Journal of Contemporary Educational Research, 2023, Volume 7, Issue 12
http://ojs.bbwpublisher.com/index.php/JCER
ISSN Online: 2208-8474
ISSN Print: 2208-8466

Reform and Reconstitution of Core Courses in Mechanical and Electronic Engineering Under the Background of New Engineering

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Abstract: With the arrival of the intelligence era of Industry 4.0, social development has shown complex and diversified characteristics, gradually forming an innovation ecological environment constructed by vertical interaction of multi-layer innovation systems and horizontal collaboration of multiple organizations and departments, which has posed extremely challenging requirements for higher engineering education to cultivate engineering talents with comprehensive engineering qualities who can solve complex engineering problems. However, practical engineering problems may involve a complex knowledge chain of interdisciplinary and multi-disciplinary cross-coupling. Therefore, higher engineering education needs to form a new interdisciplinary and multi-disciplinary integrated engineering innovation talent training system. Based on the characteristics of the mechanical and electronic engineering major, we will reshape and reconstruct the core courses of the mechanical and electronic engineering major. Two core courses are formed: Drive and Measurement and Control I and Drive and Measurement and Control II, with information flow and energy flow as the main lines, following up with the comprehensive practical curriculum system based on the unity of knowledge and practice and ability-oriented thinking, supporting teaching objectives, promoting students' individual development, and providing guidelines for relevant curriculum reforms.

Keywords: New engineering; Mechanical and electronic engineering; Cross-coupling; Major integration

Online publication: December 25, 2023

1. Introduction

Provided with sufficient theoretical support for educational reform and learning innovation in the knowledge era, learning is examined from a multidimensional perspective to construct a new multi-level learning system framework and theoretical system. With the advancement of technology and the rapid changes of the times, the lifecycle of knowledge is shorter than ever and competitiveness has become an important asset [1]. With the arrival of the intelligence era of Industry 4.0, social development has shown complex and diversified characteristics, gradually forming an innovation ecological environment constructed by vertical interaction of multi-layer innovation systems and horizontal collaboration of multiple organizations and departments [2].

New engineering professional training pays more attention to students' comprehensive engineering qualities than traditional education, including engineering practical skills, interdisciplinary ability, innovation ability, humanistic literacy, and social responsibility [3-5]. In order to meet the demands for comprehensive engineering professionals in the future society, higher education institutions must carry out a reform on the professional training system of engineering innovation that integrates multiple disciplines and majors.

The Mechanical and Electronic Engineering major cultivates advanced composite professionals in the field of mechanical and electronic engineering who master the basic theories and professional knowledge of multidimensional structures such as machinery, electronics, control, and computer applications, and possess the ability to research, design, develop, and manage electromechanical and hydraulic integrated components and systems with characteristics of electro-hydraulic control. Taking advantage of the new engineering reform, in response to the characteristics of interdisciplinary integration in the field of mechanical and electronic engineering, the knowledge logic of interdisciplinary integration is reorganized to achieve the goal of cultivating innovative professionals.

2. Major characteristics of mechanical and electronic engineering

The mechanical and electronic engineering major has developed from engineering practice and application, which has become an important component of the mechanical engineering discipline. It is a rapidly developing profession in recent years.

The mechanical and electronic engineering major focuses on key issues such as energy and information conversion, system and process regulation in traditional mechanical equipment and systems, as well as manufacturing processes. Based on this, it integrates technologies such as microelectronics, control, information, and intelligence to construct a scientific system composed of common basic theories and principles of core technology with the main characteristics of comprehensiveness and practicality [6-8].

2.1. Comprehensiveness

The knowledge structure of mechanical and electronic engineering is massive and involves a wide range of core technologies, including mechanical technology, electronic technology, information processing technology, automatic control technology, detection and sensing technology, etc., which puts higher demands on the technical professionals trained in mechanical and electronic engineering. In order to achieve the teaching goal of cultivating students' ability to comprehensively apply multiple technologies and integrate cross-disciplinary knowledge in mechanical and electronic engineering to solve complex problems in practical engineering systems, it is crucial to establish the logical relationship between course settings and knowledge, then to continuously guide and increasingly improve the previous and subsequent courses.

2.2. Practicality

Mechanical and electronic engineering professionals not only need to master a certain technical ability, but also need to have various knowledge and skills to guide engineering practice, solve practical problems, and integrate their knowledge and skills into practice. Nowadays, the basic scientific theories of mechanical and electronic engineering are being gradually improved, which is not only the internal driving force for the continuous development of the profession itself but also a strong traction force from "practice" and back to "practice." In order to enhance students' practical skills and comprehensive engineering quality, the new engineering curriculum reform has been promoted by combining theory and practice driven by the concept of unity of knowledge and practice in the field of mechanical and electronic engineering [9].

3. Reconstructing and reshaping the core curriculum of mechanical and electronic engineering

The 2019 version of the training program focuses on mechanical systems based on the characteristics of the mechanical and electronic engineering major, with electronics, control, and computers infiltrating them in different modes and methods, forming an electromechanical integration course system composed of elements such as electric machinery, control, drive, signal processing, computer interface, and simulation modeling, etc. However, multiple courses have formed relatively independent knowledge, with low correlation among knowledge of each independent course, scattered knowledge fragments, inadequate support for subsequent practical courses, weak practical course system, and insufficient overall connection between theoretical teaching and practical system, making it difficult for students to establish a systematic and "Big Engineering" perspective.

To help students establish a systematic design concept in mechanical and electronic engineering, it is necessary to cultivate their practical skills, engineering literacy, and problem-solving capability. This includes the capability to innovate product development and creation design. Students are expected to gain familiarity with the impact of social technical specifications, costs, health, safety, law, and culture in the process of product development. Additionally, the curriculum aims to instill a sense of social responsibility among engineers and cultivate students' basic engineering qualities. The students need to study the related follow-up courses on the general education platform and major platform before they enter the core curriculum level, which lays a solid foundation for professional core curriculum learning. With these characteristics of mechanical and electronic engineering majors, we reconstruct and reshape the core curriculum of professional education. Based on the concept of starting from engineering problems and returning to engineering, the originally scattered knowledge of multiple courses was reintegrated and reorganized to form two professional core courses with information flow and energy flow as the main lines, namely Drive and Measurement and Control I, and Drive and Measurement and Control II.

3.1. Drive and Measurement and Control I

Drive and Measurement and Control I takes information flow as the principal line and actual systems as the research object based on the concept of engineering regression, using mathematical language to appropriately describe and reasonably simplify engineering problems, abstracting the scientific problems to be studied with mathematical tools and various professional principle knowledge to analyze, solve, design, simulate, and experiment the formulaic or modeled scientific problems of the former construction. Ultimately, the original complex engineering problems were solved. This logical process mainly covers the control principles of electromechanical systems, typical motor control systems, sensors and signal processing, control system synthesis and correction, modern testing technology, etc. Drive and Measurement and Control I breaks away from the traditional rigid method of interspersed engineering examples, but integrates the engineering examples of individual cases with general engineering principles, which helps students establish correct engineering thinking methods. The principal attributes of this course are reflected in both inheriting classics and infiltrating the forefront.

3.2. Drive and Measurement and Control II

Drive and Measurement and Control II focuses on energy flow as the motor and motor control system is the most typical electromechanical integration equipment and system. The core framework is the system energy conversion, transmission, distribution, and motion control in the course of Drive and Measurement and Control

II, which also originates from engineering problems, analyzes and solves engineering problems, covering knowledge content such as mechanical body, actuators, power amplifiers and drives, signal detection, and system analysis based on control targets. The principle and external characteristics of electromechanical energy conversion devices represented by typical motors are the main lines, highlighting the physical essence and system concepts, clarifying concepts and theories, and strengthening the integration of theory with practice. The core curriculum of Mechanical and Electronic Engineering, formed through reconstruction and reshaping, organically combines value shaping, skills cultivation, and knowledge transfer, promoting the updating and integration of the knowledge system of mechanical and electronic engineering, helping students establish a systematic view and "Engineering with a Big E."

4. Construction of a comprehensive practical course system driven by the concept of knowledge and practice integration in mechanical and electronic engineering majors

The mechanical major itself is an engineering major with strong practicality. How to improve the level and quality of practical teaching and cultivate students' engineering practical innovation ability is an important research direction in the current teaching reform of mechanical majors [10,11]. It involves transforming traditional education, promoting individual development of students, inspiring students to convert the data and information to their knowledge in the theoretical learning stage, practicing in the independent design stage to transform knowledge into skills, promoting practice skills through knowledge, and seeking knowledge through practice [12]. It is of great significance to reconstruct a comprehensive practical curriculum system based on the concept of knowledge and practice integration.

The essence of comprehensive practical course teaching following core courses of mechanical and electronic engineering majors is the teaching activities that enable students to grasp and apply the knowledge of professional core courses learned through working practices, and subsequently create new knowledge and solve complex engineering problems [9]. Taking advantage of the new engineering reform, it is necessary to further clarify the development process of practical teaching research in mechanical and electronic engineering, and elucidate ideas for practical teaching reform [13]. The comprehensive practical course system takes typical electromechanical integration systems as the teaching carrier, which highlights the comprehensive and practical characteristics of professional knowledge. The main comprehensive practical courses include the innovative design of intelligent robots, innovative production of surface navigation vehicles, and innovation training of programmable control vehicles by increasing the assessment of scene design and innovative design, using concise graphical methods to demonstrate students' knowledge application and establishment of a deep learning framework. The assessment results submitted by students can be included in the library of pre-class previews for the next class. In this spiral-upward approach, the quality of student assessment results in the work library is improved and forms a virtuous cycle of the curriculum. It is necessary to strengthen the cultivation of students' ability to apply and make good use of independent learning, innovation and entrepreneurship learning, cross-border integration, and engineering leadership.

5. Conclusion

The Mechanical and Electronic Engineering major aims to cultivate engineering professionals with comprehensive engineering qualities who can solve complex engineering problems in this field. A new cross-discipline and multi-specialty integrated engineering innovation system of professional training need to be established for practical engineering problems involving cross-coupling of multiple disciplines and specialties.

Based on the concept of originating from engineering problems and ultimately returning to engineering, after reintegration and reorganization, two core courses of Drive and Measurement and Control I and Drive and Measurement and Control II have been formed.

Continuing with the comprehensive practical course system, a learning system framework has been constructed driven by the concept of knowledge and practice integration in the field of mechanical and electronic engineering. Thinking of competence-based education, supporting teaching objectives, and promoting students' individual development, we provide reference models for relevant curriculum reforms, promoting the updating and integration of the knowledge system in the field of mechanical and electronic engineering, solving the problem of deep integration between teaching and learning and between learning and application, and help students establish a systematic view of "Engineering with a Big E," effectively ensuring the achievement of professional cultivation goals and their compliance with social needs.

Disclosure statement

The authors declare no conflict of interest.

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