

Teaching Innovation and Practical Exploration of “Electrical Machinery” Empowered by Information Technology in the Context of New Engineering Disciplines

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Abstract

As a core compulsory course in the field of electrical engineering, “Electrical Machinery” presents significant teaching challenges due to the invisible nature of magnetic fields, abstract principles, and complex structures. In traditional teaching, an excessive focus on knowledge transfer between teachers and students has resulted in a disconnect between the course and practical engineering applications. Additionally, the integration of ideological and political education in courses with the concept of new engineering disciplines remains insufficient, making it difficult to meet the cultivation requirements for applied engineering and technical talents in the new era. To address these challenges, the teaching team has constructed a diversified teaching system that combines “online-offline hybrid teaching, comprehensive resource support, school-enterprise collaborative case teaching, and student-centered ideological and political education in courses.” By leveraging information technology to enhance teaching efficiency, implementing tiered teaching to cater to individualized needs, integrating industry-education to strengthen practical abilities, and incorporating ideological and political education to stimulate intrinsic motivation, the team has achieved an organic unity of theoretical knowledge, practical skills, and value orientation. This approach provides a practical pathway for cultivating high-quality electrical engineering talents that meet the development needs of new engineering disciplines.

Keywords

New engineering disciplines; Electrical machinery; Information technology; Ideological and political education in courses; Integration of industry and education

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1. Introduction

The construction of emerging engineering disciplines is oriented towards industrial demands, focusing on the deep integration of innovation and industry, with the core objective of cultivating high-quality engineering and technical talents equipped with innovative thinking, practical abilities, and comprehensive qualities^[1]. Curriculum-based political and ideological education, as a crucial vehicle for fostering virtue and nurturing talents, deeply aligns with the educational philosophy of emerging engineering disciplines. Its essence lies in integrating value guidance throughout the entire process of professional teaching, aiming to cultivate engineering talents who possess a firm political stance, solid professional foundations, and a strong sense of social responsibility, thereby providing talent support for China's industrial optimization and upgrading as well as technological innovation^[2].

“Electrical Machinery” serves as a core course in the Electrical Engineering and Automation major, covering fundamental theories, structural characteristics, and operational mechanisms of electrical machines. It acts as a critical bridge connecting foundational disciplines such as electromagnetism and circuit analysis with engineering applications like electric drives and industrial automation. It plays an irreplaceable role in cultivating students' abilities to comprehensively analyze and solve complex engineering problems^[3]. Against the backdrop of the coordinated advancement of emerging engineering disciplines and the integration of ideological and political education into curricula, the teaching of “Electrical Machinery” needs to break free from the constraints of traditional models, highlight the cultivation of a sense of mission and craftsmanship spirit, and guide students to integrate theoretical knowledge with engineering practice using scientific thinking methods, thereby shaping their professional qualities during technological exploration^[4]. Based on this, this paper addresses the prominent issues currently present in the teaching of “Electrical Machinery” and constructs a teaching reform plan that aligns with the requirements of emerging engineering disciplines, providing references for the teaching reform of similar courses.

2. Current teaching situation and challenges of the “Electrical Machinery” course

2.1. Inherent course characteristics result in a high learning threshold

The core difficulties of “Electrical Machinery” lie in the unobservability of magnetic fields, the abstractness of electromagnetic principles, and the complexity of electromechanical coupling relationships, making it a widely recognized “difficult to teach and difficult to learn” course^[5]. In traditional teaching, both teachers and students often focus their primary efforts on explaining and memorizing basic theories, neglecting the integration of engineering practice scenarios and the expansion of cutting-edge technologies. This leads to a situation where students, although they have mastered theoretical formulas, struggle to tackle real-world engineering problems, creating a dilemma of “theory and practice being disconnected.”

2.2. Insufficient teaching adaptability and personalized needs

Motor technology, which is a crucial and advanced technological domain, is extensively and widely applied in a multitude of different fields. These fields include energy, where it plays a vital role in power generation and energy conversion; manufacturing, where it is used in various production processes to drive machinery and equipment; and transportation, where it powers vehicles and enables efficient movement of people and goods. As the application scope of motor technology continues to expand, the industry's demand for talent shows diverse characteristics. Different sectors within the industry require professionals with specific skills and knowledge to meet their unique needs.

However, when it comes to the current teaching content of the course “Electrical Machinery,” it often adheres to a unified standard. This means that regardless of the different application scenarios in the real-world industry and the personalized development needs of individual students, the teaching materials and methods remain the same. There is a lack of targeted design that takes into account the specific requirements of different fields such as energy, manufacturing, and transportation.

This situation leads to a low match between students' willingness to learn and the teaching content. Since the teaching fails to address their specific interests and career aspirations, students may find the course unappealing and less relevant to their future development. As a result, it becomes extremely difficult to fully stimulate their learning initiative. They may not be as motivated to engage actively in the learning process, which can have a negative impact on their academic performance and the cultivation of industry-relevant talents.

2.3. Disconnection between practical teaching and engineering practice

In the current state of existing teaching scenarios, the utilization and application of teaching methods like PBL (problem-based learning) come with quite obvious limitations. When it comes to the discussion questions that are designed within the framework of this teaching method, a large majority of them belong to the category of theoretical derivation types. These theoretical derivation-type questions mainly focus on abstract concepts and mathematical or logical deductions, and they severely lack the necessary support from real-world engineering backgrounds. Real engineering backgrounds involve actual engineering projects, practical engineering challenges, and the complex situations that engineers encounter in their day-to-day work.

This shortcoming in the design of discussion questions means that it fails to meet the goal that new engineering disciplines strongly emphasize, which is the cultivation of the ability to "solve complex engineering problems." New engineering disciplines place great importance on enabling students to handle the intricate and multifaceted problems that exist in the real engineering world. However, due to the lack of real-world engineering context in the teaching method, students are not exposed to the full spectrum of challenges they will face in their future engineering careers. As a result, the improvement of students' engineering practical abilities is rather limited. Students may be well-versed in theoretical knowledge but find it difficult to translate that knowledge into practical solutions when confronted with actual engineering problems.

2.4. Integration of ideological and political education into courses lacks depth and effectiveness

Although students have the willingness to engage in professional learning, there is a widespread issue of weak learning initiative. In traditional teaching, ideological and political education is often presented in a fragmented manner, not naturally integrated with professional content. It fails to effectively transform value guidance into students' intrinsic learning motivation, making it difficult to achieve the coordinated advancement of knowledge transmission and value shaping^[5].

This disconnect between ideological and political education and professional learning has led to a situation where students may perceive the former as irrelevant to their academic and career development, thus reducing their enthusiasm for both.

3. Implementation paths for the teaching reform of "Electrical Machinery" under the context of emerging engineering education

3.1. Empowering with information technology to build an efficient teaching medium

To address the challenge of abstract course content, the teaching team systematically integrated and developed a diverse range of teaching resources, establishing a comprehensive teaching resource library that includes 3D animations, virtual simulations, physical teaching aids, and online courseware. Through 3D animations, core physical processes such as rotating magnetic fields and electromagnetic induction are visually presented, enabling students to better understand these concepts. Virtual simulation platforms allow students to independently adjust motor parameters and simulate operational states, making abstract principles concrete and complex structures intuitive, thereby effectively overcoming key teaching challenges. Based on the development of this resource library, a three-dimensional teaching model integrating "theoretical knowledge learning, exploration of cutting-edge technologies, and practical operational training" has been established. In classroom instruction, multimedia resources are used to efficiently convey core knowledge, freeing up time for in-depth interactive

activities such as engineering case discussions and analyses of cutting-edge technologies. After class, online platforms provide extended learning resources to guide students in understanding the latest developments in motor energy-saving technologies and permanent magnet motor advancements, achieving an organic combination of knowledge transfer and skill enhancement.

3.2. Hierarchical teaching design to meet personalized learning needs

Leveraging the MOOC platform, we have established a two-tier online resource system comprising “core fundamentals + advanced expansion” to precisely implement hierarchical teaching. On one hand, key course concepts are carefully selected to form the foundational modules of the MOOC, serving as a theoretical groundwork for offline seminar classes. Students can autonomously manage their learning pace through the online platform and revisit unmastered concepts as needed. On the other hand, teachers utilize learning tools to track students’ online learning behavior data, focusing on analyzing key indicators such as video replay frequency and quiz error distribution to accurately identify areas of weakness. Based on this analysis, teachers dynamically adjust offline teaching content and tutoring strategies. For students with exceptional learning capacity, we provide extension resources such as motor design optimization, interpretation of industry standards, and overviews of cutting-edge technologies, creating a personalized learning model that combines “core content delivery with optional extended content.” This approach ensures that all students master core knowledge while meeting the in-depth exploration needs of some students, thereby achieving the teaching objective of “tailoring teaching to students’ abilities.”

3.3. Deep integration of industry and education to strengthen engineering practical abilities

We deepen the collaborative education mechanism between universities and enterprises, establishing stable partnerships with companies in the fields of motor manufacturing and energy services. A dual-instructor teaching team consisting of “university faculty + corporate engineers” is formed. Enterprise engineers select typical engineering cases based on actual production conditions,

such as “efficient design of motors for industrial pumps” and “permanent magnet transformation of old motors.” Teachers then organically integrate these cases with the theoretical knowledge points covered in the course, designing a step-by-step chain of questions. During the teaching process, students first master fundamental theories through online MOOCs and then explore the cases under the guidance of a dual-instructor team, following the engineering workflow of “theoretical analysis–scheme design–simulation verification–optimization and improvement.” For instance, in the case of motor design optimization, students are required to collaborate in teams to address practical issues such as parameter matching, efficiency enhancement, and cost control. Some of the optimization schemes they ultimately develop have already achieved favorable results in real-world corporate applications. Through this process, students not only deepen their understanding of theoretical knowledge but also enhance their engineering problem-solving abilities and workplace competencies, achieving a transformation from “knowledge recipients” to “engineering practitioners.”

3.4. Infiltration of ideological and political education in the curriculum to achieve synergy between value guidance and knowledge transmission

Adhering to the principle of “organic integration and subtle influence,” we deeply explore the ideological and political elements embedded in the curriculum and construct a four-in-one ideological and political education system in the curriculum that encompasses “national needs–professional ethics–scientific thinking–technological foresight”:

Anchor to national strategies and strengthen the sense of mission and responsibility. By integrating with national development plans such as the “dual carbon” strategy, energy conservation, and emission reduction, we will analyze the significance of improving motor efficiency for energy conservation and carbon reduction. We will also interpret the roles and responsibilities of electrical engineers in the country’s energy transition, guiding students to closely align their personal career development with national needs and clarify their paths of striving.

Inherit the industry spirit and cultivate professional qualities. By recounting the development history of China's motor industry and stories of scientists tackling key challenges (such as cases of independent innovation in motor technology), we will foster students' scientific spirit of daring to question and innovate, as well as the craftsmanship spirit of striving for excellence and pursuing perfection. In practical teaching, we will emphasize engineering ethics, guiding students to establish a professional philosophy centered on "quality first and safety supreme."

Integrate philosophical thinking and enhance critical thinking skills. By introducing engineering philosophy, we will guide students to apply dialectical thinking to solve technical challenges: for instance, using the principle of "quantitative change leading to qualitative change" to analyze the relationship between motor heating and insulation lifespan, and employing the method of "grasping the principal contradiction" to resolve the contradiction between "reducing current" and "increasing torque" during the starting of asynchronous motors, thereby cultivating students' ability to think systematically and make scientific decisions.

Focus on cutting-edge technologies and cultivate forward-thinking mindsets. Guide students in reviewing the development and evolution of AC and DC motors, exploring the technological logic behind why "AC motors have repeatedly replaced DC motors without completely doing so," analyzing the application prospects of cutting-edge technologies such as permanent magnet synchronous motors and brushless DC motors, and fostering students' keen insights into technological development trends and innovative awareness.

4. Implementation cases of teaching reform

Taking the teaching of "Principles and Applications of AC Motors" as an example, using the unit on "Principles and Energy-Saving Applications of AC Motors" as a carrier, a three-stage teaching model of "pre-class independent preview–in-class in-depth exploration–post-class expansion and improvement" is constructed, with specific implementation as follows:

Pre-class stage: In this crucial pre-class phase,

the focus lies on building solid foundations online and precisely pinpointing the difficulties that students may encounter. Students are actively engaged in the self-learning process. They independently explore and study fundamental theories through the MOOC platform. Specifically, they delve into the structural composition and rated parameters of synchronous motors and induction motors. These theoretical aspects are the cornerstones of understanding the working principles of these motors. After the self-learning, students complete online quizzes to test their understanding and knowledge acquisition.

On the teachers' side, they play a vital role in analyzing the platform data. By carefully examining the data generated from students' learning activities, such as video-watching records and quiz results, teachers make an important discovery. They find that more than 85% of the students repeatedly replay the videos related to the "generation and characteristics of rotating magnetic fields." This high frequency of video re-watching clearly indicates that this content poses a significant challenge to the students. Therefore, teachers identify this content as the core difficulty in the pre-class learning. Based on this accurate identification of the difficulty, teachers then formulate targeted teaching plans. These plans are designed to specifically address the core difficulty and help students better understand and master the challenging content during the subsequent in-class teaching.

In-class phase: Combining the virtual and the real, and driving inquiry with case studies. At the beginning of the class, the teacher intuitively presents the formation process of rotating magnetic fields through demonstrations with physical teaching aids and dynamic simulations via 3D animations, thereby solving the problem of understanding abstract concepts. Subsequently, the teacher introduces a case study on the "energy-saving renovation of fan motors in commercial buildings," which was developed in collaboration with enterprises, and poses a series of tiered questions: "In what aspects do synchronous motors demonstrate energy-saving advantages over asynchronous motors?" "How can energy-saving benefits and the payback period of investment be quantified based on motor nameplate parameters?" "How does the renovation plan align with the requirements of the 'dual carbon' strategy?" Students

engage in discussions and analyses in groups, and, under the guidance of the teacher and enterprise engineers, complete the design and demonstration of technical solutions, followed by presentations of their outcomes.

Post-class phase: In this crucial post-class period, the main objective is to carry out expansion and extension activities so as to deepen the cultivation of students' abilities. After the formal class is over, students are required to complete comprehensive case reports. These reports are designed to integrate multi-dimensional content. They cover various aspects, including in-depth technical analysis, which involves a detailed examination of the technical principles, processes, and potential improvements. Economic evaluation is also an important part, where students need to assess the cost-effectiveness, investment returns, and long-term economic viability of relevant projects. Additionally, environmental benefit analysis is included, which focuses on evaluating the positive and negative impacts on the environment, such as energy consumption reduction, pollution prevention, and sustainable development contributions.

Meanwhile, students are encouraged to independently select additional learning resources for in-depth exploration. For example, they can choose materials like "Interpretation of International Motor Efficiency Standards (IE Classes)." This resource offers a comprehensive understanding of the international standards for motor efficiency, including the background, specific requirements, and the significance of these standards in the global market. Another option is "Analysis of the Correlation between Motors and the Dual Carbon Strategy," which delves into how motors play a role in achieving the goals of carbon peaking and carbon neutrality, and the corresponding strategies and measures. Through this entire process, students not only have the opportunity to consolidate their theoretical knowledge learned in class but also gradually develop an engineering mindset. This mindset emphasizes considering the synergy of "technology–economy–environment," enabling them to make more comprehensive and rational decisions in future engineering practices.

5. Conclusion

Against the backdrop of the new engineering discipline initiative, the teaching reform of "Electrical Machinery" is rooted in the fundamental principle of cultivating students with moral integrity and aims to meet industrial demands. Through a four-in-one reform pathway that "empowers teaching efficiency with information technology, adapts to individuality through tiered design, strengthens practice through industry-education integration, and leads value with curriculum-based ideological and political education," a collaborative education system integrating "theory, practice, and values" has been established. This reform program effectively addresses prominent issues in traditional teaching, such as the disconnection between theory and practice and insufficient student initiative, achieving the talent cultivation goal of producing individuals with "strong political qualities, solid professional foundations, and outstanding innovative capabilities." Teaching practices have demonstrated the significant effectiveness of this reform model: the "Electrical Machinery" course has been recognized as a first-class blended online and offline course in Guangdong Province and a model course for ideological and political education in Guangdong Province. Leveraging the Smart Electrical Industry College under the Ministry of Industry and Information Technology and the Guangdong Provincial Modern Industry College for Smart Electrical Engineering, the school-enterprise cooperation mechanism has been continuously deepened, providing solid support for teaching reform.

The teaching reform framework constructed in this study is not only applicable to the course of "Electrical Machinery," but also provides replicable and promotable practical experience for other engineering disciplines to carry out curriculum-based political and virtuous education and hybrid teaching reforms in the context of the new engineering discipline initiative. In the future, we will further optimize the construction of teaching resource repositories, deepen the industry-education integration mechanism for talent cultivation, and continuously improve the quality of talent development, so as to supply more high-caliber professionals for the high-quality development of China's electrical industry.

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