies close to actual engineering, aiming at cultivating students' ability to solve practical problems. For example, in the operation optimization of air conditioning system, the course provides key parameters of the water system, wind system parameters, and chiller on state and other parameters, students through the diagnosis of the proposed control scheme, and system calculations to assess the energy-saving effect of the control measures. In addition, the course also simulates the operation and maintenance scenarios of air conditioning systems, allowing students to play the role of operation and maintenance personnel, and the teacher sets up scenarios such as system design defects, water temperature settings, and the number of chillers to guide the students to solve key problems in daily operation and maintenance, so as to cultivate the formation of empirical and perceptualized operation models, and to grasp the core points of improving the overall energy efficiency of the air conditioning system.

(3) Monitoring and analysis of energy-saving operation data: the new module covers real-time monitoring and analysis skills of energy consumption data, enabling students to observe changes in energy consumption and assess the energy-saving effect of the system through sensor devices and data analysis software. This not only helps to improve students' data analysis skills, but also develops their awareness of energy-saving improvements in real projects.

3.3 Instructional Content Design and Effectiveness Assessment

The updating of the course content focuses on a phased approach to ensure that students master the basics while progressively delving into the application of energy-saving controls. First, at the basic stage, the course explains the basic principles of air-conditioning systems and the functions of each component to help students gain a comprehensive understanding of air-conditioning systems. Then, in the advanced stage, energy-saving control technology is introduced, with specific information on equipment and regulation methods, so that students can master how to realize energy saving. Finally, through the practical stage, using the air-handling unit in the training room and the centralized air-conditioning system in the library, students practice energy-saving control operations and data analysis, applying what they have learned to the real system and improving their practical skills. In order to evaluate the teaching effect, the effectiveness of the course system was assessed through student questionnaires after the implementation of the 16-lesson course. The results showed that students' learning motivation was significantly improved. Although there is still room for improvement in the understanding and mastery of energy-saving control, all the students agreed that this reform can better stimulate their learning commitment compared with the traditional teaching mode.

4. Widespread use of project-based learning

4.1 Concept and significance of project-based learning

Project-based learning has always been a teaching mode respected by higher vocational education, but it has not yet achieved the expected results in actual implementation. For students majoring in construction equipment engineering, the ventilation and air conditioning system requires both complex and demanding theoretical knowledge, and at the same time cannot be separated from the support of actual cases. Therefore, the course “Ventilation and Air Conditioning Engineering” must strengthen project-based learning, through the actual project design, to help students closely integrate theoretical knowledge with practical problems, enhance practical ability, and lay a solid foundation for their future career.

4.2 Integrated project case studies

In the project design of this course, the instructor sets up a comprehensive air-conditioning system project, combining several typical problems in real projects, and guiding the students to gradually analyze the system and identify potential energy-saving improvement points through actual cases. Students are required to actively observe and analyze the various

aspects of the air conditioning system in the project, and propose possible problems in energy saving control and operation management, while the instructor gradually explains the principles behind the system and provides technical guidance according to the problems identified by the students. The task setup of the project includes the following major components:

(1) Analysis of the current state of the system: Students begin by observing and data logging the operational status of the chiller and chilled/cooled water pumping system to identify possible energy efficiency issues with the system, such as poor chiller operating efficiency or insufficient cooling tower heat dissipation.

(2) Problem identification and questioning: In the analysis process, students need to raise questions about problems in the operation of the system through practical observation and data analysis. For example, students found that the pumps of the cold source system operate inefficiently, the heat and humidity control in the air treatment process is unreasonable, or there are energy losses in the system piping and other phenomena.

(3) Problem Analysis and Improvement Guidance: Based on the problems raised by the students, the teacher will explain in detail the potential causes of the problems and guide the students to propose optimization solutions, such as increasing the frequency control of the pumps, modifying the cooling tower cooling method, or establishing a real-time energy consumption monitoring system. Teachers will explain how each program can improve system performance while reducing energy consumption, thus allowing students to have a deeper understanding of the energy-saving control of air-conditioning systems.

Through this comprehensive program, students are able to gradually build up the concept of energy-saving control of air-conditioning systems in the process of systematic observation and problem formulation. Under the explanation and guidance of the teacher, they not only learn how to identify problems, but also master the practical application of different energy-saving technologies in the process of analyzing and solving problems.

4.3 Teaching and Learning Implementation and Assessment

The teacher takes the role of a facilitator to encourage students to take the initiative in identifying problems, and to analyze and discuss improvement solutions step by step in response to the problems raised by the students. By taking a comprehensive project, students are guided to write a project report and reflect on the process of analyzing and solving the problems in the project. During the execution of the project, the students have significantly improved their ability to grasp the key issues, and their problem-solving ability has been enhanced, but it is still insufficient. Overall, the course still needs to further strengthen the combination of theoretical knowledge and practical projects to better enhance students' comprehensive ability.

5. Conclusion

Through exploring the teaching reform of the higher vocational “Ventilation and Air Conditioning Engineering” course, this study explores the reform measures of interactive practical teaching platform, dynamic optimization of the curriculum system and content, and extensive application of project-based learning for construction equipment engineering students. These reform measures aim to effectively improve students' practical ability, help them closely integrate theoretical knowledge with practical problems, and thus enhance their professionalism and ability to solve practical problems. Through the implementation of the curriculum and student feedback, the reforms have significantly stimulated students' learning motivation, especially in the areas of energy-saving control and practical skills. However, further optimization of the course still needs to strengthen the integration of theory and practice to better adapt to the development of the industry and student needs. Through these pedagogical innovations, students are not only able to better integrate into the industry development needs, but also lay a solid foundation for future career development in the field of energy saving, emission reduction and air-conditioning system operation and maintenance management.

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