Exploration and Practice of Blended Teaching Mode in Electrical Engineering Courses

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Abstract. "Electrical Engineering" is a crucial foundational course in engineering colleges and universities in China. This paper utilizes the SPOC platform of Zhihuishu to develop the online course of "Electrical Engineering". Combining MOOC and flipped classroom, the "Four-Integration" flipped classroom teaching model has been carried out, which incorporates ideological and political education, industry-academia collaboration, online and offline learning, and in class and extracurricular activities. The theoretical instruction is integrated with the BOPPPS model, while the experimental training adopts a project-based approach. A multidimensional and diversified system for teaching evaluation is built and put into practice. An exploration into the teaching model of this course has resulted in the improvement of students' comprehensive qualities and abilities, accomplishing the integration of value orientation, knowledge transmission, and capacity cultivation.

Keywords: blended teachi mode, Electrical Engineering, four integration, flipped classroom

1 Introduction

In the context of the "Internet Plus" era, the Massive Open Online Course (MOOC) phenomenon has gained massive global momentum[1]. While MOOC teaching offers significant convenience, it also faces challenges such as low student persistence, high dropout rates, and difficulties in assessing learning outcomes[2]. Consequently, this gave rise to the emergence of the Small Private Online Course (SPOC) model[3], which combines MOOC resources with traditional classroom. Not only does it ensure the sufficiency of SPOC teaching resources by fully sharing the abundant online courses of MOOCs, but it also raises the course entry threshold and reduces student cohort size. Combined with traditional physical classrooms, this approach makes education more targeted, significantly enhancing teaching quality and efficiency[4]. Since then, a substantial body of research on the MOOC+SPOC teaching model has continuously emerged, encompassing studies on teaching reform, curriculum development, and practical applications.

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The flipped classroom differs from the traditional classroom teaching model[5]. Firstly, It fundamentally reverses the traditional order of teaching and learning. In this model, the acquisition of new knowledge is completed individually before class, while in-class time is reserved for teacher-student collaboration on problem-solving, marking a fundamental shift from a "teaching-before-learning" to a "learning-before-teaching" framework. Secondly, the roles of the teacher and students are reversed. The teacher's role transforms from the sole authority in the classroom to an active participant, from a mere lesson plan writer to an architect of learning resources, and from a transmitter of knowledge to an organizer of learning activities. Rather than being the "actor" on the teaching stage, the teacher now becomes the "director". This teaching model shifts the focus of the classroom to the students, transforming their attitude from a passive "make me learn" to a proactive "I want to learn". Finally, the smooth implementation of the flipped classroom requires information technology as a backbone. MOOC and SPOC can serve as high-quality extracurricular learning resources, providing strong support for the implementation of the flipped classroom[6]. Therefore, integrating the MOOC+SPOC model with the flipped classroom allows more capable students to acquire deeper knowledge, while enabling those with weaker foundations to compensate through repeated study, thereby enhancing overall teaching effectiveness[7].

"Electrical Engineering" is a crucial foundational course in engineering colleges and universities in China. Catering to non-electrical engineering majors such as Mechanical, Energy, Chemical, and Materials Engineering, this course bears the critical mission of establishing a comprehensive electrical engineering knowledge system for future non-electrical engineers and engineering managers upon graduation[8]. Targeting the Electrical Engineering course, this paper explores and practices a four-integration blended teaching model that incorporates ideological and political education, industry-academia collaboration, online-offline learning, and in-class and extracurricular activities.

2 Integration of Ideological and Political Elements for Enhanced Educational Function

We have integrated ideological and political elements into the Electrical Engineering syllabus in a "whole-chain" manner, including learning objectives, content, teaching methods, and assessment, as shown in Figure 1.

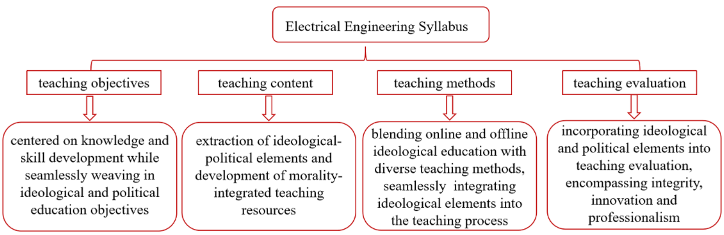

Fig. 1. "Whole-Chain" Integration of ideological and political elements into the curriculum syllabus

We have scientifically and rationally explored the ideological and political elements inherent in the Electrical Engineering course and integrate them organically into the course content, forming a "morality-integrated teaching plan" with distinctive course characteristics, as shown in Table 1.

Table 1. Styles available in the Word template

Knowledge Points	Ideological and Political Elements	Ideological and Political Education
Introduction to electrical engineering	Incorporating historical cases, including ancient Chinese understanding of electricity and magnetism, as well as compass manufacturing techniques	Patriotic education: Fostering national identity and patriotism, inspiring the historical mission to build a powerful China
Ohm's Law and Kirchhoff's Laws	The interplay between Circuit stability and topology, and the interrelationship between voltage and current	Patriotic education: Balancing family and national duties, upholding the mission with a sense of patriotic responsibility
Calculation of electric potential and Ohm's Law for magnetic circuits	The relationship between electric potential and voltage, and the duality between electric and magnetic circuits	Social conduct education: Life is not all about competition and self-interest, but more about mutual empowerment, shared growth, and collective warmth.
Thévenin's Theorem and Norton's Theorem	Representing a complex active two-port network as an equivalent circuit of a simple source with series/parallel internal resistance	Personal character education: Simplicity in character, frugality in living, and directness in action-these principles help students understand how a simple life can cultivate integrity, purify the mind, clarify purpose, and nurture virtue.
the Laws of Circuit Switching	The voltage across a capacitor and the current through an inductor cannot change abruptly.	Personal character education: Success is never instantaneous. It is built through persistent dedication to small, tangible tasks, achieved with unwavering commitment over time.
Resonant Circuit	Circuit resonance presents a dual nature, embodying both beneficial effects and potential drawbacks.	Personal character education: All things have two sides, which can transform into each other, illustrating the dialectical principles of unity of opposites and reversal at the extreme.
Components of the power system	The stable operation of the power system relies on the coordinated interaction among its five core components: generation, transmission, transformation, distribution, and consumption.	Social conduct education: The power of a team is immense. Its members must work in a coordinated manner with clear division of labor, for only through such collaboration can great victories be achieved.

Knowledge Points	Ideological and Political Elements	Ideological and Political Education
Magnetic properties of ferromagnetic materials	To avoid saturation, the operating point is typically set near the knee point of the curve.	Social conduct education: In daily life and interactions, one should avoid extremes and leave room for flexibility, as this is the key to enduring harmony.
Structure of three-phase induction motor	Squirrel-cage and wound rotors each have distinct advantages and limitations, making the choice of motor type dependent on the specific application.	Social conduct education: Clearly identify your strengths and weaknesses, and learn to maximize your advantages while mitigating shortcomings. Furthermore, observe and adopt the strengths of your peers to achieve mutual growth.
Reduced-voltage start for three-phase induction motors	The purpose of reduced-voltage starting is to decrease the starting current, but it also results in a reduction of the starting torque.	Social conduct education: One must learn the art of letting go and prioritize the bigger picture, for only by discerning what truly matters can wise choices be made.

In classroom teaching, different teaching methods such as heuristic and analogical approaches are flexibly selected according to specific content. Emphasis is placed on ensuring the compatibility and appropriate integration points between ideological and political education and theoretical knowledge instruction, thereby avoiding excessive introduction or insufficient integration while preventing both the overgeneralization and oversimplification of ideological and political education[9]. For instance, when explaining the calculation of electric potential, the heuristic teaching method can be employed to guide students in contemplating and understanding the relationship between electric potential and voltage. This approach naturally leads to introducing Confucius' perspective on interpersonal relationships: "A gentleman helps others fulfill their virtuous deeds but never assists them in evil acts." By citing historical examples such as the story of Emperor Wen of Han and his minister Zhang Shizhi, as well as Emperor Taizong of Tang and his "Twenty-Four Meritorious Officials of Lingyan Pavilion," teachers can seamlessly integrate teachings on principles of conduct. The entire process unfolds naturally and seamlessly, without being abrupt or overshadowing the main content, thereby achieving a subtle educational impact.

3 Course Content Reconstruction Via Sci-education and Industry-education Convergence, Embodying Frontier Knowledge, Advanced Rigor, and Innovation

We have innovated and restructured the "3331" framework for electrical engineering courses. The course is structured around three main content threads: "Circuits" , "Electrical Energy" , and "Control." Specifically, the Circuits component comprises three modules (3 = 1 Model + 2 Analyses), the Electrical Energy component consists of three modules (3 = 1 Overview + 2 Technologies), and the Control component includes one module, as illustrated in Figure 2.

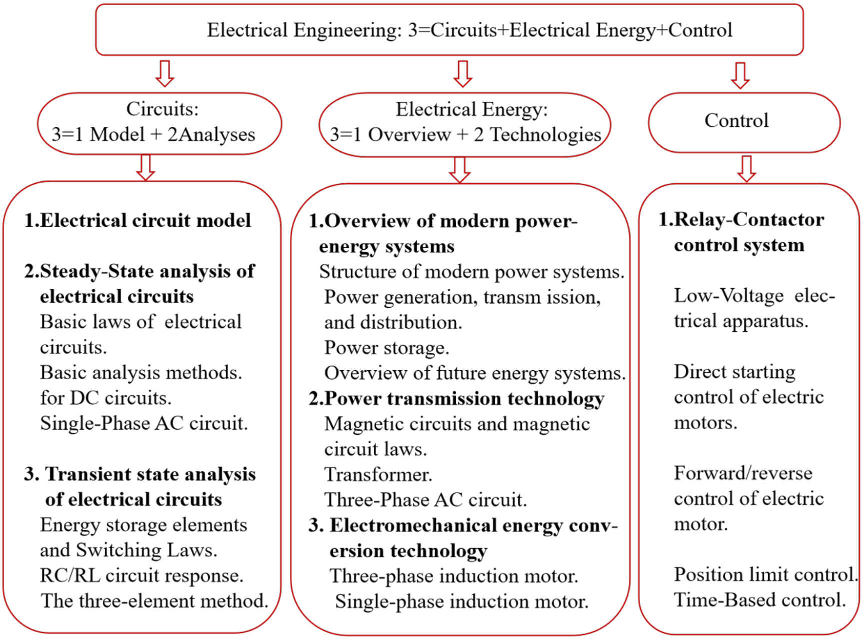

Fig. 2. The "3331" curriculum content system

The course progresses from circuits to electrical energy and then to control, evolves from models to objects and finally to systems, and advances from theory through technology to practical applications. This logical progression ensures clear content flow and a coherent structure, helping students develop sound scientific thinking methodologies.

Within the cou framework, teachers infuse their latest research findings into the course as teaching cases for case-based instruction, and integrate practical engineering applications with experimental platforms for scenario-based learning. This approach demonstrates the course's cutting-edge nature, intellectual rigor, innovation, and contemporary relevance. It successfully stimulates students' learning interest and research enthusiasm while enhancing their practical innovation capabilities, as detailed in Table 2.

Table 2. Infusion of research and engineering achievements into the curriculum content system

Curriculum content	Integration of research and education	Integration of industry and education	Features of the curriculum content
RC/RL circuit response	Research project: State estimation for power batteries in new energy vehicles	Application examples: Flashlight&Automotive ignition circuit	Frontier, High-Order, Innovative

Curriculum content	Integration of research and education	Integration of industry and education	Features of the curriculum content
Power generation, transmission, distribution, and storage	Research project: Forecasting, grid Integration, and planning for new energy generation and energy storage	Application examples: New energy generation technologies such as solar and wind power	Frontier, High-Order, Innovative
Overview of future energy systems		Application examples: Leveraging renewable energy to achieve the Dual Carbon goals	Frontier, Contemporary relevance
Transformer	Research project: Study on DC Bias of transformers	Application example: Audio frequency electrotherapy device	High-Order, Innovative
Three-phase induction motor	Research project: Permanent magnet motor	Application example: Application of electric motors in Radial Drilling Machines	High-Order, Innovative

4 Through Online-offline Integration and In-class-out-class Integration, Enabling Innovations in Teaching Methods, Learning Environment Development, and Education Assessment Reform

We fully utilize the rich resources of MOOCs to curate and recommend quality courses for students, while also building the online electrical engineering course on the Zhihuishu SPOC platform. The course content was modularized into 30 key knowledge points, with teaching videos produced for each, ranging from 10 to 15 minutes in duration. We have developed both online and offline courseware, and enriched supplementary teaching materials such as exercise banks, knowledge graphs, and ideological-political case studies.

By leveraging the complementary strengths of MOOCs and SPOCs and integrating the flipped classroom model with the BOPPPS framework[10], we have implemented a blended teaching approach that fuses online with offline learning and in-class with out-of-class activities. This has resulted in a comprehensive learning cycle, as illustrated in Figure 3, which encompasses self-directed learning before class, interactive seminar-style teaching during class, and knowledge expansion, consolidation, and application after class.

In participatory learning sessions, we emphasize a student-centered approach where instructors create a relaxed and dynamic learning environment. This environment encourages students to express their ideas freely, engage in exploration and discussion with confidence, and dare to question authority. The instructional approach prioritizes problem-chain questioning, heuristic methods, and analogical techniques alongside in-class exercises, shifting from didactic instruction to a constructivist paradigm. This transition enables students to independently identify and solve problems, formulate their own perspectives, and ultimately reverses the traditional classroom dynamic by highlighting student agency and reinforcing the teacher's guiding role.

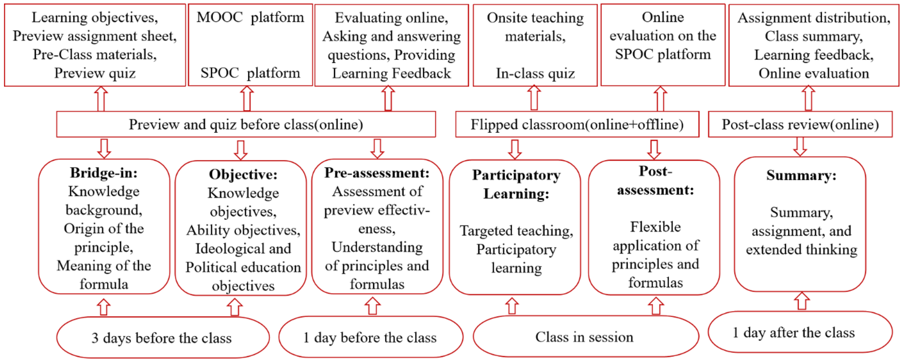

Fig. 3. Teaching implementation process

We implement project-based experimental teaching by meticulously designing hands-on projects that are closely aligned with the curriculum. Each project is structured into three phases: pre-class project preparation (online), in-class project implementation (offline, integration of teaching, learning, and practice), and post-class project extension (online). This approach emphasizes the development of students' learning initiative and engagement while enhancing their practical hands-on skills and innovative capabilities.

We have constructed, implemented, and continuously optimized a diversified and multi-dimensional evaluation system, incorporating assessment indicators for ideological and political elements, as shown in Table 3.

5 Conclusion

The implementation of the "Four-Integrations" blended teaching model has yielded the following outcomes.

1) It has enriched the course content and thereby demonstrated its frontier nature, advanced complexity, innovativeness, and modern character.

Table 3. Teaching evaluation system for the electrical engineering course

Evaluation Type	Evaluation Point	Evaluation Indicator	Evaluation Content	Evaluator	Weighting(%)
Formative assessment	Before class	Online learning engagement	Level of understanding and mastery	Teacher	4
		Online assignments and quizzes	Completion quality, Professional attitude, Integrity		4
		Online discussion	Participation		2

Evaluation Type	Evaluation Point	Evaluation Indicator	Evaluation Content	Evaluator	Weighting(%)
	During class	Class participation	Participation in discussions, Quality of responses	Teacher and students	10
		Experimental skills	Hands-on ability, Compliance with standards		8
		Comprehensive literacy	Collaborative spirit, Innovative initiative		5
	After class	Online assignment, Project report	Completion quality, Creativity and innovation	Teacher	5
		Task extension, Online discussion	Completion quality		2
Summative assessment	Final Exam	Theory Exam	Fundamental concepts and principles, Formula application, Adherence to regulations		60

2) It has significantly fostered students' awareness of self-directed learning and self-management. Consequently, classroom engagement has markedly improved, evidenced by increased eye contact, active participation, and heightened motivation, creating a vibrant learning atmosphere that seamlessly integrates online with offline and in-class with out-of-class activities.

3) It has enabled students to acquire a more solid grasp of theoretical knowledge while demonstrating significant improvement in comprehensive abilities and competencies, including practical innovation, communication and collaboration, and critical thinking.

4) The teaching team has significantly enhanced their digital pedagogical skills, achieving substantial outcomes in both curriculum development and team building.

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