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An Exploration and Practice of Online-Offline Blended Teaching in Circuit Analysis Based on the OBE Philosophy

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Abstract: Against the backdrop of the New Engineering Education initiative, the Circuit Analysis course faces salient problems, including the rigidity of its traditional teaching model, the disconnect between online and offline teaching, and the lack of diversity in assessment. To address these problems, we undertook an exploration and practice of online-offline blended teaching guided by the Outcome-Based Education (OBE) philosophy. We reformulated the course's educational objectives, built a closed-loop, multidimensional teaching framework, designed a progressive three-stage implementation pathway spanning the pre-class, in-class, and post-class phases, and constructed a whole-process, diversified assessment system that integrates formative and summative assessment. The reform has yielded a closed-loop teaching mechanism capable of iterative optimization.

Keywords: OBE Philosophy; Circuit Analysis; Online-Offline Blended Teaching; Whole-Process Assessment

1. Introduction

Circuit Analysis is a core foundational course for electronic information majors and some non-electrical majors. It bears the important task of cultivating students' theoretical foundation in circuits and their engineering thinking, and is characterized by strong theoretical logic, complex formula derivations and abstract, scattered knowledge points [1-2]. The teaching effectiveness of this course directly determines the quality of students' subsequent study in specialized courses and also affects the development of their engineering thinking and engineering innovation ability, thus occupying a pivotal position in the engineering talent cultivation system [3-4]. With the continuous advancement of New Engineering Education, the talent cultivation model in higher education is transforming from the traditional "knowledge-instilling" type to an "ability-output" type. The traditional teaching model, centered on teacher lecturing and oriented by textbook content, can no longer meet the requirements of New Engineering talent cultivation [5-6]. Outcome-Based Education (OBE), as the core educational philosophy of New Engineering reform, upholds the principles of "student-centeredness, outcome-orientation and continuous improvement" and serves as a key guiding principle for engineering course teaching reform in universities today [7]. Online-offline blended teaching, in turn, provides technical support for overcoming the bottleneck of limited class hours and enabling personalized learning. How to deeply integrate the OBE philosophy with blended teaching to build a student-centered, outcome-oriented teaching model for the Circuit Analysis course has become an important topic in current teaching reform. In the context of educational informatization, online-offline blended teaching, with its advantages of diversified resources, flexible learning and multidimensional processes, has broken the spatiotemporal constraints of the traditional classroom and become a mainstream model of university course teaching reform [8-9]. However, blended teaching in the Circuit Analysis course at some universities remains a mere formality and has not been integrated with the OBE philosophy; it suffers from problems such as ambiguous teaching objectives, disconnected teaching processes and an assessment system lacking diversity, making it difficult to achieve differentiated cultivation of students' engineering practice ability and innovative thinking [10].

Based on the talent cultivation objectives of Beijing Information Science and Technology University and guided by the OBE philosophy, this paper addresses the pain points in

traditional Circuit Analysis teaching by reconstructing the course teaching system, designing an online-offline blended teaching framework, and building a whole-process, diversified teaching assessment system. Through multi-semester teaching practice, it verifies the reform's effectiveness, summarizes the reform's shortcomings and directions for dynamic optimization, and aims to provide a reference for the OBE-based teaching reform of foundational engineering courses and the implementation of blended teaching models.

2. Instructional Design under the OBE Philosophy

Following the three core principles of OBE — outcome orientation, student-centeredness and continuous improvement — and grounded in the talent cultivation positioning of the Circuit Analysis course, this reform addresses the pain points of traditional Circuit Analysis teaching by reconstructing a multidimensional blended teaching system characterized by "objective guidance, content support, model empowerment, closed-loop assessment and continuous optimization". In light of the actual situation of Beijing Information Science and Technology University (BISTU), the reform takes students' knowledge mastery, engineering competence, quality and innovation, and self-directed learning ability as its core orientations. It connects online and offline teaching channels, integrates theoretical instruction with engineering practice, and builds a hierarchical, diversified and closed-loop teaching framework. The overall design architecture of the reform is shown in Figure 1. Following the core logic of OBE, a six-layer progressive closed-loop blended teaching architecture is constructed, in which the layers are logically interconnected and support the attainment of the educational objectives layer by layer.

Overall Architecture of Blended Online–Offline Instruction in Circuit Analysis under the OBE Concept

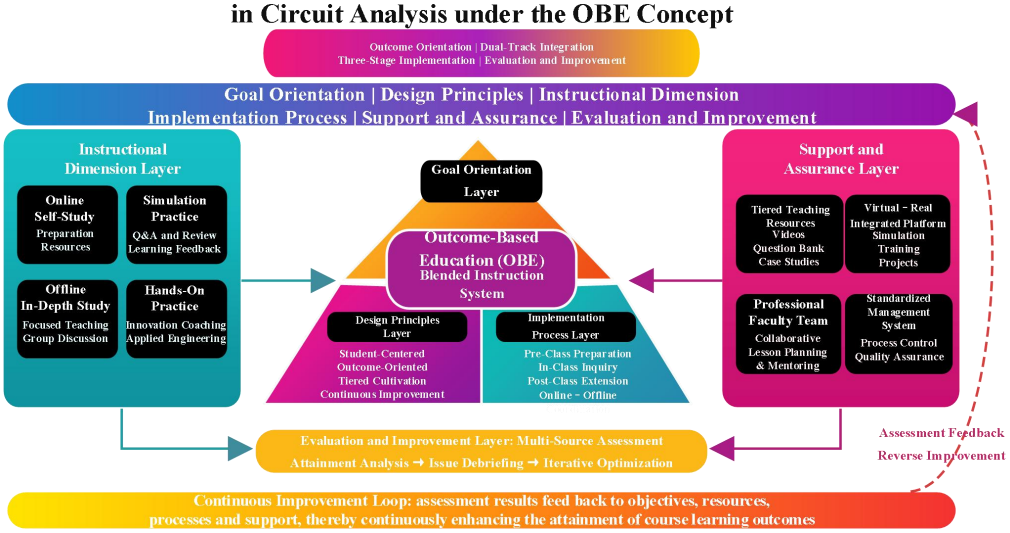


Figure 1. Overall Architecture of Instructional Design

2.1 Positioning of the Core Objectives

In line with the talent cultivation standards for New Engineering Education, BISTU has broken down the teaching objectives of the Circuit Analysis course into three tiers that correspond to the outcome orientation of OBE. First, the knowledge objective: students should master core concepts such as DC circuits, AC circuits and dynamic circuits, and proficiently apply various circuit theorems to circuit analysis and calculation. Second, the ability objective: to strengthen students' core abilities in theoretical analysis, hands-on debugging, and the analysis and solution of engineering problems, and to equip them with self-directed learning, teamwork and innovative design abilities. Third, the quality objective: to cultivate students' rigorous engineering thinking and a craftsmanship spirit of striving for perfection, so that they align with the professional quality requirements of industry positions.

2.2 Core Principles of the Overall Design

(1) Student-Centered Principle: All teaching activities are designed around students' learning conditions, learning needs and ability development throughout the teaching process. The traditional teacher-dominated teaching model is abandoned, and emphasis is placed on

students' role as active agents in self-directed learning and proactive inquiry.

(2) Outcome-Oriented Principle: All teaching content, teaching activities and practical components are designed around the preset outcome objectives in knowledge, ability and quality, and teaching effectiveness is measured by the extent to which student learning outcomes are attained.

(3) Online-Offline Integration Principle: The respective roles of online and offline teaching are clearly defined: online learning focuses on self-directed preview, resource-based learning, simulation exercises, and question answering and review, while offline teaching focuses on intensive instruction in key and difficult points, interactive discussion and hands-on training, thereby achieving complementary advantages and closed-loop synergy.

(4) Tiered Cultivation Principle: Based on differences in students' foundations, a tiered teaching and cultivation model comprising foundation, enhancement and innovation tiers is designed to accommodate the learning needs of different students, so that all students meet the standards while high-performing students are further stretched.

(5) Continuous Improvement Principle: Drawing on whole-process assessment data, teaching problems are dynamically reviewed and teaching content, teaching models and teaching tasks are optimized in real time, thus forming a long-term improvement mechanism.

2.3 Overall Teaching System Architecture

Centering on student outcome attainment, this Circuit Analysis teaching reform integrates online self-directed learning with offline immersive teaching, spans the entire process from pre-class preview through in-class inquiry learning to post-class extension learning, and undergoes continuous optimization through the four closed loops of objectives, teaching, assessment and improvement. In addition, tiered teaching resources, diversified practical platforms and a whole-process assessment system are in place to comprehensively support the realization of the course's educational objectives.

3. Teaching Implementation Pathway under the OBE Philosophy

Based on the overall reform design framework and the characteristics of course teaching, a blended teaching implementation pathway featuring "online self-directed preview before class, in-depth offline inquiry learning during class, and online-offline extension and enhancement after class" has been put into practice. The pathway clearly defines the teaching content and teaching tasks of each stage, achieves deep integration of online and offline teaching, and fully realizes the OBE educational objectives. The specific implementation process is shown in Figure 2.

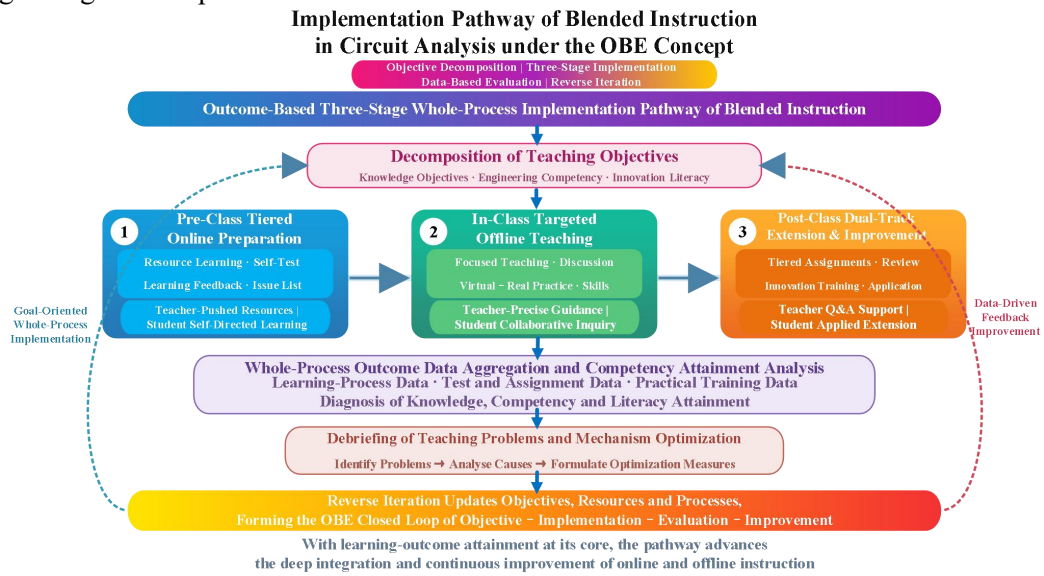


Figure 2. Teaching Implementation Pathway

Aligned with the core outcome objectives of the course in knowledge, ability and quality, the key and difficult teaching points of each chapter are broken down. During the pre-class phase, tiered learning resources are delivered through the online teaching platform, and students are

organized to engage in self-directed learning and self-assessment exercises, so as to gauge students' learning conditions and identify their knowledge doubts and weak points. During the in-class phase, targeted, in-depth instruction is delivered in response to students' learning pain points; through intensive instruction in key and difficult points, group discussion and tiered hands-on practice, the teaching difficulties are overcome. During the post-class phase, tiered assignment training, question answering and review, and innovative practical training are carried out both online and offline to consolidate learning outcomes and expand students' engineering application ability. At the end of the teaching cycle, students' whole-process learning data are aggregated, a dedicated analysis of the attainment of ability objectives is carried out, the weaknesses and problems in teaching are reviewed, and the teaching objectives, teaching resources and teaching process are iteratively optimized in reverse, thereby forming a closed-loop teaching system capable of sustainable iteration.

3.1 Pre-Class Online Self-Directed Preview: Consolidating the Foundation and Precisely Diagnosing Learning Conditions

The pre-class phase is delivered through the online teaching platform and focuses on laying a foundation in basic knowledge and gauging students' learning conditions, thereby enabling targeted offline instruction. In accordance with the teaching objectives of each chapter, the teacher breaks down the key and difficult points of knowledge and produces tiered online learning resources, including micro-lectures on basic knowledge points, courseware, pre-class exercises, basic simulation cases and popular-science videos on engineering. For students with weak foundations, basic knowledge resources and introductory exercises are delivered to ensure their mastery of core concepts; for high-performing students, extended engineering cases and advanced thinking questions are provided to encourage early inquiry. Students independently complete resource-based learning, self-assessment exercises and simulation-based preview on online platforms such as Xuexitong, and post their preview questions and learning reflections in the discussion forum. Through the platform's back-end data, the teacher tracks in real time students' learning progress, exercise accuracy and frequently raised questions, gaining an accurate picture of the class's overall learning conditions and individual differences and identifying the blind spots in knowledge common among students. On this basis, the teacher determines the teaching focus, interactive content and hands-on tasks for the offline classroom, thereby thoroughly resolving the problem of "aimless teaching" in traditional instruction and achieving instruction tailored to students' aptitudes.

3.2 In-Class Offline In-Depth Inquiry Learning: Overcoming Key and Difficult Points and Strengthening Ability Development

In-class offline teaching focuses on the key and difficult problems identified from pre-class learning feedback and is delivered through intensive instruction, interaction and discussion. First, targeted intensive instruction on key and difficult points: in response to the misconceptions and difficult problems commonly found in students' preview, knowledge points are broken down with the aid of engineering cases; tedious formula derivations are de-emphasized, and the explanation of knowledge application scenarios is strengthened. Second, interactive classroom discussion: interactive segments such as group discussion, case analysis, focused review of frequently missed problems and quick-response quizzes are arranged, and students are organized into groups to explore typical engineering circuit problems, thereby cultivating their collaboration and problem-analysis abilities. Third, hands-on training integrating virtual and physical practice: supported by Multisim simulation software and offline laboratory benches, practical instruction covers basic verification, circuit debugging and troubleshooting, and the teacher provides on-site guidance as students work through problems encountered in practice, strengthening their hands-on ability. Fourth, tiered classroom tasks: differentiated classroom exercises and hands-on tasks are assigned to students with different foundations, ensuring that all students make effective progress.

3.3 Post-Class Online-Offline Extension and Enhancement: Consolidating and Deepening Knowledge and Extending Engineering Applications

The post-class phase relies on the online platform and offline question answering to consolidate knowledge and enhance abilities. First, tiered assignment delivery: three tiers of assignments—foundation-consolidation, ability-enhancement and innovative-design—are delivered online. Foundation-tier students complete routine exercises to consolidate their knowledge; enhancement-tier students complete circuit simulation and analysis tasks; innovation-tier students undertake small-scale circuit design and innovative transformation of engineering cases. Second, online review and question answering: the teacher records review micro-lectures addressing the key and difficult points covered in class and the problems most frequently missed in assignments, opens online question-answering channels to answer students' questions in a timely manner, and organizes online thematic seminars to broaden students' knowledge of cutting-edge applications in industry. Third, offline extension practical training: laboratories are kept open, and students are encouraged to use their spare time to carry out comprehensive and design-oriented circuit experiments and to participate in small-scale innovation and design competitions within the course, thereby transforming theoretical knowledge into hands-on engineering competence. Fourth, learning outcome feedback: students upload their post-class assignments, simulation results and design reports, and the teacher completes detailed grading and comments, thereby closing the learning loop.

3.4 Regularized Teaching Iteration: Implementing Continuous Improvement

After the teaching of each chapter is completed, the teacher integrates online learning data, classroom performance, assignment submissions and student feedback, analyzes students' knowledge mastery and ability attainment, and identifies problems in the teaching process such as resource alignment, classroom design and task arrangement. Accordingly, the teaching resources and teaching process for the next chapter are dynamically optimized, thereby achieving continuous iterative optimization of the teaching process and fulfilling the core OBE requirement of continuous improvement.

4. Construction of a Whole-Process, Diversified Assessment System

Following the assessment requirements of the OBE philosophy, this reform moves away from the traditional single summative assessment model and builds a three-in-one, whole-process and diversified assessment system that integrates formative assessment, summative assessment and ability attainment assessment. The system fully covers students' entire learning process across the pre-class, in-class and post-class phases, gives consideration to both knowledge mastery and ability development, and provides accurate feedback on teaching effectiveness, thereby offering data support for the continuous improvement of teaching.

4.1 Design Principles of the Assessment System

First, the comprehensiveness principle: assessment covers all teaching links, including online self-directed learning, classroom performance, hands-on practical training, assignment completion and the final examination. Second, the objectivity principle: scoring is based on objective evidence such as platform data, practical outputs and written reports, thereby reducing errors arising from subjective human scoring. Third, the outcome orientation principle: assessment focuses on students' knowledge application ability and hands-on engineering competence while de-emphasizing purely memory-based and calculation-based assessment. Fourth, the improvement principle: assessment data are used for the analysis of learning conditions and the optimization of teaching, so that assessment promotes both learning and teaching.

4.2 Specific Assessment Indicators and Weighting

The overall course grade consists of formative assessment (60%) and summative assessment (40%). In addition, a dedicated ability attainment assessment is introduced as a core basis for teaching improvement.

(1) Formative assessment (60%): online learning performance (15%), covering video learning progress, pre-class self-assessment, online discussion and post-class review; comprehensive classroom performance (15%), covering class attendance, interactive participation, group collaboration and the quality of classroom task completion; assignments and review (10%), covering the

completion of tiered assignments, the review of missed problems and the quality of learning reports; and practical training performance (20%), covering simulation experiments, offline hands-on practice, experiment reports and troubleshooting ability. According to the back-end data of Xuexitong, taking May 2026 as an example, the dynamic monitoring of class learning shows that the class recorded 1,785 learning activities, and students showed strong enthusiasm for learning. At the end of the semester, the students' average comprehensive regular score was 88 points, and 92.9% of the students reached 80 points or above in their regular scores.

(2) Summative assessment (40%): the final examination adopts a closed-book format; the structure of examination questions has been optimized by reducing purely formula-based calculation items and increasing items involving engineering case analysis and comprehensive application, so as to focus on students' knowledge transfer and engineering application ability in line with the outcome orientation of OBE.

(3) Dedicated ability attainment assessment: drawing on all assessment data and aligned with the course's three-tier outcome objectives, this assessment evaluates students' attainment of knowledge, engineering competence and innovation quality, respectively, and produces individual learning outcome reports and a class-level overall attainment analysis report.

4.3 Assessment Loop and Continuous Improvement Mechanism

After the course is completed, big data analytics is used to analyze students' attainment on each indicator across the class and to accurately identify overall teaching weaknesses and individual learning problems. For ability weaknesses common to the class, subsequent teaching content and practical components are optimized; for individual students' problems, personalized question answering and tutoring are provided. Meanwhile, assessment portfolios are established, and changes in course attainment are compared and analyzed semester by semester, so that the assessment indicators and teaching plans are continuously optimized, forming a complete closed loop of "teaching implementation - diversified assessment - data analysis - problem remediation - teaching optimization".

5. Implementation Outcomes of the Teaching Reform

5.1 Significant Enhancement of Students' Learning Motivation

The tiered, engaging and engineering-oriented teaching model has fundamentally changed students' passive learning state: the completion rate of online self-directed learning rose from 65% before the reform to 95%, and the number of students participating in classroom interaction and their enthusiasm for group discussion increased substantially. An end-of-course survey showed that more than 95% of students considered the reformed teaching model better aligned with their learning needs and enabling them to clearly grasp the key and difficult points of learning, that their self-directed learning and inquiry thinking abilities had been effectively developed, and that the former situation of aversion to learning and perfunctory engagement in the traditional classroom had been fundamentally improved.

5.2 Substantial Improvement in Course Assessment Performance

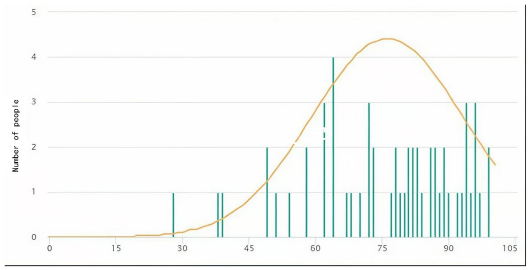


Figure 3. Normality Analysis Chart

A comparison of course assessment data before and after the reform — taking one engineering program as an example, in which 56 students sat for the examination — shows that the highest examination paper score was 99 and the lowest 28, with a mean score of 75.86 (a scoring rate of 75.86%), a standard deviation of 16.77, a discrimination index of 0.41, a difficulty of 0.76 (a difficulty coefficient of 0.24), a reliability of 0.83 and a validity of 0.31. The normality analysis of the final examination scores is shown in Figure 3. With formative assessment taken into account, the pass rate rose to 100%. In addition, the scoring rates on engineering application questions, circuit design questions and troubleshooting questions increased substantially, fundamentally resolving the prominent problem that students under

traditional teaching were "able to solve problems but not to apply knowledge", and significantly strengthening students' knowledge application ability.

5.3 Comprehensive Improvement in the Attainment of the Course's Educational Objectives

Through the closed-loop teaching oriented by the three-tier outcome objectives, students' knowledge mastery, engineering competence and professional quality improved comprehensively. The attainment of the abilities mapped to the program's graduation requirements increased from 78% before the reform to 94.5%, closely aligning with the objectives of New Engineering talent cultivation and effectively improving the educational quality of foundational courses for electrical engineering programs.

6. Conclusion

Circuit Analysis is a core foundational course for engineering programs, and the quality of its teaching directly affects the effectiveness of New Engineering talent cultivation. Guided by the OBE philosophy and addressing the prominent problems of the traditional course, such as the ambiguity of teaching objectives, the rigidity of the teaching model and the lack of diversity in assessment, we reconstructed a systematic online-offline blended teaching system, designed a three-stage closed-loop teaching implementation pathway, and built a whole-process, diversified teaching assessment system, achieving three core transitions: from "teacher-centered" to "student-centered", from "knowledge-oriented" to "ability- and outcome-oriented", and from "terminal assessment" to "whole-process, closed-loop assessment". Teaching practice has demonstrated that this reform has effectively stimulated students' self-directed learning motivation, consolidated their theoretical foundation in circuits, substantially enhanced their hands-on engineering competence and innovative thinking, and significantly improved the educational quality of the course, meeting the requirements of the New Engineering education reform. Going forward, the Circuit Analysis course team of BISTU will remain committed to the OBE principle of continuous improvement, continue to optimize the teaching resources, teaching models, the practical teaching system and the assessment mechanism, further deepen industry-education integration and personalized cultivation, and steadily enhance the course's talent cultivation performance, thereby laying a solid foundation for cultivating high-quality applied engineering talent.

Acknowledgments

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