Teaching Reform of Principle of Automatic Control in Electrical Engineering Major Based on the Integration of Teaching, Research, and Ideology under the Background of Emerging Engineering Education

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Abstract. In the context of the development of new engineering disciplines, this paper addresses the challenges faced by the course of Principle of Automatic Control, such as outdated teaching content, insufficient practical ability training, and the lack of ideological and political elements. With the core concept of integrating "teaching-research-ideological and political education," a "three-dimensional collaborative" teaching reform framework is established. This framework includes measures such as restructuring the modular course system, implementing case-based teaching with research feedback, building a virtual-real fusion experimental platform, and innovating the integration path of ideological and political education. These efforts form a "knowledge transmission - ability cultivation - value guidance" triad model, which can effectively promote the collaborative development of theoretical learning, research literacy, and ideological awareness.

Keywords: Emerging Engineering Education, Principles of Automatic Control; Integration of Teaching, Research, and Ideology, Teaching Reform.

1 Introduction

As an important discipline, electrical majors shoulder the important task of cultivating talents in the power and energy industries for the country. Driven by the "dual carbon" goal, China's new energy power generation and the construction of new power systems are undergoing profound changes [1,2]. As one of the core courses of electrical majors, the teaching reform effect of automatic control principle is directly related to the quality of talent supply in the fields of new power system and new energy. However, with the deep integration of information technology and teaching, the way of knowledge acquisition and teaching has undergone significant changes[3].

In view of the teaching reform of the course of automatic control principle, scholars have carried out research in different directions. He Ying proposed to take the "principle of automatic control" course teaching as an example, and build a blended teaching model that includes three links: before, during, and after class, by integrating online

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resources, reforming the course teaching mode, and optimizing the course assessment mechanism [4]. In view of the current situation of the automatic control principle course, Yue Dongdong et al. put forward reform suggestions such as strengthening ideological and political guidance, strengthening basic knowledge, and optimizing teaching content, so as to provide theoretical reference and practical experience for cultivating automation talents with both "international vision" and "Chinese characteristics" [5]. Xiao Youhong et al. reconstructed the course content of automatic control principles and carried out experimental teaching combining virtual and real science in response to the requirements of talent training in the context of new engineering [6]. Taking the automatic control principle course as an example, Ping Yuhuan researched and explored the automation professional course, and proposed heuristic teaching and case-based teaching to guide students to learn independently [7].

However, the current curriculum construction and reform still face some difficulties, which are mainly reflected in the following aspects: (1) The teaching content is outdated and out of touch with cutting-edge technology. Traditional textbooks have long followed the framework of classical control theory. (2) The degree of professional integration is insufficient, and there is a fault between the curriculum and the demand for electrical engineering. The existing curriculum system does not fully reflect the characteristics of electrical engineering. (3) The practice link is fragmented, and the training of engineering application ability is insufficient. The course is still mainly based on theoretical teaching, and the practical part accounts for less than 30%. (4) The ideological and political elements are superficial, and the cultivation of the sense of responsibility is weak.

In view of the above problems, this paper implements the reform concept of "teaching-scientific research-ideological and political integration", implements the requirements of "salt into water" in the Guiding Outline for Ideological and Political Construction of Curriculum in Colleges and Universities, and constructs a "three-in-one" collaborative education framework. Through the teaching reform, the deep integration of knowledge impartation, ability training and value guidance is realized, and a practical paradigm is provided for cultivating outstanding engineers with family and country feelings and innovation ability.

2 Design and Implementation of Teaching Reform Programs

2.1 Implementation Path: Build a "Three-in-one" Collaborative Education Framework

Based on the needs of new engineering construction and the accreditation standards of engineering education, the reform path of "professional teaching, ideological and political education, and scientific research guidance" is proposed around the three-dimensional goal of "knowledge-ability-literacy", as shown in Figure 1. Through the actual needs in the field of power system, the results of teachers' scientific research projects

are transformed into teaching resources, and a progressive training chain of "theoretical teaching-experimental verification-engineering practice" is formed.

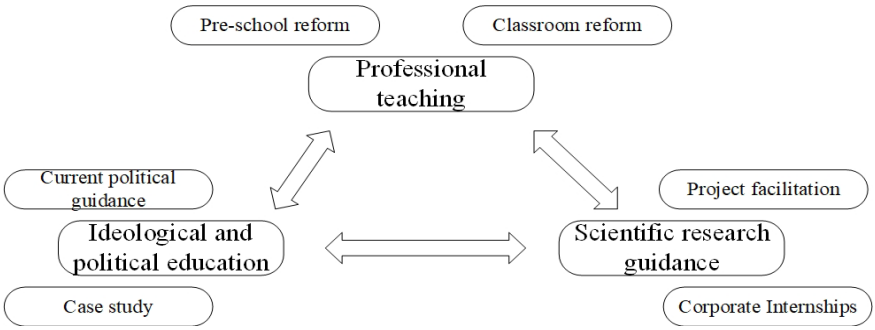

Fig. 1. The framework of teaching and research thinking

2.2 Reconstruction of Theoretical Teaching: Modular Design Driven By Scientific Research Projects

The three-level module system of "basic theory-interdisciplinary-cutting-edge technology" is constructed, and through the reconstruction of the course content system, it aims to improve students' system modeling and analysis ability, interdisciplinary integration ability and innovative design and practice ability.

Basic Theory Module. Fundamental theories are the foundation of the automatic control principles course, such as transfer function, root trajectory method, frequency domain analysis, stability criterion, PID control, etc., which are the cornerstones of understanding and designing control systems. Only on the premise of correctly understanding the core content of the course can students have the ability to construct a disciplinary cognitive network and learn to analyze problems rationally. The curriculum reform can integrate professional cases in power systems while retaining the core content, and use the actual scenarios of the cases to help students master the ability to transform from physical systems to control models.

Interdisciplinary modules. Interdisciplinarity refers to a research or teaching paradigm that breaks the boundaries of traditional disciplines and solves complex problems together by integrating theories, methods and technologies from different disciplines. In the curriculum reform of "Principles of Automatic Control", the interdisciplinary module improves students' comprehensive practical ability, knowledge transfer ability, scientific research and innovation ability by integrating multiple disciplines such as electrical engineering and computer science.

Cutting-edge technology module. The cutting-edge technology module focuses on the latest development of intelligent, digital and collaborative technologies in the field of automatic control, aiming to deeply integrate emerging technologies such as artificial intelligence, digital twins, and swarm intelligence with electrical engineering. With the integration of a variety of cutting-edge technologies and courses, the quality of students can be comprehensively improved, the dynamic response ability to complex energy systems can be improved, and the collaborative optimization ability of complex systems

can be cultivated. For example, in the collaborative optimization control of wind, solar, and storage, the charging and discharging strategy of energy storage is adjusted in real time based on the deep reinforcement learning algorithm to solve the power imbalance caused by the fluctuation of new energy output.

2.3 Practical Teaching Optimization: a Step-By-Step Training Method That Integrates Virtual and Real

In view of the pain points of "fragmentation, simulation, and detachment from engineering reality" in the traditional practice link, a three-level experimental system of "basic verification layer-comprehensive design layer-innovation practical layer" was designed.

Basic verification layer. The experimental platform was used to complete the basic experiments such as step response analysis of the system, drawing the root trajectory and system analysis, measuring and analyzing the frequency characteristics, and series correction analysis of the linear system.

Comprehensive design layer. Through the development of new energy grid-connected control strategies through simulation software, students are examined to comprehensively use the transfer function and PID control knowledge in the principle of automatic control.

Innovate the actual combat layer. Guide students to participate in scientific research competitions such as the "Challenge Cup" to further improve the overall quality of students. For students with higher scientific research level and higher enthusiasm, they can also be guided to join scientific research projects to further enhance students' scientific research and innovation capabilities.

2.4 Ideological and Political Construction of Curriculum: Double Closed-Loop Feedback and Education Mechanism

Referring to the concept of double closed-loop control, the dual-driven model of "closed-loop value shaping + closed-loop knowledge impartation" is constructed.

Value closed-loop design. Guided by the core values of socialism, the closed-loop of value shaping deeply integrates ideological and political elements such as craftsman spirit and serving the country with science and technology into the whole process of professional teaching through the circular path of "case guidance-practical experience-reflection internalization".

Closed-loop knowledge transfer. The closed-loop knowledge transfer is based on the engineering education accreditation standard, and the closed-loop design of "theoretical input-practical verification-feedback optimization" ensures a complete link from understanding to application of professional knowledge.

3 Analysis of the Effectiveness of Teaching Reform and Data

This study conducted a questionnaire analysis on the issues identified in the teaching reform, with the statistical results illustrated in Fig.2. In the figure, labels A–D correspond to the four key problems analyzed in Section 2, while the vertical axis indicates the urgency of reform required. The data reveal that these issues are currently of significant severity.

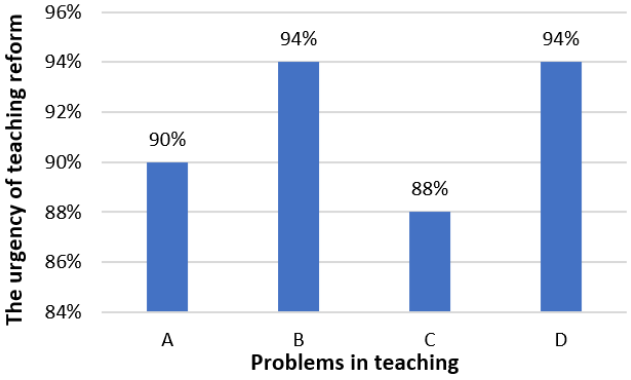

Fig. 2. Urgency of problems in teaching

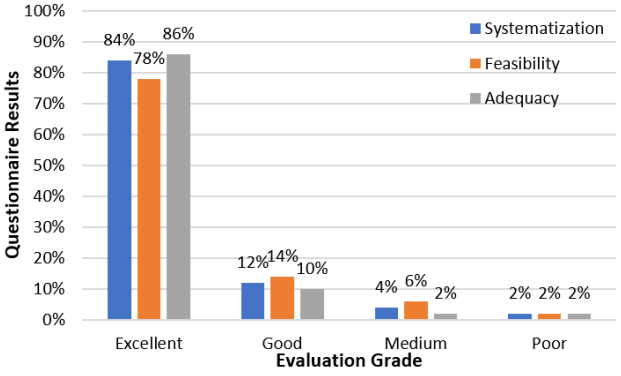

Fig. 3. Outcomes of teaching reform effectiveness

To evaluate the outcomes of the teaching reform, we assessed the following dimensions. As shown in Fig. 3, the questionnaire results demonstrate satisfactory progress, with all three evaluation criteria scoring above 80 points.

(1)The systematization of reform design

Guided by the three-dimensional goal of "knowledge-ability-literacy", the curriculum reform plan constructs a complete framework covering the reconstruction of teaching content, the innovation of teaching mode, the optimization of practice system and the integration of ideology and politics. The modular design of the teaching content

breaks the disciplinary barriers, which can effectively respond to the problem of insufficient professional integration.

(2)The feasibility of the implementation path

The collaborative education framework has established a progressive training chain of "theory-experiment-practice" through the school-enterprise joint innovation center and the virtual and real integration experimental platform. The blended teaching mode can break through the limitations of traditional experimental equipment and help students complete the transition from simulation verification to real-world scenario development.

(3)The adequacy of support conditions

The multi-dimensional guarantee system provides basic support for the reform and accelerates the transformation of scientific research achievements into teaching resources: the improvement of teachers' ability can enhance teachers' engineering practice experience, and the integration base of industry and education can provide hardware guarantee for the practice of virtual and real integration. However, the balance between teachers' scientific research tasks and teaching investment still exists.

We compared the academic performance, practical ability, and political literacy of students before and after the teaching reform. As shown in Fig.4, we found that the highest improvement was a 42% increase in practical ability, followed by a 33% increase in political literacy, and finally a 6% increase in theoretical performance. This is because before the reform, theoretical learning was the main focus, and there was a lack of practical and political literacy learning.

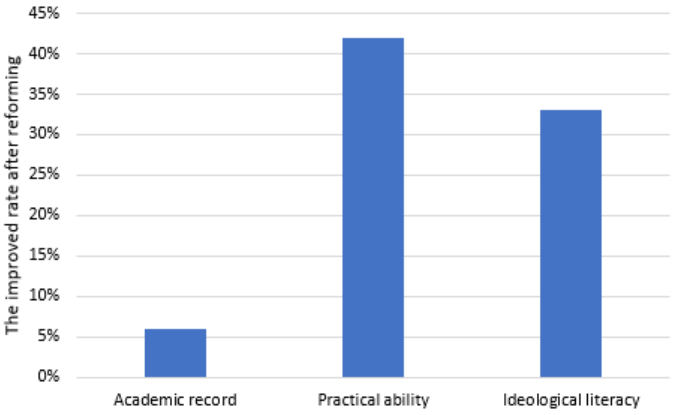

Fig. 4. The improved rate after reforming

4 Conclusion

The teaching mode of "teaching, research and ideology" constructed in this paper effectively solves the problems of disconnection between theory and practice, separation of scientific research and teaching, and separation of knowledge and value in traditional courses. In the future, we will further deepen the teaching application of electrical engineering, artificial intelligence and other technologies.

Acknowledgments

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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