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Exploration of Experimental Course Reform in Control Majors under the Background of New Engineering

Yanqiu Zhao, Mingxi Yan

Qingdao University of Technology, Qingdao 266000, China

Abstract: The Ministry of Education is actively promoting the development of new engineering disciplines, placing new demands on talent cultivation. Considering issues such as aging hardware resources, limited experimental content, and a disconnect between industry and education in control courses, this article discusses experimental curriculum reform initiatives from the perspectives of teaching philosophy, experimental course design, teaching models, evaluation systems, and safety education. This article provides a reference for other universities in cultivating innovative talent in new engineering disciplines.

Keywords: Experimental teaching reform; New engineering; Curriculum ideological and political education; Safety education.

1. Research background and significance

In recent years, the Ministry of Education has actively promoted the construction of new engineering disciplines, issuing notices such as "Notice on Conducting Research and Practice in New Engineering", actively exploring the Chinese model of engineering education, and assisting in the construction of a strong higher education country. New Engineering aims to cultivate high-quality engineering talents with innovative and entrepreneurial abilities, cross-border integration abilities, and comprehensive practical abilities. New Engineering focuses on innovation, cross-border and forward-looking, and strives to cultivate outstanding engineering and technical talents with strong theoretical foundations, strong practical abilities, excellent innovation literacy, and high cross-border capabilities [1]. At the same time, with the vigorous development of the economy, the demand for talents in society is shifting towards compound, innovative, and application-oriented directions. These have put forward new requirements for talent cultivation in universities, especially in enhancing students engineering practice ability and innovative application ability. Therefore, exploring and practicing talent cultivation models that enhance students innovative application abilities is of great significance for cultivating new engineering talents who can adapt to industry needs and have the ability to solve complex and unknown problems in the future.

As an experimental course, cultivating innovative engineering talents occupies a core position. In the context of new engineering disciplines, the reform of experimental courses needs to revolve around the three core concepts of "innovation, integration, and practice":

1). Interdisciplinary integration: Breaking down traditional disciplinary barriers, building a multidisciplinary experimental teaching system, constructing comprehensive experimental projects in multiple fields, enabling students to have a broader knowledge perspective and interdisciplinary problem-solving abilities.

2). Practice orientation: Strengthen the cultivation of engineering practice ability, focus on solving complex engineering problems, increase openness, design comprehensive experiments, encourage students to independently propose solutions, design modular and hierarchical interdisciplinary course modules, gradually guide students to explore and practice deeply from basic theory to advanced application.

3). Technological innovation: Introducing cutting-edge technologies, digitization, and intelligence to cultivate students innovative thinking and research and development abilities.

The construction of the experimental course system timely integrates the latest technologies, standards, and trends in the industry into the course content, such as artificial intelligence, the Internet of Things, big data processing, etc., to maintain the timeliness and foresight of the course content.

2. Construction of Layered Experimental Teaching System under the Background of New Engineering

The four layer experimental teaching system of "foundation synthesis innovation practice" constructed in this article aims to systematically bridge the gap between theoretical teaching and engineering application, and promote the step-by-step development of students abilities from shallow to deep. A new curriculum system [2] has been proposed to address the current problems in the curriculum, such as the disconnect between theory and practice in the teaching mode, overly single teaching methods, and unreasonable assessment methods, which make it difficult to meet the requirements of cultivating new engineering talents. The following will delve into the teaching objectives, design logic, and roles of each level in the overall training program.

2.1. Basic Experimental Layer: Consolidate theoretical cognition through classic confirmatory experiments

This level is the cornerstone of building a systematic knowledge system for students. The teaching design logic is to achieve a high degree of synergy between practical operations and theoretical courses through carefully selected classic experiments that have been tested over time, such as the verification of the Thevenin theorem in "Circuit Principles" and the transient response analysis of second-order systems in "Automatic Control Principles". This foundational step lays an indispensable conceptual and methodological foundation for the cultivation of more complex and comprehensive abilities in the future. Following a progressive cognitive sequence from simple to complex, from software simulation to hardware practice, and from general scenarios to specific applications [3] .

2.2. Comprehensive Design Layer: Cultivating System Design Capability in Multidisciplinary Intersections

This level is a crucial transition for students from understanding knowledge to integrating and creating knowledge. The core design principles are "modularity" and "interdisciplinary integration", such as the electronic clock design project in the course of "Electronic Design Automation", which requires students to connect discrete knowledge points into a complete system solution. This type of project aims to train students systems thinking, forcing them to face and solve cross domain problems that arise in design, thus completing the ability transition from "understanding components" to "architectural systems".

2.3. Innovative Research Layer: Inspiring Academic Exploration and Innovation Potential through Real Research Scenarios

This level marks a fundamental shift in teaching mode from "guided learning" to "autonomous exploration". The core mechanism is to transform teachers research topics into teaching and modularization, and integrate them into experimental teaching, so that students can be immersed in real scientific research situations. At the same time, by systematically organizing and guiding students to apply for projects such as the "College Student Innovation and Entrepreneurship Training Program", this immersive experience of the complete research cycle - from topic selection, project proposal, implementation to summary - is the core link in cultivating future scholars and innovative engineers.

2.4. Engineering practice layer: bridging the gap between academia and industry through school enterprise collaboration

By establishing deep strategic cooperation with leading enterprises in this field, real engineering cases from the front line of the industry are introduced into experimental teaching, and an ecosystem of "school enterprise collaboration and talent cultivation" is constructed. This collaboration not only ensures the synchronization of course content with technological frontiers and industry demands, but also enables students to practice under real engineering constraints and professional standards, effectively bridging the last mile from "academic learning" to "professional practice".

3. Practice exploration and implementation of teaching reform in control related professional courses

3.1. Modernization update path of experimental teaching content

To cope with the challenges of the new round of technological revolution and industrial transformation, it is imperative to update the experimental teaching content. Zhao Xuejuan and other scholars proposed that in order to strengthen students engineering thinking and innovation awareness, three levels of experiments can be set up to innovate and design teaching content: verification, design, and comprehensiveness [4] . Therefore, the core direction of experiments in control related majors is to proactively integrate empowering technological elements such as artificial intelligence, big data, and the Internet of Things, and systematically add relevant teaching content in emerging strategic fields such as intelligent manufacturing, robotics, and new energy technology to ensure that talent cultivation resonates with future trends in technology and industry development. In the context of new engineering disciplines, teachers should actively transform their educational philosophy and update their teaching methods. By fully utilizing high-quality online resources and practical platforms, actively carrying out blended learning practices, promoting flipped classroom models, and achieving student-centered teaching transformation. The focus of teaching should shift from traditional knowledge imparting to thinking enlightenment, and from simple knowledge imparting to cultivating students professional abilities required for future industries [5].

In this context, our school has explored an effective practical path through the "Blue Bridge Cup National Software and Information Technology Professional Talent Competition (Electronic Category)" as a specific carrier. Promoting learning and teaching through competitions, this competition is aimed at many engineering majors such as electrical engineering, computer science and technology, automation, electronic information, robotics engineering, etc., and has a natural interdisciplinary nature. This project takes this as an opportunity to integrate existing course modules from various majors and construct interdisciplinary course modules guided by practical competition problems. This process effectively constructs a new curriculum system of "competition education linkage and innovation driven". This system not only significantly enhances students comprehensive ability to solve complex engineering problems, but also strongly promotes the innovation of new engineering talent training models.

3.2. Innovative Path of Experimental Teaching Mode

In order to effectively improve the quality and efficiency of experimental teaching, our school has implemented two core teaching mode innovations: blended experiments combining virtual and real elements and project-based process experiments. These models aim to overcome the limitations of traditional teaching and cultivate students comprehensive abilities to deal with complex engineering problems.

Our school has systematically developed a hybrid experimental method that combines virtual and real elements, verifies each other, and progresses layer by layer. This method combines virtual and real experiments through scientific teaching design, complementing each others functions and forming a complete teaching loop aimed at deepening knowledge understanding, strengthening engineering thinking, and cultivating innovative abilities. This model integrates virtual and real experimental activities to create a hierarchical and efficient experimental teaching environment.

Applying mainstream simulation software such as Proteus and Multisim to traditional confirmatory experiments, students are required to complete simulations and physical experiments in parallel, and deepen their understanding of the differences between theoretical models and the real world through comparative analysis of results, cultivating their scientific literacy in error analysis and model verification; The teaching application of augmented reality (AR) and virtual reality (VR) technology, the closed-loop process of "virtual rehearsal entity verification", effectively enhances students spatial understanding and operational skills through multidimensional cognitive reinforcement.

To cultivate students systematic thinking and teamwork skills in solving complex engineering problems, our school adopts a project-based teaching method and systematically reconstructs the organizational model of experimental teaching. This model simulates the complete engineering development lifecycle from concept proposal to product iteration, using real projects from high-level academic competitions as carriers.

In specific implementation, teaching activities strictly follow the iterative engineering process of "requirement analysis scheme design implementation verification optimization and improvement". Taking the "Dual Car Follow" project in the National College Student Intelligent Car Competition as an example, this task itself constitutes a microsystem engineering covering multidisciplinary knowledge. Students need to form interdisciplinary teams under a unified project objective, collaborating to complete the entire process from micro level code writing and circuit debugging to macro level system integration and performance testing. This practice not only organically integrates theoretical knowledge that was originally scattered across different courses, but also focuses on cultivating students ability to make balanced decisions, collaborative development, and project management under multiple constraints.

3.3. Integrating ideological and political education into curriculum, strengthening quality cultivation

The purpose of higher education is to provide excellent talents for socialism. In order to achieve the educational essence of cultivating virtue and educating people, ideological and political education is introduced in the process of introducing instruments, guiding students to establish the correct values of promoting the country through science and technology.

Integrating ideological and political education into experimental teaching, conducting performance analysis and improvement prospects on relevant instruments, guiding students to transform and innovate traditional instruments, and developing more accurate and applicable instruments for future high standard measurement processes; In the process of conducting design experiments and innovative experiments, guide students to dare to innovate and practice.

3.4. Reform of Teaching Evaluation System

To comprehensively evaluate the development of students comprehensive abilities and literacy, our school has established a comprehensive teaching evaluation system that is diverse, multidimensional, and covers the entire process.

The establishment of multiple evaluation indicators emphasizes the evaluation orientation of both ability and literacy, and strengthens the assessment of the experimental process on the basis of focusing on the accuracy of experimental results. Including: scientificity of scheme design, standardization of operation process, effectiveness of team collaboration, and innovation in analyzing and solving problems; Establish a collaborative evaluation mechanism among teachers, students, and industry experts based on multidimensional evaluation subjects; Whole process evaluation: experimental preview, experimental operation norms and problem solving, report data analysis and summary, etc. This system achieves continuous improvement through multi-source feedback, providing data support for teaching optimization.

3.5. Experimental Safety Education System

To ensure the safe and orderly conduct of experimental teaching, our school places safety education at the forefront. The laboratory implements a strict admission system, and students must pass a safety exam that covers general safety guidelines and special specifications for new technology experiments in order to obtain operational qualifications. Special safety training will be conducted for specific experimental modules such as intelligent manufacturing and high-voltage electrical systems to ensure that students are proficient in equipment operation procedures and emergency response processes. This system aims to cultivate students safety operation habits and professional responsibility through institutional constraints and systematic training, fundamentally preventing safety accidents caused by operational errors or equipment failures.

4. Conclusions

The new engineering experimental teaching system has put forward higher requirements for students sel f-learning and engineering practice abilities. Future experimental teaching is not only a training ground for professional skills, but also an incubator for systematic thinking and innovative abilities. It will guide students to examine problems from the perspective of engineers, explore solutions through scientific methods, and cultivate their core competitiveness in dealing with future technological challenges and industrial changes.

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