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Project Driven Teaching Innovation and Practice of "Basic Engineering Course Design for Rail Vehicle Engineering"

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Abstract. With the rapid development of high-speed railway and urban rail transit industry in China, the demands for complex knowledge of disciplinary expertise and internationalized personnel in rail transit equipment are becoming stronger and stronger. Therefore, in accordance with the teaching requirement of "Basic Engineering Course Design for Rail Vehicle Engineering", this paper puts forward the guiding principle and practice basis in the teaching practice of this course. On this basis, we made the project-driven as the orientation, established modular design projects such as train traction and control, data acquisition and processing, rail vehicle virtual design and calculation and so on. In the teaching practice, progressive teaching methods including basic-skill experiment, extensive-design experiment and innovative-enhancing practice are taken to do a comprehensive examination of students' computer application, practical ability, logical thinking, report-writing, expressive ability and reaction skills. Practice shows that the curriculum design consolidates the theoretical knowledge of relevant basic courses, stimulates students 'interest in the flexible application of rail transit expertise, and enhances students' engineering application skills.

Introduction

The competition in the 21st century is the competition of talents. The 19th report of the Communist Party in China clearly pointed out, “we must cultivate a large number of strategic and scientific talents with international standards, leading talents in science and technology, young scientists and high-level innovation teams.” With the implementation of China’s “Medium and Long-Term Railway Network Plan” and the “Thirteenth Five-Year Plan for Development of Railways” [1-2], the development of the rail transit industry is rapid, which is known for its advantages of high-speed, high-capacity and environmental-safety, and is comprehensive for. The requirements for students’ comprehensive quality and innovation capabilities have gradually increased in the talent market, and the demand for talents, especially high-quality skilled talents, has become increasingly urgent in the new environment.

In order to meet the needs of the industry, universities have been committed to making progress in the reform of curriculum teaching experiments. The Institute of Rail Transit of Tongji University focuses on cultivating industry-leading talents for the future construction of the rail transit field. In recent years, it has made reform and innovation in teaching means and teaching methods continuously on the basis of strengthening the teaching of theoretical

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courses such as mechanical, electrical, vehicle, and signal analysis. On the one hand, it continues to enrich and improve various experimental platforms including the comprehensive test line of rail transit, structure and strength laboratory, brake technology laboratory, and traction control laboratory and so on. On the other hand, by strengthening practical courses like basic course design of railway vehicle engineering and curriculum design of railway vehicle engineering specialty, it efficiently circumvents the negative phenomena of copying experimental materials, students' mechanical simulations, and single examination methods in traditional experimental courses[3],focusing on cultivating students' active innovative ideas and diligent spirits, fully reflecting the characteristics like education principles for combination of production, study and academic in school, and theories combine practice in science and engineering education.

Course Teaching Guidelines

Under the background of "getting rooted in China's land and building a world-class university", the basic curriculum design of railway vehicle engineering specialty is a project-oriented and professional basic course design[4] based on the "Comprehensive Talent Training for Rail Transit" innovative experimental area of our institute. This course is aimed at the cultivation of students' ability and guided by various types of subject cases, focusing on the combination of professional qualities and innovation capabilities. It insists on the professionalism of rail transit education and the need of the industry for healthy, coordinated, and sustainable development.

This course is designed as a practical course involving basic theoretical courses such as mathematical modeling, mechanical drawing, fluid mechanics, electrical and electronics, professional basic courses such as sensor and test technology, train design and system integration, motor and power electronics, train traction and control, and track vehicle dynamics. The aim is to help students strengthen their expertise in rail transit, deepen their understanding of common hardware and software in the industry, familiarize with the basic process of rail vehicle related engineering design, encourage students' strong interest in professional learning, and lay a good foundation for the follow-up of professional courses and graduation design.

Thoughts Reform of Curriculum Teaching

Promote Project-Oriented Teaching and Present Rail Transit Specialty Characteristics

Introducing projects with specific tasks or situations into teaching and guiding students' autonomous communication, and division of labor in various directions is very popular nowadays. The new model, which is based on the students' exploration and the teacher's answer to the question, is not only the optimization of the traditional class, but also helps students convert the passive acceptance to active research, and the space for students to show themselves is huge. In the course of educational practice, the teacher gives the design topics related to the major and explains the theoretical knowledge in order to guide the students to visit the field, observe the objects or show the relevant cases. On this basis, the students are divided into groups according to the selected topics, submit their works within the specified time and oral defense. The teacher would answer if there are any questions.

Set up Modular Experiment Projects and Provide Multiple Vertical Topics

According to the actual situation of laboratory in our college and the difference of students' knowledge structure system, the experimental items are divided into several modules, and the vertical topics are set up under each module. Through the continuous accumulation and innovation of projects, each module has its own research direction, and also belongs to the major category of rail transportation, which is closely related to each other, and has continuity and expandability. Meanwhile, for the teaching content keeps pace with the times, it could effectively prevent cheating, the accumulated components and experimental equipment can also provide valid resources for the follow-up innovation and promotion of the practice stage.

Divide the Multi-Level Progressive Stage and Raise Students' Ability of Innovating Scientific Research

The courses are divided into three stages: basic skills experiment, extended design experiment and innovation to enhance practice. The difficulty and the amount of tasks are improved step by step. The students are guided through the process of theoretical learning and practical application, inspired studying spirit, research consciousness as well as innovative thinking combined with theory and practice. Also help students improve their ability of doing scientific research independently in rail transit.

(1) The first phase is the study of basic engineering. It is required to complete the construction and testing of basic projects, and master professional software including Multisim, Altium Designer, CAD and so on to perform virtual simulation or model verification;

(2) The second stage is the study of the extension project. On the basis of the first phase, it is required to complete the design, parameter calculation, graphic drawing and system analysis of the extended project;

(3) The third stage is the study of the forward direction (students choose to do). The professional tutors with rich experience in scientific research lead the students to study the forward issues in this direction, help students to upgrade their experimental results by using professional advantage resources, based on personal interests and career planning, or combining the platforms like college students' innovative projects and research competitions.

Optimize Curriculum Evaluation Strategies to Measure Students' Professional Comprehensive Quality

At present, some science and engineering majors attach importance to natural science education, and lack of attention to the enhancement of humanistic quality, which lead to students' poor abilities of language and written expression. The assessment mechanism for the design of this course takes a variety of forms to measure the comprehensive quality of the students, and the final achievement is evaluated from the following aspects [5].

(1) The drawing of software works, examine the students’ ability of computer language and software application ability;

(2) The practicality and beauty of hardware works, examine the students’ ability of industrial design and working in the laboratory;

(3) The integrity and accuracy of the written report, examine the students’ ability of logical thinking and paper writing ability;

(4) Oral speech and answer for teachers' questions, examine the students' ability of oral expression and strain response ability;

(5) Students score mutual evaluation and exchange of works, this part greatly improves their interest of learning in class, so that they can learn from each other and complement one another.

Through the above five aspects of comprehensive evaluation, in order to achieve the fairness and justice of the assessment process, give full play to students' subjective initiative and make teaching evaluation open and diversified.

Design of Project-Oriented Curriculum Experiment Project

Course of Experimental Project

The experimental project of "Basic Course Design for Rail Vehicle Engineering" includes 12 separate topics for "rail vehicle design and integration", "rail vehicle instrumentation and testing" and "rail vehicle data acquisition and control", as shown in Table 1.

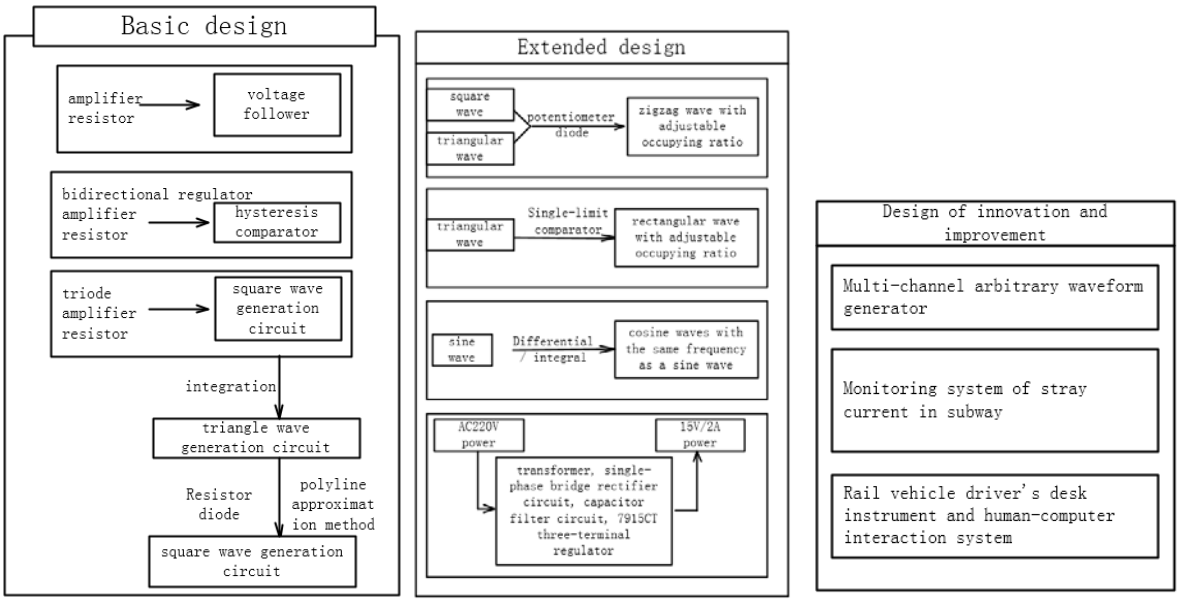
Table 1 Modular Experimental Project of "Basic Course Design for Rail Vehicle Engineering"

Module name	Discrete topic	Content Overview
Design and integration of rail vehicle	Design of traction parameters for rail vehicle	For typical rail vehicles, comprehensive consideration of various boundary conditions of vehicle traction design, design and check basic parameters such as vehicle traction and traction power.
	Body design for rail vehicle	Design typical railway vehicle body structure, taking the lightweight, workmanship and aesthetics of car body into account, on the premise of meeting the safety and basic functions of car body.
	Bogie design for rail vehicle	Design various parameters of the running parts of the vehicle, especially the suspension parameters. At the same time, consider the design of bogies that can effectively reduce the height of the floor of the vehicle.
	System integration and optimization design for rail vehicle	Focus on the electromechanical matching between the various systems and components of the rail vehicle, and integrate and optimize the design of each system to complete the overall design of the rail vehicle.
Instrumentation and testing of rail vehicle	Design of semiconductor triode sorter	The low-frequency low-power crystal triode is operated in a linear amplification state to measure its DC current amplification factor, and the current/voltage conversion is compared with the reference voltage to realize the beta value of triode binning and display.
	Design of multi-function digital	Make the digital clock that enables day

	electronic clock	display, time display and timed alarm by using basic logic gates and medium-scale digital integrated circuits.
	Design of function waveform generator	The oscillator circuit is designed by using active devices such as triodes and operational amplifiers, and is transformed by filtering or calculus to generate various waveform outputs.
Data acquisition and control of rail vehicle	Design of DC/DC power supply template	The power supply based on DC/DC conversion technology is designed. The input is 110V DC power generated on the train. The output voltage is generally 5V, 12V, 24V, etc., depending on the design of the system. Good electrical isolation is needed between the input and output for the power supply of system, as well as good electromagnetic compatibility (EMC) performance.
	Design of car control unit chassis	Adopt standard 3U×64R chassis structure, the structure can meet 8 boards, namely:1 power board, 2 DI boards, 2 DO boards, 1 AD/DA board, 1 main control board and 1 Communication board. Signal connection between boards via backplane bus or serial communication bus.
	Design of digital input/output boards	Based on the AT96 bus as the data transmission bus, using channel isolation technology to design digital input/output boards that meet functional requirements and power requirements.
	Design of analog input/output boards	Based on AT96 bus as data transmission bus, with typical A/D and D/A chips as the core, with peripheral chips, design A/D conversion boards that meets functional requirements.

Case Analysis of a Typical Module

Figure 1 shows the design of the function waveform generator in the experimental module of "Instrumentation and testing of rail vehicle". This topic mainly examines the students' engineering application ability of related basic knowledge like electrical engineering and electronics. Through the study of engineering and virtual simulation, consolidate students' electrical knowledge and allow students to do innovation and practice combining their professional fields.



(a)Project of basic skills (b)Project of extended design (c)Project of innovation and improvement

Figure 1 Case analysis for the design of function waveform generator

Combined with the professional characteristics of rail vehicle, the design content and specific requirements of the three stages for the selected topic, namely basic skill experiment, extended design experiment and innovation promotion practice, are as follows:

(1) The basic skill experiment adopts diode, voltage regulator, crystal triode and operational amplifier to design the basic waveform generator, also completes the circuit welding and debugging. This stage focuses on the students' basic knowledge of analog electronics, digital electronics, circuit theory, as well as the basic experiment skills such as assembly of printed circuit board, component soldering, and the use of conventional instrumentation like oscilloscope and multi-meter.

(2) The extended design experiment requires students to perform circuit parameter calculation and component selection according to design requirements, and design the conversion circuit between conventional waveforms such as square wave, triangle wave and sine wave. At this stage, students' comprehensive knowledge application and application skills of common computer software are examined. It is required to use Altium Designer to complete the circuit schematic drawing and use Multisim to accomplish the simulation verification of the circuit function.

(3) The innovation and improvement design is based on the above design and combines professional features. It mainly examines the students' theoretical knowledge combined with the practical engineering application. The design content includes: designing arbitrary waveform generators through waveform superposition, frequency synthesis, and so on; analyzing and designing the mechanism of the generation of scattered current in subway, and designing the stray current monitoring system; designing the driver's station instrument and human-computer interactive display system according to the requirements of driver in rail vehicle.

Summary

The theoretical class is the basis and support of the practical class, and the practical class consolidates the theoretical teaching content. The two are parallel, interconnected and inseparable. The design of the experimental project in this course not only runs through the theoretical knowledge in the book, but also expands the knowledge not covered in the book and the theoretical knowledge contained in the experimental technology itself, and cultivates the students' ability to acquire knowledge independently and apply flexibly. After several years of teaching practice, the "Basic Engineering Course Design for Rail Vehicle Engineering" has accumulated more than ten modular projects for students of different research directions to choose, and the comprehensive ability of students has generally improved. Some students actively complete a number of design of scientific and technological innovation works by what they have learned, participated in the “Challenge Cup” academic technology and entrepreneurship competition, the “Haoting Cup” science and technology innovation competition, and other college student competitions, achieved excellent results and reached the teaching purpose of knowledge acquisition as well as skill promoting. This course has laid a good foundation for students to cultivate their comprehensive ability, develop and promote their experimental level, innovation level and professional level in our major.

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