Exploration of Online-Offline Blended Teaching Mode for Circuit Theory Course

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Abstract: In the traditional teaching of Circuit Theory, there exist such problems as limited teaching hours, the disconnection between theory and practice, the insufficient integration of digital technology and teaching design, and the difficulty in integrating ideological and political education. This paper proposes a blended online and offline teaching mode combining OBE concept based on the *StudyLink* platform. Relying on online platforms, it shares ideological and political resources, provides knowledge preview services, and answers students' questions; offline classes focus on the teaching of key and difficult points and the guidance of practical operations, giving full play to the coordinated advantages of online and offline teaching. Meanwhile, project design and virtual simulation technology are integrated into the entire teaching process, promoting the transformation from "indoctrination-oriented" teaching to "open inquiry-oriented" teaching, integrating the diversified assessment and evaluation model to form a closed loop of "teaching, improvement, evaluation". This mode can effectively stimulate students' learning initiative and help achieve the trinitarian teaching objectives of knowledge imparting, ability cultivation, and value guidance.

Keywords: Circuit teaching, Online and offline, Blended teaching, Virtual simulation, Multi-faceted assessment, Digital transformation, Project-driven teaching, OBE concept, Value-driven.

1. INTRODUCTION

Circuit Theory is a core professional course for majors including Electrical Engineering, Automation, and Electronic Information in agricultural universities (Hu *et al.,* 2022). It systematically elaborates on the basic theories and analytical methods of circuits, helping students develop fundamental abilities in circuit analysis, calculation, and experimental operation (Zeng *et al.,* 2024). Its teaching effect directly influences the learning quality of students' subsequent professional courses and their career development potential (Zhang *et al.,* 2022). In recent years of teaching practice, several key problems have been found.

(1) Insufficient integration of teaching content with ideological and political elements, such elements are not adequately explored. There is a lack of typical themes for cultivating students' patriotism and professional literacy of ideological and political content is often integrated mechanicaly rathen than seamlessly (Na *et al*., 2025).

(2) The teaching methods are relatively single. Classrooms are mainly dominated by theoretical lectures. The engineering practice links is weak. The extracurricular expansion is limited due to class hour constraints. These problems cannot keep up with modern technological development and meet students' diversified learning needs (Cui *et al*., 2022).

(3) Lack of innovation in teaching organization. The application of digital technology and flipped classrooms in teaching is also inadequate, and there is a lack of effective integration of digital technology with interactive teaching links. This leads to students' passive learning, low initiative, and low classroom efficiency. This situation is not conducive to cultivating their critical and innovative thinking (Zhu *et al*., 2022).

(4) Unscientific assessment methods, over-reliance on final closed-book exam results. The process assessment system is imperfect. Online platforms such as *StudyLink* are under-utilized, which cannot realize real-time monitoring of students' learning status or design diversified assessment schemes for individual differences (Li *et al*., 2022).

To address these problems, scholars have carried out fruitful explorations on teaching reform.

Sui *et al*. (2023) proposed an online-offline blended teaching method, established a supporting evaluation method, and verified its effectiveness in practical teaching. Zhang *et al*. (2025) integrated flipped classroom and participatory learning to enrich interactive teaching links and enhance students' in-class participation. Meanwhile, Wang *et al*. (2025) proposed a multi-point integrated "in-class + after-class" blended teaching method and applied it to the Power Electronics Technology course. Furthermore, Yuan *et al*. (2026) carried out reverse design of blended teaching for engineering courses based on the OBE concept. By reconstructing course objectives, teaching procedures and evaluation systems under an outcome-oriented approach, they effectively improved students' drawing ability and comprehensive quality.

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The OBE concept (Spady, 1994), emphasizes that teaching design and implementation should be centered on the learning outcomes ultimately obtained by students, and holds that all students can achieve success through scientific teaching guidance. Its development presents obvious international consensus and localized characteristics, focusing on balancing students' personalized learning needs and core competence cultivation. Some studies adopted an OBE-oriented approach to analyze big data in flipped classrooms, so as to predict learning performance and realize continuous improvementn (Qian *et al*., 2022; Li *et al*., 2023). To address the problem of insufficient integration of outcomes, the OBE concept is integrated with SRT projects to achieve in-depth synergy (Zou *et al.,* 2025). Some studies have proposed the SPLAM-OBE (Mishra, A, 2025) framework, construct a student-centered and outcome-based engineering education model, improving the quality of talent training Ma *et al*., (2026) integrated the OBE concept and BOPPPS model into the Object-oriented Software Construction course, which effectively improved the achievement of course objectives.

This study proposes and implements a goal-oriented integrated with OBE concept for curriculum reform. Its main innovation lies in that the three-dimensional teaching objectives of knowledge instruction, ability cultivation and value guidance are refined and decomposed into specific tasks. These are deeply integrated into the whole process of pre-class, in-class and post-class learning. Supported by an intelligent, data-driven evaluation system, this mechanism overcomes the limitations of traditional inculcation-based learning, such as insufficient integration and lack of analytical feedback.

2. TEACHING MODE DESIGN METHODS

2.1. Construction of the Teaching Reform

2.1.1. Research Objects

Students of the 2020 cohort majoring in Electronic Information Engineering (traditional teaching mode, N=166) were selected as the control group, and those of the 2021 cohort (reform-based teaching mode, N=114) as the experimental group. No significant differences were found between the two groups in academic foundation, cognitive ability, and professional background, which met the basic requirements for a comparative study.

2.1.2. Teaching Reform Model

Based on the core requirements of the OBE concept, combined with the professional characteristics and teaching pain points of the Circuit Theory course, the construction of the teaching reform method model is carried out to provide systematic support for the optimization of course teaching. In the construction of the teaching reform method model for the Circuit Theory course, the OBE concept should be taken as the guide, focusing on solving three core problems: first, clarifying the learning outcomes expected to be achieved by students (*i.e.*, the teaching objectives of

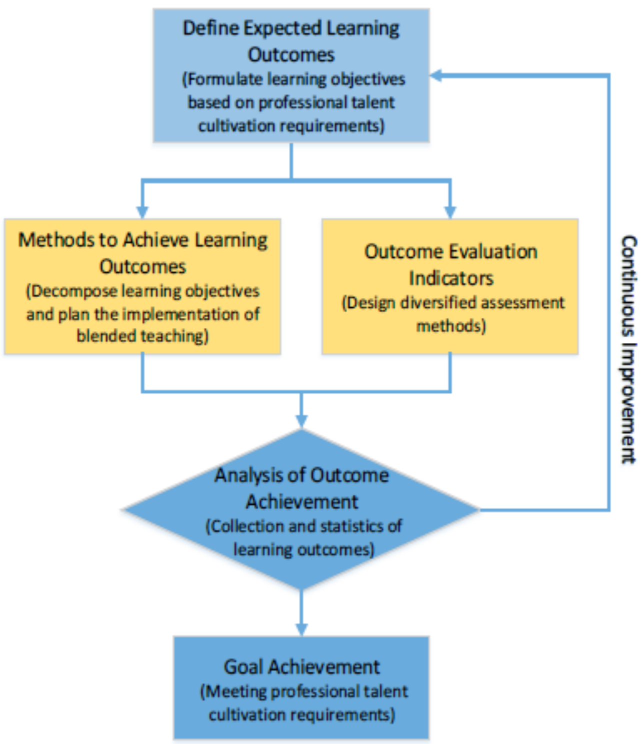

Figure 1: Teaching Reform Model.

the Circuit Theory course, including core competencies such as circuit analysis, fault diagnosis, and engineering practice); second, exploring effective paths to help students achieve the outcomes (by decomposing the course objectives, scientifically planning teaching methods and implementation processes, and integrating teaching reform methods such as project-based learning and flipped classroom); third, establishing a scientific outcome evaluation system (designing diversified assessment methods), and carrying out continuous improvement based on the evaluation results to continuously optimize the teaching reform model and improve the teaching quality. The model is shown in Figure **1**.

2.2. Design of the Teaching Mode

In response to the above issues, based on the existing teaching resources and platform conditions of the electrical and electronic discipline in Nanjing Agricultural University, and adhering to the trinity talent cultivation objective of knowledge imparting, innovative ability training and value shaping (Zhang *et al.,* 2020; Ding *et al.,* 2020). This paper designs an online-offline blended teaching model oriented by "competency objectives and talent demands", and constructs a guiding and enlightening teaching practice platform. The specific teaching model implementation workflow is shown in Figure **2**.

(1) Excavate the ideological and political connotation in depth to consolidate the foundation of moral education for personnel cultivation. Teachers should devote more effort to exploring the ideological and political elements contained in the Circuit Theory course. They should focus on the daily collection and accumulation of ideological and political resources, including the latest scientific research achievements of the discipline, the development history of circuit technology, the deeds of industry pioneers, and typical engineering cases. These efforts aim to cultivate students' moral qualities such as patriotism, professionalism and engineering awareness, and inspire their aspirations to serve the country through dedication. By organically integrating these ideological and political elements into the teaching of Circuit Theory, teachers can guide students to foster a profound sense of national belonging, uphold the craftsman spirit, and establish scientific thinking while imparting professional knowledge. This will further inspire them to commit themselves to the construction of national agricultural modernization.

(2) Develop a sophisticated online three-dimensional knowledge repository to solidify students' foundational competencies. Centering on consolidating students' theoretical foundation of circuit knowledge and cultivating their fundamental learning abilities. We systematically construct a diversified online knowledge repository consisting of modules such as an online teaching video library, an exercise bank, an assignment bank, and an extended resource library. The teaching video library is divided into several-minute micro-videos according to specific knowledge points, catering to students' fragmented learning needs for pre-class preview and post-class review. The exercise and assignment banks are closely

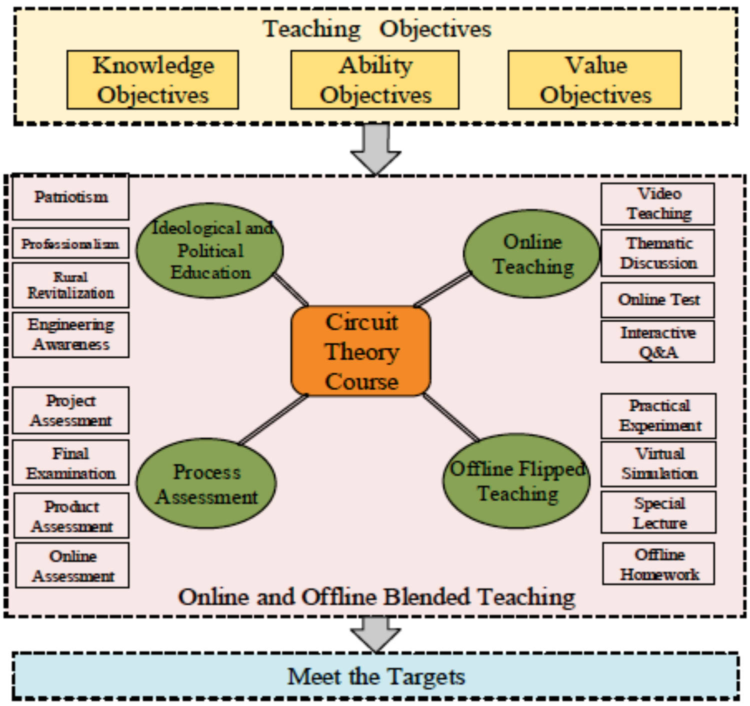

Figure 2: Teaching Mode Implementation Workflow of Circuit Theory.

aligned with the chapter content of the course, with basic, advanced, and extended questions designed hierarchically to realize targeted practice and consolidated learning. The extended resource library supplements cutting-edge developments in the circuit discipline and engineering application cases, enabling students to complete the systematic accumulation of basic knowledge in their spare time and lay a solid foundation for in-depth offline inquiry and practical operation.

(3) Deepen Offline Flipped Classroom to Stimulate Interest in Autonomous Learning. Teacher will give full play to the interactive advantages and situational value of offline teaching, and restructure the teaching process with the flipped classroom model. The flipped classroom incorporates thematic lectures, hands-on experiments, virtual simulation experiments, case analysis, and other forms. It guides students to integrate theoretical knowledge with engineering practice and cultivates their engineering thinking and problem-solving abilities.

(4) Improve Diversified Assessment Indicators to Make Good Use of the Guidance for Students' Learning. The stduy attach equal importance to process assessment and outcome assessment, with an emphasis on regular process evaluation, and adopt an integrated approach combining project incentives, final examinations, and online regular assessments. A detailed knowledge and competency assessment is conducted for each chapter and knowledge module, establishing a multi-stage assessment system that covers diverse learning outcomes. The increased volume of regular tasks urge students to take the initiative in learning during the semester, avoiding last-minute cramming for final exams, and indirectly mobilizing the enthusiasm and diversity of their autonomous learning. This multi-dimensional and phased assessment model fully covers the core objectives. These include knowledge mastery, practical ability, and innovative thinking. It compels students to focus their learning on daily study, effectively stimulates the enthusiasm and initiative of autonomous learning. Moreover, it lays a solid assessment foundation for the cultivation of innovative electrical engineering talents.

3. REFORM IMPLEMENTATION

3.1. Clarify the Three-Dimensional Teaching Objectives

Closely focusing on the core of the trinity talent cultivation of "knowledge imparting, ability training, and value guidance", the teaching objectives of the Circuit Theory course are decomposed.

(1) Knowledge Imparting Objective: Emphasize the learning of basic concepts and fundamental theories of the course. First, divide the knowledge points and teaching objectives of each chapter. Identify the key and difficult points of the chapters, reasonably optimize the teaching class hours of each chapter, clarify the teaching context, construct an overall mind map of the course. Upload the above knowledge context to learning platforms such as "Learning Pass" to help students establish a complete theoretical knowledge system of circuit accurately grasp the key points of learning. This lays a foundation for autonomous learning and in-depth learning.

(2) Ability Training Objective: On the basis of strengthening the learning of theoretical knowledge, comprehensively exercise students' practical operation ability, autonomous learning ability, team management and cooperation ability, and communication and expression ability. Such abilities are trained through literature reading, online and offline interactive communication, experimental operation, simulation design, project achievement report and other forms. These approaches help improve students' engineering practice and problem-solving literacy.

(3) Value Guidance Objective: Organic integration of theoretical knowledge and ideological and political education to realize subtle value guidance. Integrate ideological and political contents. Scientific stories, celebrity biographies, and engineering innovation cases are integrated into key knowledge points. It helps to cultivate students' patriotic feelings, professionalism, and engineering awareness, and consolidate the foundation of moral education for personnel cultivation.

3.2. Implementation Process of Online and Offline Blended Teaching

3.2.1. In-depth Integration of Ideological and Political Education System and Knowledge System into the Whole Teaching Process

Combined with the content of the curriculum knowledge system, the ideological and political elements contained in relevant knowledge points are deeply explored and organically integrated into the whole process of pre-class preparation, in-class teaching, and after-class consolidation. This breaks the disconnection between ideological and political education and professional knowledge, and gives full play to the core function of moral education in curriculum teaching. The specific implementation is shown in Figure **3**.

(1) Construction of the Knowledge System

The knowledge system consists of theoretical knowledge and practical knowledge. The theoretical knowledge is divided into three core modules: DC

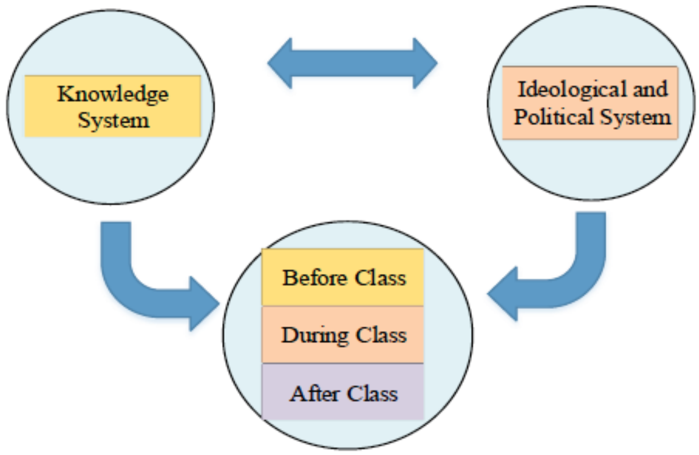

Figure 3: Ideological and Political Education Integration in Circuit Theory Course.

circuits, AC circuits, and dynamic circuits. For relatively straightforward knowledge points, such as basic concepts and principles that require students to grasp and comprehend, short instructional videos are pre-recorded and uploaded to the *StudyLink* learning platform. A certain number of objective question banks for students to complete pre-class preview assessments and unit knowledge consolidation. Teachers provide real-time answers to students' difficult or erroneous questions through online channels, including *StudyLink* and *QQ.* For challenging knowledge modules and those closely integrated with practice, a blended online-offline approach is adopted: basic content is delivered onlineIn-depth analysis is conducted offline through thematic discussions and centralized Q&A sessions, enabling students to master such knowledge effectively and thoroughly.

The practical part is driven by two pillars: offline hands-on experiments and virtual simulation design. Well-designed practical experiment content is developed, with Tianhuang circuit experiment equipment and Multisim simulation software serving as the primary tools for hands-on practice. A closed-loop practical teaching model of learning by doing and doing by learning is formed. Starting with confirmatory experiments to cultivate students' interest in experiments, design-oriented experimental projects are added as students become more proficient in operating circuit equipment and deepen their understanding of circuit theories. This helps to enhance their practical skills. During the practice process, problems encountered are carefully summarized, and the difficulty and comprehensiveness of experimental assessment are gradually refined.

(2) Construction of the Ideological and Political Education System

Circuit theory knowledge is extensively applied in industrial and agricultural production as well as daily life, and numerous valuable ideological and political elements can be explored from it. These include the life stories and biographies of scientists in the electrical field, such as Kirchhoff, Thevenin, and Tesla. Engineering innovation cases like China's ultra-high voltage DC transmission projects and the development of smart power grids are also coverd In addition practical elements can better stimulate students' interest, such as the actual impact of power factor on users and cases of large-scale power grid blackouts. Relevant ideological and political materials and videos are released before each class, corresponding content is explained in class in combination with knowledge points, and incorporated into after-class knowledge assessments. Thus, education on an outlook on life and values is imparted such as patriotism and professionalism. Meanwhile, the experimental and practical teaching also embodies value objectives, including safety awareness, rule awareness, innovation awareness, and teamwork spirit.

3.2.2. Design of Interactive Online and Offline Teaching for the Whole Stage

A blended model of online independent learning + offline flipped classroom is adopted, This forms a three-dimensional interactive teaching closed loop for pre-class, in-class, and after-class stages, so as to realize the accurate connection and efficient advancement of teaching in all links.

(1) Pre-class Self-directed Learning on the Platform to Activate the Independent Inquiry Ability

To stimulate students' awareness of auto- nomous exploration, a pre-class self-study module is designed based on an online learning platform. Preview resources including short videos on key knowledge points, difficult points and typical examples, engineering cases and ideological and political materials are provided in advance through the *StudyLink* platform. Corresponding self-assessment exercises for each chapter are also released synchronously to help students conduct self-monitoring during preview.

For selected knowledge modules, group collaborative discussions are organized with flexible grouping modes such as random grouping by student ID or free grouping. Targeted pre-class tasks are assigned to each group, and group members complete task reports through mutual communication and cooperation. This practice helps break the limitations of individual learning, and promotes the development of teamwork spirit and communication competence through task division and collaborative participation.

In addition, a short pre-class warm-up test is conducted via the *StudyLink* platform at the beginning of each class. By reviewing exercises of the previous session, students can quickly enter the learning state, and teachers can obtain real-time feedback on students' mastery of prior knowledge, so as to accurately grasp students' learning status.

(2) In-class Communication and Interaction to Create a Diversified and Efficient Classroom

Aiming at the problems and knowledge gaps reflected in students' pre-class tests, targeted intensive lectures on key topics are carried out to clarify difficult points and supplement knowledge blind spots in online learning.

With projects as the carrier, students are organized to present their learning achievements. For instance, after completing the chapter of AC circuits, students are assigned tasks such as the design and simulation verification of AC resonant circuits. The presentation process effectively improves students' language expression and logical thinking abilities, enhances their learning interest.

Diversified interactive activities are implemented by using multiple functions of the *StudyLink* platform, including various sign-in methods, real-time quizzes and bullet-screen interactions. These measures enrich classroom experience and create an atmosphere of full participation.

Ideological and political elements are organically integrated into classroom teaching. Combined with chapter content, the origin, development and typical figures of circuit analysis and related technologies, as well as industry hotspots, are introduced appropriately.

For students with strong learning ability and innovative motivation, exploratory practices such as the production of small electronic circuit products are encouraged. By supplementing applied cases and cutting-edge innovations in circuit technology.

(3) Post-class Review and Enhancement for Differentiated Ability Cultivation

After class, targeted homework is assigned, and short videos explaining typical error-prone questions are recorded and uploaded to the StudyLink platform according to students' performance in tests and assignments. Both online and offline counseling channels are provided to solve students' learning problems timely and eliminate knowledge obstacles.

The post-class experimental link integrates hands-on experiments and virtual simulation experiments. With the assistance of Multisim simulation software, students are guided to compare experimental results, simulation outputs and theoretical analyses, so as to broaden their thinking, stimulate exploration enthusiasm and deepen their understanding of professional knowledge.

Challenging design-oriented experiments are added for students with innovative intentions. Through the promotion of differentiated experimental design, the goal of talent cultivation with individual characteristics can be effectively achieved.

4. ANALYSIS AND DISCUSSION OF THE TEACHING SYSTEM

4.1. Analysis of Teaching System

Based on students' individual differences, an assessment system featuring process-oriented evaluation as the main focus, result-oriented evaluation as the supplement, and multi-dimensional assessment is constructed, highlighting the guiding role of assessment in independent learning (Yang *et al*., 2025). The weight of process assessment is increased, and the dimensions of assessment content are enriched. The system not only covers traditional assessment items (performance in offline classroom interaction, quality of after-class homework completion, mid-term phased tests), but also fully incorporates online teaching links into the assessment scope. These involve online video learning rate, attendance check-in, accuracy rate of in-class quizzes, participation in platform discussions, and frequency of teacher-student interaction. In this way, the full-process tracking of the online learning process is realized. The comparison of the assessment system before and after reform is shown in Table **1**.

To evaluate the implementation effect of the teaching reform, the achievement of teaching

Table 1: Comparison of the Assessment System Before and After Reform

Aspect	Before Reform	After Reform
Core Orientation of Assessment	Focus on outcome evaluation, with knowledge mastery as the core	Process-oriented, outcome-supplemented, highlighting the guiding role in independent learning
Weight of Process-oriented Assessment	Low proportion, mainly based on outcome assessment (*e.g.*, final written exam)	Significantly increased weight, forming a scientific ratio of "process - outcome" (process proportion ≥ 40%)
Dimensions of Assessment Content	Single, focusing on traditional offline links	Diversified and comprehensive, covering both offline and online scenarios
Online Assessment Items	None	Online video learning completion rate, attendance check-in, in-class test accuracy rate, and platform discussion participation
Offline Assessment Items	Class attendance, after-class assignments, and final exam	Offline classroom interaction performance, after-class assignment completion quality, mid-term phased test (retaining and optimizing traditional core items)
Core Goal of Assessment	Testing the degree of knowledge, memory, and mastery	Comprehensively evaluating independent learning ability, process participation, knowledge application ability, and learning effectiveness

objectives is verified, and improvements are made through questionnaires, student feedback, and other methods, so as to continuously improve teaching quality and revise teaching methods.

The reform practice was carried out on the 2021-grade students majoring in Electronic Information, with a comparative study conducted against the 2020-grade students of the same major. Student score distribution showing a more reasonable normalization after the reform is presented in Figure **4**. After the reform, the excellent rate (scores above 90 points) increased from 32.53% to 37.72%, a rise of 5.19 percentage points, the failure rate dropped from 1.81% to 0%, achieving zero failures.

To fully grasp the implementation effect of the teaching reform in the Circuit Theory course, an anonymous student satisfaction questionnaire survey was conducted among students of the two majors. The questionnaire focused on six core dimensions: the clarity of the explanation of Circuit Theory knowledge points, the rationality of the assessment methods, the comprehensibility of key and difficult knowledge. They also cover the improvement of engineering practice ability, the penetration effect of family and country feelings and engineering literacy, and the overall teaching quality of the course, with a double-column comparative evaluation before and after the reform. The specific results were shown in Figure **5**.

From the data, it can be seen that the satisfaction levels in terms of the comprehensibility of key and difficult knowledge, the assessment methods, and the improvement of engineering literacy have all greatly improved.

4.2. The Sustainability of Teaching System

The mode is compatible with the existing teaching resources and can be replicated and promoted in other similar courses. The intelligent evaluation system and hierarchical project library constructed can be continuously optimized according to the changes of industry demands and teaching objectives. The training of teachers' digital teaching ability can ensure the long-term implementation of the model.

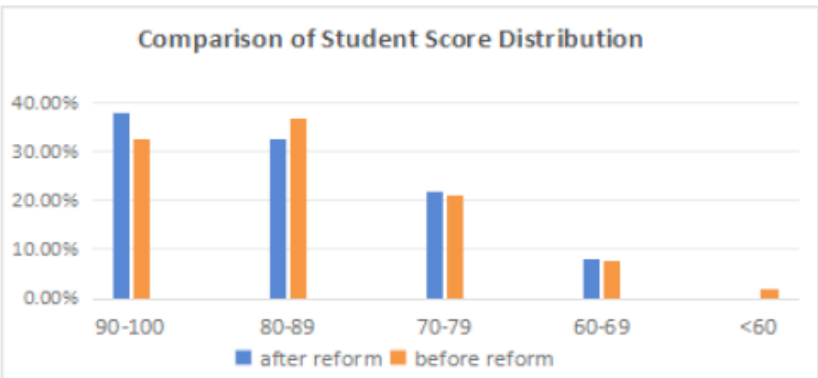

Figure 4: The Comparison of Student Score Distribution Before and After Reform.

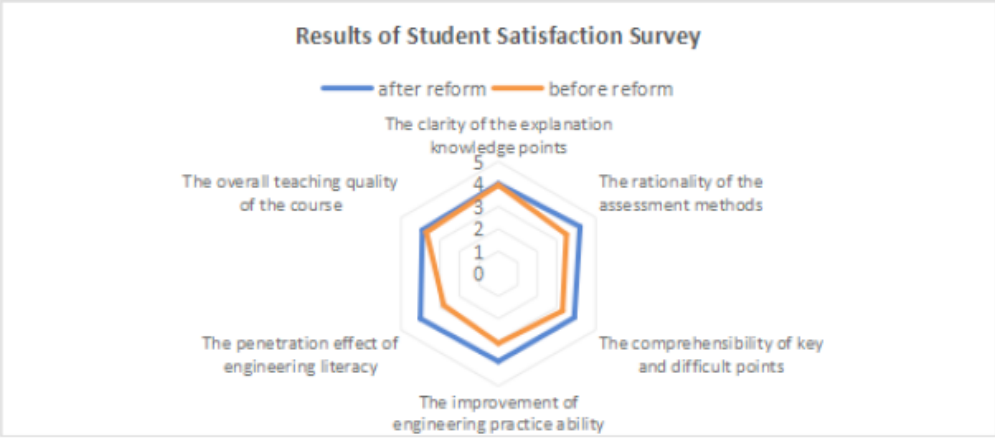

Figure 5: The Student Satisfaction Survey Results.

4.3 Limitations

Although the online-offline blended teaching model has achieved certain results in the Circuit Theory course, it still faces numerous limitations and challenges in practice.

(1) The depth and breadth of teaching resource construction need improvement. Current online resources mostly lack interactive learning materials that are deeply adapted to the disciplinary characteristics of Circuit Theory. Particularly in courses like circuit analysis, which require extensive derivations and graphical thinking, video-only explanations can hardly replace the cognitive guidance role of blackboard-based derivations. Students are prone to the phenomenon of "understanding while watching but failing to apply" during online learning. In some teaching practices, there is partial repetition between online preview and offline classroom activities, failing to truly form an organic closed Loop of "learning knowledge online, applying knowledge offline."

(2) The means for managing student learning differences remain underdeveloped. The blended teaching model places higher demands on students' autonomous learning abilities. However, existing teaching platforms have limited intelligent analysis capabilities for learning behaviors, and providing personalized intervention solutions still requires time.

(3) The coverage of the research samples is limited. This teaching practice was only carried out on one cohort of students from a single major, with a limited number of samples, and the generalization of the conclusions needs further verification.

5. CONCLUSIONS AND PROSPECTS

5.1. Conclusions

This study successfully demonstrated the efficacy of a systematically constructed online-offline blended teaching system in reforming the "Circuit Theory" course. The main contributions and conclusions are as follows.

Taking *StudyLink* as the teaching carrier and focusing on the teaching pain points of the Circuit Theory course, this paper promotes the reform of the online and offline blended teaching model, realizing the shift of the teaching focus from teacher-centered to student-centered, and driving the iteration of classroom teaching from the traditional instructive teaching to open exploratory teaching. A series of measures were implemented, such as constructing three-dimensional teaching objectives, building a refined online knowledge base, deepening the offline flipped classroom, improving the diversified assessment system, and organically integrating ideological and political elements into the course. These measures effectively stimulate initiative and exploratory interest of students in learning, and their independent learning and innovation abilities are enhanced. This reform also addresses the problems of the Circuit Theory course, such as a single teaching form, limited class hours, and lagging moral education, thus achieving the goal of educating people through teaching.

5.2. Prospects

In the future, the blended teaching reform of circuit courses should continue to deepen in the direction of becoming more intelligent, engineering practical.

(1) Construct intelligent and personalized learning support systems. Leverage artificial intelligence and learning analytics technologies to achieve whole-process tracking and precise profiling of student learning behaviors. Through intelligent diagnosis of students' learning difficulties, dynamically push personalized learning resources and practice questions, providing differentiated learning paths for students at different levels. For students with learning difficulties,

the system can automatically issue warnings and remind teachers to intervene promptly, realizing the educational ideal of teaching according to aptitude.

(2) Promote the deep integration of virtual simulation and physical experiments. With the development of technologies such as digital twins and augmented reality, a new ecology of circuit experiment teaching characterized by "integration of virtual and real, connection between online and offline" can be constructed in the future. Students can conduct scheme designing and parameter debugging in virtual environments, verify actual effects in physical experiments, and deepen their understanding of circuit theory through virtual-real comparison. Meanwhile, the popularization of remote real-scene experiment platforms will break Spatio-Temporal Limitations, enabling students to conduct experimental inquiries anytime and anywhere.

(3) Deepen industry-education integration and align with engineering practice needs. Introduce engineering projects into teaching content, constructing an integrated training chain of "classroom teaching—simulation design—engineering practice." Invite enterprise engineers to participate in online lectures and project guidance, enabling students to be exposed to cutting-edge industry technologies during the learning process, thereby enhancing their engineering practice abilities and professional competence.

FUDING

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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