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Technology Empowerment, Practice Foundation, and Ideological and Political Cultivation: Teaching Reform and Practice of the National First-Class Course "Electrical Machinery"

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Abstract: Addressing the traditional teaching challenges in the "Electrical Machinery" course, such as abstract magnetic fields, complex principles, disconnected practical applications, and weakened ideological and political education, as well as the dual demands of emerging engineering disciplines for high-quality engineering talents with both "innovative practical abilities and value-oriented qualities," this study constructs and implements a three-dimensional teaching reform model of "technology empowerment, practice foundation, and ideological and political cultivation." By developing visual teaching resources through digital technologies, establishing a practical education platform through industry-education integration, and organically embedding ideological and political elements throughout the entire teaching process, a systematic reform pathway of "resource support, closed-loop process, and value-oriented guidance" is formed. Teaching practice demonstrates that this model effectively alleviates students' fear of difficulty in course learning, enhances their engineering application abilities, and values-oriented qualities. The course has been successively recognized as a national first-class hybrid online-offline course and a Guangdong Provincial Ideological and Political Education Demonstration Course. The relevant experience has been promoted in multiple universities, providing a replicable practical paradigm for the high-quality construction of core engineering courses in the context of emerging engineering disciplines.

Keywords: Electrical Machinery; First-class course; Technology empowerment; Practice-based foundation; Ideological and political cultivation

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1. Introduction

The construction of emerging engineering disciplines focuses on the demands of industrial upgrading and technological innovation, with the core objective of cultivating high-quality engineering talents equipped with digital application capabilities, the ability to solve complex engineering problems, as well as a sense of patriotism and professional ethics [1]. "Electrical Machinery" serves as a core foundational and compulsory course for the Electrical Engineering and Automation major, systematically covering the fundamental electromagnetic relationships, structural characteristics, operational characteristics, and other core aspects of typical electrical machines such as transformers, asynchronous motors, synchronous motors, and DC motors. The course content combines theoretical depth with engineering practicality, acting as a crucial bridge linking foundational theory with professional applications and serving as a core vehicle for cultivating students' abilities in engineering modeling, system analysis, and solving complex problems [2]. However, under the traditional teaching model, which primarily relies on teacher-led instruction and separates theory from practice, this course has long faced multiple prominent challenges that significantly constrain the improvement of educational quality:

Firstly, there is a disconnect between theoretical abstraction and cognition. The course spans multiple fields such as electricity, magnetism, and mechanics. Since magnetic fields are invisible, winding structures are complex, and operational principles are difficult to visualize, it is known as the "foremost of the four most challenging textbooks in electrical engineering." Students generally have a fear of difficulty and only have a superficial understanding of core knowledge points.

Secondly, there is a disconnect between teaching content and industry needs. The textbooks place a heavy emphasis on classical theories, and due to limited class hours, teachers find it difficult to expand on engineering application scenarios. In particular, they are unable to systematically explain content such as the energy-saving transformation of motors under the "dual carbon" goals and their practical applications in smart grids. This results in a lag between the knowledge system students master and the actual job requirements of enterprises.

Thirdly, there is a disconnect between practical teaching and ability development. Motor experiments are plagued by issues such as complex operations, high associated costs, and stringent safety requirements. They are mostly verification-based, making it difficult to cultivate students' innovative abilities in solving complex engineering problems.

Fourthly, there is a disconnect between ideological and political education and professional knowledge. Ideological and political elements are often presented in the form of "additional cases," lacking logical coupling with professional knowledge points, and making it difficult to achieve deep synergy between value shaping and knowledge transmission [3].

While scholars have explored pedagogical reforms for "Electromechanics" courses—including integrating ideological-political elements and developing blended learning models [4,5]—existing research predominantly focuses on isolated dimensions (e.g., technical or ideological-political aspects) without achieving systematic integration of "technology-practice-ideology-politics." Moreover, insufficient attention has been paid to the practical implementation of teaching models and holistic educational outcomes. Guided by constructivist learning theory, the Objectives-Based Education (OBE) framework, and value clarification theory, this study proposes a tripartite reform model: "technology empowerment, practice foundation, and ideological-political soul-casting." Through systematic resource development, process design, and ideological-political integration, it addresses traditional teaching challenges and provides practical references for engineering curriculum reform in the new engineering education era.

This paper takes "student-centered, output-oriented, and continuous improvement" as its core, and based on the requirements of the new engineering discipline construction and the characteristics of the course, achieves coordinated efforts across three major dimensions:

Technology empowerment: Leveraging digital and intelligent technologies to overcome the abstract challenges of the course, optimizing the learning experience and teaching efficiency;

Practice foundation: Strengthening engineering practice sessions through a school-enterprise collaboration platform to enhance students' ability to solve real-world engineering problems;

Ideological and political cultivation: Uncovering the value elements embedded in the course to achieve an organic unity of knowledge transmission, ability cultivation, and value shaping.

2. Technology empowerment to build a new digital teaching ecosystem

In response to the course characteristics of "Electrical Machinery," which spans multiple fields including electricity, magnetism, and mechanics, with invisible magnetic fields, abstract principles, and complex structures, as well as the practical challenges of students having varying levels of foundational knowledge, rapid technological iteration in the industry, and a heavy emphasis on theoretical content in textbooks, the teaching team aims to "make abstract knowledge visual, personalized learning precise, and autonomous learning intelligent." Through systematic construction of digital resources, innovation in blended teaching models, and reform of evaluation mechanisms, a new technology-empowered teaching ecosystem is established, providing core support for the "three-in-one" reform model.

2.1. Development of a three-dimensional digital resource system

Guided by the core objectives of "resolving teaching bottlenecks and meeting learning needs," we will establish a diverse resource repository encompassing "visual resources, systematic resources, and intelligent tools," facilitating the concrete transformation of abstract knowledge and precise coverage of learning support.

Visual teaching resources: Focusing on core challenges such as motor magnetic fields, structures, and principles, we will develop simulated 3D animations to achieve "visualization of complex structures, vivid representation of abstract magnetic fields, and lively depiction of teaching difficulties" through dynamic demonstrations. Additionally, we will record videos covering key knowledge points.

Systematic learning resources: Leveraging national-level high-quality resource-sharing courses, we will carefully select core knowledge units from MOOCs to construct a tiered resource system comprising "compulsory and elective" components. Compulsory resources will concentrate on fundamental knowledge points and experimental preview essentials, ensuring that students solidify their professional foundations. Elective resources will cover emerging motor technologies, cutting-edge industry applications, energy-saving transformations under the "dual carbon" goals, and extended literature, catering to the personalized learning needs of students with varying backgrounds.

Intelligent teaching tools: We constructed a knowledge graph for Electrical Machinery on the Learning Pass platform, connecting scattered knowledge points into a systematic network of "principles–structure–application" to help students organize logical frameworks. We also developed an intelligent course Q&A agent based on a core Q&A database, providing precise 24/7 Q&A support services to address students' post-class knowledge queries and practical issues, overcoming the limitations of traditional classroom Q&A sessions constrained by time and space.

2.2. Innovative practice in blended teaching models

Guided by the core logic of "efficient offline foundation-building and stratified online expansion," we implemented blended teaching to achieve coordinated advancement in "knowledge transfer, skill development, and personalized enhancement."

2.2.1. Offline "four-in-one" efficient and advanced classroom

In-class sessions utilize visual resources such as 3D animations and physical teaching aids to efficiently deliver key and challenging content, enhancing classroom efficiency and freeing up time for discussions, explorations of cutting-edge technologies, and engineering applications. While ensuring a solid grasp of foundational theoretical knowledge, we emphasize the "breadth, depth, and warmth" of the curriculum by constructing a "theory + frontiers + practice + ideological and political education" four-in-one teaching framework. This approach achieves knowledge transfer, skill enhancement, and value-oriented guidance without increasing students' academic workload.

2.2.2. Mandatory pre-class learning and optional post-class learning online

The online approach employs a tiered design of "mandatory pre-class learning + optional post-class learning," transforming fundamental knowledge points into challenge-based tasks that all students are required to complete before class to solidify their foundational knowledge. The optional learning section covers core course content and supplementary resources, enabling students with weaker foundations to selectively review and fill knowledge gaps online, reinforce their understanding through repetition, and identify their weak areas precisely based on online learning data such as knowledge point replay rates and test accuracy rates. This not only provides data support for continuous teaching improvement but also dynamically delivers personalized learning resources, forming a "data-driven–continuous improvement" teaching loop. Students with stronger academic capabilities can autonomously select supplementary resources for in-depth exploration, ultimately constructing a complete learning loop of "pre-class foundational learning—in-class advanced discussions—post-class tiered expansion," truly achieving the teaching goal of scaled, individualized instruction.

2.3. Technology-empowered diversified evaluation

To enhance the systematicity and effectiveness of teaching reform and promote the in-depth integration of technology empowerment with practical teaching and evaluation systems, it is imperative to reform the traditional evaluation mechanism. Based on digital teaching data, a process-oriented and multi-dimensional diversified evaluation system is established, which breaks the single evaluation mode of "one examination determining the final outcome." By organically combining formative evaluation with summative evaluation, the system comprehensively and objectively reflects the whole process of students' learning and the development level of their comprehensive literacy.

(1) Formative evaluation

It covers core dimensions, including the completion rate of online learning progress, the performance in in-class exercises, the quality of participation in in-depth classroom discussions, the standardization of experimental operations, and the outcomes of group project practice. A tripartite evaluation mechanism integrating teachers' professional evaluation, students' peer assessment, and industry evaluations from enterprise mentors is adopted to achieve the diversification of evaluation subjects and the objectivity of evaluation results, giving full consideration to both the effectiveness of theoretical learning and the ability of practical application.

(2) Summative evaluation

The proposition structure of the final examination is optimized by increasing the score weight of analysis-evaluation and comprehensive-application questions, with a focus on assessing students' ability to apply professional theoretical knowledge to solve complex engineering problems. Meanwhile, ideological and political scenario-based questions are added, integrating professional ethics judgment and value orientation guidance into the evaluation process, so as to realize the organic unity of knowledge assessment, competence evaluation, and value shaping.

(3) Supplementary incentive mechanism

An incentive system for co-construction of teaching resources is established to encourage students to take the initiative in participating in course resource development, such as recording key knowledge explanation videos, selecting and recommending high-quality extended learning resources, and compiling practical case databases. Corresponding academic bonus points are awarded for such contributions, which serve to stimulate students' learning initiative, participation enthusiasm, and innovative thinking, thus forming a positive cycle of "teaching and learning benefiting each other, and resources being co-constructed and shared."

3. Deepening industry-education integration and building an engineering-oriented practical teaching system

Guided by the core principles of Outcome-Based Education (OBE) accreditation, and leveraging collaborative platforms such as the Ministry of Education's industry-university-research cooperation projects and the Ministry of Industry and Information Technology's Modern Industrial College for Intelligent Electrical Engineering, we promote the deep integration of real-world engineering scenarios with practical teaching. This approach facilitates the construction of a systematic, engineering-oriented, practical teaching system, effectively enhancing students' engineering application capabilities and innovative qualities.

3.1. Construction of a case library for school-enterprise collaborative engineering

Leveraging the platform advantages of the "Modern Industrial College of Intelligent Electrical Engineering" under the Ministry of Industry and Information Technology, we have engaged in in-depth cooperation with leading enterprises in the electrical equipment sector to select real-world engineering projects in areas such as energy-efficient motor retrofitting, fault diagnosis, and permanent magnet remanufacturing. The case design adheres to the principles of "engineering orientation and task decomposition." For example, in the case of "Permanent Magnet Remanufacturing of Old Motors," enterprises provide decommissioned motor specimens, actual operational parameters, and industrial retrofitting objectives, guiding students to complete the entire process in project teams, thereby achieving precise alignment between engineering problems and teaching modules.

3.2. Implementation of closed-loop practical teaching combining virtual and real elements

We have established a four-in-one closed-loop practical teaching process that integrates "online preview–offline hands-on practice–virtual simulation–enterprise practice," breaking through the temporal, spatial, and resource constraints of traditional practical teaching:

Online preview stage: Students familiarize themselves with experimental principles, operational procedures, and key control points in advance through customized experimental explanation videos, laying a solid theoretical and operational foundation for offline hands-on practice.

Offline hands-on practice stage: Hands-on training is conducted in professional laboratories to enhance students' practical operational skills and awareness of engineering standards.

Virtual simulation stage: Integrate into national-level first-class virtual simulation teaching projects such as the "Virtual Simulation Experiment of Electric Motors Driven by Engineering Data and Scenarios." This approach breaks through the limitations of physical experiments in terms of space, equipment costs, and safety risks, thereby expanding the depth and breadth of practical teaching.

Enterprise practice stage: Leveraging the school-enterprise cooperation bases, students are arranged to enter enterprise production workshops and participate in real engineering tasks, achieving a seamless transition from classroom practice to industrial scenarios.

4. Ideological and political nurturing: Uncovering value elements to achieve value guidance throughout the entire process

Centered on student development, we systematically uncover the ideological and political elements embedded in the curriculum and organically integrate them into the entire teaching process, achieving subtle yet impactful value guidance. Based on the characteristics of the "Electrical Machinery" course and the growth needs of students, the team has identified three core categories of ideological and political elements, ensuring that ideological and political education is "rich in content, vivid in context, and profound in spirit."

The first category is "Patriotic Sentiment" cases: From the pioneering efforts of Mr. Zhong Zhaolin in establishing China's first electric machinery department to the inspiring stories of Academician Ma Weiming overcoming challenges in integrated ship power systems; from China's remarkable achievements in surging hydropower installed capacity and grid scale to the in-depth interpretation of national strategies such as the "Dual Carbon Goals," "New Energy Generation," and "West-to-East Power Transmission," these cases enable students to intuitively grasp the development trajectory of the industry, clarify the mission of electrical engineers in this era, and enhance their national pride and sense of responsibility in contributing to science and technology for the nation.

Second, there are "professional quality" cases: sharing the perseverance story of Wang Jin, a master craftsman of a great power, who conducted live-line operations to ensure the safety of the power grid, and recounting the anecdote of Steinmetz refusing a high salary offer from Ford and adhering to his original intention of gratitude; by integrating the beauty of technology, environmental protection, and industry inherent in motor technology, students are guided to view grassroots positions dialectically and establish the professional belief that "ensuring that ordinary people have access to electricity at all times is the responsibility of electrical engineers." Many students have voluntarily taken root in grassroots power departments after graduation, applying their knowledge to serve rural revitalization and energy construction, which is a vivid demonstration of the effectiveness of ideological and political education in the curriculum.

Third, there are "thinking method" cases: delving into the philosophical logic behind the structure and principles of motors—interpreting the law of "transformation from quantitative change to qualitative change" by analyzing the relationship between rotational speed and torque, and imparting the method of "grasping the principal contradiction" by dissecting the fault diagnosis process, helping students develop the ability to solve engineering problems using philosophical thinking, thereby improving learning efficiency and shaping a correct worldview.

5. Conclusion and prospects

5.1. Research conclusion

Aiming at the traditional teaching pain points of the Electrical Machinery course, such as abstract theories, disconnection from practical applications, and insufficient integration of ideological and political education, as well as the dual training requirements for high-quality engineering talents under the emerging engineering education initiative, this study constructs and practices a three-dimensional teaching reform model of "Technology Empowerment, Practice Orientation, and Ideological and Political Cultivation," which is underpinned by constructivist learning theory, the OBE concept, and value clarification theory.

By systematically developing digital teaching resources, innovating the blended teaching model, and reforming the diversified evaluation mechanism, this model effectively addresses the key teaching challenge of the course's abstract and incomprehensible content, achieving precise and personalized knowledge delivery. Relying on the university-enterprise collaborative platform, an engineering-oriented practical system has been established. Through the three-dimensional efforts of case transformation, virtual-real integration, and platform support, students' practical capabilities and innovative literacy in solving complex engineering problems have been significantly enhanced. By deeply embedding ideological and political elements into the entire teaching process, the organic integration of knowledge imparting, competence development, and value shaping has been realized.

Teaching practice verification shows that this reform model has yielded remarkable results: students' fear of the course has been effectively alleviated, their learning initiative and participation have been significantly improved, and their engineering application capabilities, innovative thinking, and professional ethics have achieved coordinated development. The course has successively been recognized as a national first-class online and offline blended course, and a demonstration course for ideological and political education in Guangdong Province, with relevant teaching experience promoted and applied in many peer universities. Rooted in the core characteristics of the Electrical Machinery course and responding to the requirements of the emerging engineering education initiative, this model provides an operable and replicable practical paradigm for core engineering courses to address the integration dilemma of "theory-practice-ideological and political education."

5.2. Future prospects

Although this study has achieved phased results, teaching reform is a continuous and iterative systematic project. Future efforts can be further deepened and expanded in three aspects:

First, in terms of technology empowerment, we can integrate cutting-edge technologies such as artificial intelligence and digital twins to develop more interactive, immersive teaching scenarios, build a full-process smart teaching closed loop of "data-driven, intelligent adaptation, and precise feedback," and further improve the accuracy of personalized teaching.

Second, in terms of industry-education integration, we can deepen the university-enterprise collaborative talent training mechanism, promote the dynamic synchronization between "authentic enterprise projects" and "course teaching content," co-construct a cross-regional and cross-industry platform for sharing practical case resources, and expand the breadth and depth of students' engineering practice.

Third, in terms of ideological and political education, we can focus on new national strategic demands such as the "dual carbon" goals and the construction of new power systems, continuously explore ideological and political elements in cutting-edge industry developments, build a dynamically updated ideological and political case database, and strengthen the contemporaneity and pertinence of value guidance.

Meanwhile, we will further track the long-term effectiveness of the reform outcomes, continuously optimize the teaching model through multi-round practical verification in multiple universities, and provide more solid practical support for the high-quality development of higher engineering education under the background of emerging engineering education.

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Disclosure statement

The authors declare no conflict of interest.

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