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Reform of the Comprehensive Practical Course System for Mechanical and Electronic Engineering Majors Under the Background of New Engineering

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Abstract: Under the background of new engineering, the reform of the comprehensive practical course system for mechanical and electronic engineering majors actively responds to the challenges posed by the new round of technological revolution and industrial transformation to higher education, cultivating top-notch innovative intellectuals with comprehensive engineering qualities, meeting the requirements of being able to solve complex engineering problems rather than just cognitive capabilities, forming two core courses through reconstructing and reshaping the core courses of the major. The core courses include Drive, Measurement, and Control I and Drive, Measurement, and Control II, which highlight the comprehensive framework of mechanical and electronic engineering professional knowledge, continuing the comprehensive practical course system based on the unity of knowledge and practice, following the trend of new engineering, highlighting the practicality of professional innovation, assisting engineering education reform, and promoting high-quality development of new engineering professionals cultivation.

Keywords: Comprehensive engineering quality; Mechanical and Electronic Engineering; Practical course system; New engineering

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1. Introduction

Rapid globalization, the profound impact of artificial intelligence and information technology, as well as the strong demand for social development under international competition, have all become the driving forces for educational reform and learning innovation in countries around the world. Although traditional education nominally imparts knowledge, the process of imparting knowledge that is truly meaningful to learners accounts for a small proportion, and the vast majority of time is simply spent transmitting data or information. In order to actively respond to the challenges posed by the new round of technological revolution and industrial transformation to higher education, the New Engineering Program was officially launched by the Ministry of Education in 2017, cultivating top-notch innovative talents with comprehensive engineering qualities, achieving the goal of being able to solve complex engineering problems rather than just cognitive abilities [1], requiring students to have solid professional knowledge and strong practical and innovative capabilities [2,3]. Practicality is the nature and core of engineering, thus practical teaching is an important link in higher engineering education which is an important way to improve the practical capability of students and the quality of professional cultivation [4,5]. It is obvious that the characteristics of mechanical and electronic engineering major are comprehensiveness and practicality. The major core courses have been restructured and reshaped, continuing with the comprehensive practical course system reform based on the unity of knowledge and practice, relying on the opportunity of the new engineering reform, promoting high-quality development of professional cultivation, achieving the goal of cultivating innovative professional with the ability to solve complex engineering problems.

2. Reform of the comprehensive practical course system for new engineering in mechanical and electronic engineering majors

Based on the comprehensive, practicality, and interdisciplinary integration characteristics of the mechanical and electronic engineering major, we will reconstruct and reshape the core courses of the major, establishing two core courses: Drive, Measurement, and Control I with information flow as the main line and Drive, Measurement, and Control II with energy flow as the main line, highlighting the comprehensive knowledge framework of the mechanical and electronic engineering major, breaking through the traditional superficial learning mode of only transmitting data and information in the process of imparting knowledge, reasonably guiding students to transform information into knowledge, and immersing a deep learning mode. The core courses after reconstructing and reshaping have a high degree of correlation among the knowledge points of cross integration and clear lines of professional knowledge, continuing the reform of the comprehensive practical course system based on the unity of knowledge and practice, highlighting the practical extension of mechanical and electronic engineering majors, closely linking the theoretical teaching to the practical system as a whole, building a solid foundation for comprehensive practical course system, providing strong support for core courses, and helping students to establish a systematic view and "Engineering with a Big E."

The essence of practical teaching is a teaching activity in which students deeply understand and apply the professional core course knowledge learned through working practice, and then learn to create new knowledge [6]. The mechanical and electronic engineering major originates from engineering, reorganizing knowledge structure, integrating resources, improving problem-solving methods, and cultivating students' ability to solve complex engineering problems in the process of creation practice. With the arrival of a new round of technological revolution and the flourished development of new form industries, new requirements have been posed for the cultivation of mechanical engineering talents. Higher education workers have researched extensively in the mechanical and electronic engineering practical teaching reform and constructed a multi-module, deep-level teaching mode and practical education training system. Based on ability-oriented thinking, the comprehensive practical course system uses typical mechatronics systems as teaching carriers, promoting individual development of students, inspiring students to deep learning and knowledge internalization in the theoretical learning stage, practicing in the independent design stage to transform knowledge into abilities, promoting practice skills through knowledge and seeking knowledge through practice [7]. The main courses of the comprehensive practical course system include Innovative Design of Intelligent Robots, Innovative Production of Marine Vehicles, and Innovative Training of Programmed Vehicles.

3. Main courses of the comprehensive practical course system

3.1. Innovative Design of Intelligent Robots

Through innovative design training for robots which are typical mechatronics systems, students can understand the innovative design methods of robots, the technical specifications, costs, safety, legal, and cultural impacts in product development; cultivate basic engineering qualities, awareness of applying basic principles to solve engineering problems, comprehensive debugging ability, engineering ability and innovation ability; experience the innovative research and development process of robots guiding by top-level design and system analysis; master the integrated application of robot mechanical structure and control circuit; and strengthen labor awareness and their national feelings [8].

Through theoretical learning and practical production of the course, students can understand the history and future development direction of robotics technology, the basic principles of robot structure and control, the basic composition and application of modular robot platform structural components, and the composition and application of robot control systems, as well as master the construction of typical robot structures and the development of control systems [9]. The theoretical teaching content includes basic knowledge of innovative design and basic concepts of robot design for intelligent robots, principles and processes of robot design, overview of modular robot platform; introduction and use of mechanical components on modular robot platforms, introduction to the hardware of the robot platform control system and classic programming frameworks for robot platforms. The demonstration teaching content includes the demonstration of simple structure and control circuit, mechanical structure composition and assembly of dual wheel flatbed trucks, and LED flow light control. The practical teaching content includes vehicle-mounted robotic arm with three degrees of freedom, double-wheel universal chassis assembly, assembly of a robotic arm with three degrees of freedom, vehicle-mounted three-degree-of-freedom robotic arm control, and scene design and overall demonstration.

3.2. Innovative Production of Marine Vehicles

By relying on professional characteristics and taking marine vehicle competitions as the starting point, students can have the basic ability and awareness to apply theoretical knowledge and technology to solve practical problems, understand the principles, structures, and design methods of automatic control of ships, design and produce aircraft parts by using modern 3D printing technology, improve capability of designing and using advanced equipment, and cultivate basic ideas and skills in analyzing problems through the process training of assembly and debugging. These lay a solid foundation for solving complex engineering problems in the future, allowing students to understand the significance of teamwork with the group training mode, experience the communication methods of cooperative members that reflect the benefits and strength of cooperation based on individual division of labor, cultivate basic ability to express technical ideas, thought, and basic thinking in product structure design and control circuit design by writing a course scheme design report, learn to flexibly apply knowledge, and enhance the ability to learn and explore independently through this course guidance.

Students establish safety awareness and understand the competition of marine vehicle design and production through learning the course [10,11]. The theoretical content includes fundamentals of ship hydrodynamics; ship statics and ship seakeeping; fundamentals of ship speed; principles, types, and forms of propeller; the geometric characteristics and the hydrodynamic principle of propeller; ship resistance; ship maneuverability; control system of aircraft: basic structure of ship electric propulsion system; introduction to driving and control principles and typical applications; typical applications of sensors (mainly for marine vehicle competitions); typical motor and load classification and application; circuit design specifications; introduction to programming languages. The practical content includes the design and production of aircraft; training on software programming for aircraft control; hardware circuit design and debugging; processing and manufacturing of aircraft parts and rapid prototyping printing; aircraft assembly, debugging exercises, and testing.

3.3. Innovative Training of Programmed Vehicle

The wheeled programmable control vehicle is a typical mechatronics system. To help students understand the design methods of mechatronic products, it is necessary to have a basic awareness of applying basic principles of mathematics, natural sciences, mechanical and electronic technology to solve complex engineering problems, understand the impacts of social, technical specifications, costs, health, safety, legal, and cultural in product development and the social responsibilities that engineers should undertake by experiencing the development process of electromechanical products, and cultivate the basic engineering qualities. Through the comprehensive debugging process of electromechanical products, students can cultivate the basic ideas and skills to apply knowledge and equipment for analysis, testing, and solving electromechanical technical problems and lay the foundation for solving complex engineering problems. By using the mode of group training, students can understand the significance of teamwork, communicate effectively with members, and play a role according to the division of work, which reflects workability and cultivates a sense of teamwork among students. By writing course reports, students cultivate the basic capability to express technical ideas, problem-solving, and the basic thinking of engineering management principles and economic decision-making methods. After this course, students are equipped with a correct understanding of the necessity of self-exploration and learning, as well as proactive learning, continuously improving their ideological awareness [12].

The teaching content includes fundamentals of mechanical structure design; requirements of course carrier product design; steps of mechanical structure design; mechanical structure design drawing; material selection process; process design and cost analysis; product disassembly; mechanical structure assembly process; usage methods of commonly used inspection tool; standard parts collection and inspection; mechanical structure assembly of course carrier products; single chip microcomputer engineering application; constitution and component function of minimal system board for single-chip microcontrollers; basic electrical drive concepts and drive circuit of DC motor and servo motor. Based on the parameters of the carrier product, students conduct standardized circuit design analysis; based on the analysis results of design objectives, students select the standard electronic components after engineering calculation, circuit debugging and fault analysis methods, circuit production methods, drive control of motor and servo, analysis and debugging methods of motion control for teaching carrier, software compilation and download methods [13]. Practical comprehensive debugging includes comprehensive debugging methods, fault detection analysis methods, testing and hand-in the teaching carriers.

Adding scene design and innovative design, involving process assessment content with concise illustrations, and building a systematic framework for deep learning are imperative. Through system structure diagrams, circuit hardware schematic diagrams, program software flowcharts, and mechanical structure assembly flowcharts, they fully reflect the students' application of learned professional knowledge, covering the comprehensive application of key knowledge points in professional core courses and closely connecting to the engineering practice of mechanical and electronic majors, cultivating the capability to apply what the students have learned, and enhancing their self-learning ability guided by the ability to solve complex engineering problems.

4. Conclusion

The instructors of mechanical and electronic major aim to comprehensively improve the quality of undergraduate talent cultivation, implement the fundamental task of cultivating morality and talents, accurately grasp the demands of the country and society, and persevere in the concept that theoretical knowledge originates from practical engineering problems. Based on the application of cross-integration professional knowledge, we need to cultivate engineering professionals who can solve complex engineering problems in the field of mechanical and electronics and have comprehensive engineering qualities. We have reconstructed and reshaped the major core courses, forming two core courses: Drive, Measurement, and Control I and Drive, Measurement, and Control II, following up with the comprehensive practical course system including Innovative Design of Intelligent Robots, Innovative Production of Marine Vehicles and Innovative Training of Programmed Vehicles as the main focus. With the practical innovation design of three typical mechatronics systems as the direction, promoting the establishment of a deep learning framework for individual students, integrating theory with practice under the unity of knowledge and practice concept throughout the learning process, and cultivating lifelong learning abilities can be achieved. Relying on the opportunity of the new engineering reform, the goal of cultivating innovative professionals with the ability to solve complex engineering problems is achieved.

Disclosure statement

The authors declare no conflict of interest.

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