Exploration of the Project-Based Integrated Teaching Reform Model for the Theory and Practice of the "Computer Circuit Foundation" Course

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Abstract: This paper proposes a theoretical and practical project-based integrated teaching reform model, which utilizes real engineering projects as the carrier. This model breaks the traditional separated teaching pattern of "theory teaching + individual experimentation", deeply integrates circuit theoretical knowledge, engineering practical skills, and project design processes, reconstructs modular teaching content, and innovates project-driven teaching methods to achieve the teaching goal of "learning by doing, practicing in learning, and innovating in practice". Through reform, the aim is to address the pain points of course teaching, enhance students' understanding and application abilities of theoretical knowledge, cultivate their engineering thinking, innovation consciousness, and team collaboration abilities, lay a solid foundation for subsequent professional learning and career development of computer science students, and provide reference and inspiration for teaching reforms in similar engineering basic courses.

Keywords: Computer Circuit Fundamentals; Project-Based Teaching; Integration of Theory and Practice; Teaching Reform; Capacity Building

1. Introduction

In the context of the rapid development of the digital economy and the high-quality development of vocational education, the cultivation of computer-related professionals increasingly emphasizes "combining software and hardware, emphasizing both theory and practice, and aligning job requirements with course content." As a bridge course connecting computer software thinking and hardware engineering thinking, the teaching quality of "Computer Circuit Basics" directly affects the formation of students' core professional abilities.

Traditional teaching follows the order of textbook chapters, focuses on theoretical derivation, and adopts classroom lectures as the main form. Experimental training is mostly conducted as verification operations, and theoretical courses and practical courses are arranged and assessed separately, leading to a common phenomenon where students "understand the lectures, can calculate, but cannot practice or apply." Students are unfamiliar with components, unable to test circuits, and incapable of troubleshooting faults. They lack engineering thinking and practical innovation consciousness, and there is a significant gap between their abilities and the actual needs of industry positions. Traditional teaching models generally suffer from issues such as the separation of theory and practice, the disconnection between classroom lectures and skill training, fragmented teaching content, verification-oriented practical links, and single assessment methods. These issues result in students having low interest in learning, shallow theoretical understanding, weak practical abilities, and difficulty meeting the requirements for cultivating technical and skilled talents in computer-related majors in the new era [1].

Project-based integrated teaching utilizes real or typical engineering projects as the carrier, integrating theoretical knowledge, practical skills, and professional qualities into the entire process of task completion. It achieves synchronous advancement of theoretical teaching and practical training, and simultaneous achievement of knowledge learning and ability cultivation. It is an effective path to address the current pain points in computer-related basic course teaching. Based on the characteristics of the "Computer Circuit Foundation" course and talent cultivation objectives, this paper explores a project-based integrated teaching reform model to address the prominent issues in traditional teaching. It reconstructs the teaching system, optimizes the teaching process, innovates evaluation methods, promotes the transformation of the course from "knowledge impartation" to "ability cultivation", and comprehensively enhances students' circuit application abilities and comprehensive professional qualities [2].

With project-based learning as the core approach, and focusing on the five key elements of teaching objectives, teaching content, teaching process, teaching evaluation, and teaching support, we systematically construct an integrated teaching reform model for the theory and practice of "Computer Circuit Foundation" based on project-based learning. Through progressive project design, simultaneous implementation of theory and practice, and diversified process evaluation, we achieve the integration of "learning through doing, doing through learning, and the integration of teaching, learning, doing, and evaluation". This effectively enhances the quality of course teaching and the adaptability of talent cultivation, providing practical reference and paradigm for the reform of basic courses in computer-related majors [3].

2. Main issues in traditional teaching of the course "Fundamentals of Computer Circuits"

2.1 The Theory and Practice are Separated, and the Teaching System is Disconnected

In traditional teaching, theoretical courses and practical courses are implemented in stages, at different venues, and by different teachers. Theoretical classes focus on formula derivation, law explanation, and problem solving, lacking physical demonstrations and operational experiences. Practical classes are mainly verification experiments, following fixed steps of wiring, measuring, and recording data. Students complete tasks passively, unable to effectively link theoretical knowledge with circuit phenomena and measurement results [4]. Without practical support during theoretical learning, students find it difficult to understand abstract concepts; without theoretical guidance during practical operations, they cannot analyze the causes of problems encountered, ultimately leading to a disconnect between learning and application.

2.2 The Teaching Content Is Fragmented, Lacking a Main Project Thread

The content of textbooks is mostly arranged in the order of knowledge points such as DC circuits, AC circuits, sinusoidal steady-state circuits, semiconductor devices, amplifier circuits, and gate circuits. The knowledge points are scattered and the structure is independent, lacking an overall project main line oriented towards computer job applications [5]. After learning, students find it difficult to form a complete circuit thinking, and they do not know how the knowledge is applied in computer hardware, interface circuits, and control modules. The learning objectives are vague, and the learning motivation is insufficient.

2.3 Traditional and Monotonous Teaching Methods, Insufficient Emphasis on the Subjective Role of Students

The classroom teaching primarily relies on lectures, adopting an "indoctrination" teaching model that emphasizes memorization of knowledge points and problem-solving training, while lacking exploratory, task-based, and interactive teaching activities. Students are passively receiving knowledge for a long time, and their abilities in autonomous learning, team collaboration, and problem-solving are not effectively exercised. There is a lack of sufficient training opportunities for key skills such as circuit wiring, measurement and debugging, and fault diagnosis, resulting in slow improvement in practical abilities.

2.4 Weak Practical Link and Insufficient Engineering Training

The practical projects are mostly basic and verification experiments, with fewer comprehensive, design-oriented, and innovative projects, which are not highly aligned with job tasks such as computer hardware maintenance, circuit testing, and equipment assembly. Limited training conditions and lagging equipment updates result in students having less exposure to real engineering scenarios, leading to insufficient training in safety standards, engineering awareness, quality awareness, and professional ethics [6].

2.5 The Evaluation Method is Monotonous, and Process Assessment is Lacking

Course assessments are primarily based on final written exams, with the score composition emphasizing theoretical memorization while neglecting practical operation, project completion, process performance, and professional ethics. The model of determining scores based on a single exam paper cannot fully reflect students' practical operation ability, collaboration ability, and problem-solving ability. It is prone to the phenomenon of "high scores but low abilities", which is not conducive to guiding students to value practice, strengthen skills, and enhance comprehensive qualities.

3. Overall Ideas and Principles of Project-Based Integrated Teaching Reform

3.1 Overall Reform Approach

Based on the talent cultivation program for computer-related majors, guided by the demand for job competencies, supported by project tasks, and centered on ability cultivation, we break down the boundaries between theory and practice, and establish an integrated teaching model featuring "project-led, theory-practice integration, learning-doing integration, and diversified evaluation". We integrate basic circuit theory, component identification, circuit measurement, installation and debugging, fault diagnosis, and other content into a progressive project system, achieving practicalization of theoretical teaching, projectization of practical teaching, and job-oriented skill training, thereby comprehensively improving teaching effectiveness and talent cultivation quality.

3.2 Basic Principles of Reform

Principle of integration of theory and practice: Theoretical explanation and practical operation should be conducted in the same place, at the same pace, and with the same tasks. Teaching and learning should be carried out simultaneously, enabling simultaneous improvement in knowledge and skills.

Project-driven principle: Taking typical circuit projects as the main thread, integrate knowledge points into tasks, allowing students to actively construct their knowledge system during the project completion process.

Competency-based principle: Emphasize the cultivation of core competencies such as circuit analysis, practical debugging, fault diagnosis, and engineering application, while strengthening the development of professional ethics.

The principle of gradual progress: Project design progresses from simple to comprehensive, from basic to applied, and from imitation to innovation, aligning with students' cognitive patterns and skill development patterns [7].

Principle of job-course alignment: The project content should be closely related to the practicality of computer hardware jobs, emphasizing engineering standardization and practicality, and enhancing job adaptability.

4. Construction of Project-Based Integrated Teaching Model for "Computer Circuit Foundation"

This article constructs a five-in-one teaching reform model of "integrated goals, project-based content, synchronized processes, diversified evaluations, and systematic guarantees", which comprehensively covers all aspects of course teaching.

4.1 Integrated Teaching Objectives: Unification of Knowledge, Skills, and Qualities in Three Dimensions

Focusing on the requirements for professional talent cultivation, we establish an integrated teaching objective:

Knowledge objectives: Master basic circuit concepts, Ohm's law, Kirchhoff's laws, and the rules of series and parallel circuits;

Master common electronic component symbols, parameters, and testing methods; understand the working principles of basic amplifier circuits and logic gate circuits; and master circuit measurement and safe operation specifications.

Skill Objectives: Able to correctly identify, detect, and select commonly used components; proficient in using instruments and equipment such as multimeters, regulated power supplies, and oscilloscopes; capable of completing circuit assembly and debugging according to drawings; skilled in analyzing and troubleshooting simple circuit faults; and able to complete the design and fabrication of small integrated circuits [8].

Literacy goals: Cultivate awareness of safe electricity use, engineering standards, and quality responsibility; enhance abilities in autonomous learning, team collaboration, communication and expression, and problem-solving; form a professional attitude of rigor, conscientiousness, and excellence.

4.2 Project-Based Teaching Content: Reconstructing a Progressive Project-Based Curriculum System

Breaking away from the traditional chapter structure of textbooks, and based on job requirements and skill progression patterns, the course content is integrated into three levels: basic cognitive projects, comprehensive application projects, and engineering innovation projects, forming a project-based teaching system.

The basic cognitive project (introductory level) primarily focuses on recognition, detection, and operation, establishing fundamental concepts of circuits.

Project 1: Identification and Testing of Common Electronic Components

Project 2: DC Circuit Bonding and Voltage, Current, Potential Measurement

Project 3: Installation and Debugging of Simple Lighting Indication Circuit

Project 4: Use of multimeter and measurement of circuit parameters

The comprehensive application project (at the improvement level) primarily focuses on analysis, debugging, and troubleshooting, aiming to strengthen the ability to integrate theory with practice.

Project 5: Debugging and Testing of Single-Tube AC Amplification Circuit

Project 6: 555 Timer Application Circuit Fabrication

Item 7: Functional test of basic logic gate circuits

Project 8: Design and Implementation of Combinational Logic Circuits

The engineering innovation projects (at the expansion level) primarily focus on design, integration, and application, aligning with practical engineering scenarios.

Project 9: Analysis of Simple Unit Circuits for Computer Interfaces

Project 10: Design and Fabrication of Sound and Light Control Circuit

Project 11: Comprehensive Troubleshooting Training for Circuit Faults

Project 12: Design and Demonstration of Small Integrated Electronic Devices

Each project includes: task description, learning objectives, theoretical knowledge, practical steps, instrument usage, measurement records, fault analysis, extended thinking, and evaluation criteria, forming a complete learning loop.

4.3 Synchronization of Teaching Process: Implementing Integrated Classroom Teaching of Theory and Practice

Teaching is conducted in the integrated theoretical and practical training room, realizing the concept of "classroom as training room, classroom as workstation, learning as work".

Teaching process: task-based learning — inquiry learning — practical operation — summary and improvement

Task introduction: Present the project task, clarify requirements and standards, and stimulate learning motivation.

In-depth explanation of knowledge: Explain key theories in conjunction with tasks, emphasizing sufficiency, practicality, and usability.

Demonstration operation: The teacher demonstrates the use of instruments, wiring specifications, measurement methods, and fault diagnosis techniques.

Student practical operation: Complete circuit building, debugging, measurement, and recording in groups, with teachers providing guidance on a rotating basis.

Problem exploration: Guide students to analyze the causes using theory and independently solve problems based on the fault phenomenon.

Presentation and evaluation: The group presents their achievements, exchanges experiences, and receives feedback and improvement suggestions from the teacher.

Summary and expansion: Organize knowledge and skills, assign expansion tasks, and achieve ability transfer.

The teaching method integrates and comprehensively applies project-driven method, task-oriented method, group cooperation method, problem-inquiry method, and case teaching method, highlighting the main position of students and encouraging them to use their hands, brains, and mouths, truly achieving the integration of learning and doing.

Information technology supports the use of resources such as circuit simulation software, virtual training platforms, micro-course videos, and online question banks to assist in theoretical understanding and skill training. This addresses issues such as the difficulty in understanding abstract knowledge and the lack of practical training equipment, thereby enhancing teaching efficiency.

4.4 Diversification of Evaluation System: Establishing a Process-Oriented and Comprehensive Evaluation Mechanism

Replace the "one exam determines one's life" model and establish a diversified and integrated evaluation system that includes process evaluation, project evaluation, skill evaluation, and literacy evaluation, to comprehensively, objectively, and fairly reflect students' learning outcomes.

Process evaluation (30%) includes attendance, classroom performance, safety norms, learning attitude, group collaboration, timeliness of task completion, etc.

The project completion evaluation (40%) is conducted on a per-project basis, assessing the quality of circuit construction, accuracy of measurement data, debugging capabilities, troubleshooting, and project report writing.

Skill practical evaluation (20%): Randomly select skill tasks on-site, and independently complete tasks such as component inspection, circuit connection, instrument usage, and parameter measurement, assessing practical proficiency and standardization.

The final comprehensive evaluation (10%) adopts a combination of theoretical and practical assessments, focusing on the comprehensive application of knowledge and circuit analysis skills.

Through diversified evaluation, students are guided to value the process, strengthen practice, and enhance their qualities, achieving the goal of promoting learning and teaching through evaluation [9].

4.5 Systematization of Support Conditions: Supporting the High-Quality Implementation of Integrated Teaching

Venue support: Build an integrated practical training room that integrates theory and practice, equipped with workstations, power supplies, multimeters, regulated power supplies, oscilloscopes, component boxes, tool kits, etc., to meet the needs of simultaneous teaching and practice.

Resource guarantee: Develop integrated teaching resources such as project task books, teaching courseware, micro-course videos, simulation engineering files, fault case libraries, and examination question banks.

Teaching staff guarantee: Strengthen the construction of a dual-qualified teaching staff, and enhance teachers' abilities in circuit design, equipment debugging, fault diagnosis, project guidance, and engineering practice.

Institutional Guarantees: Improve systems for integrated teaching management, practical training safety management, project assessment and evaluation, and teaching quality monitoring to ensure standardized and orderly teaching operations.

5. Implementation Effectiveness of Teaching Reform

5.1 Students' Interest in Learning has been Significantly Enhanced

Project-based integrated teaching transforms abstract theories into operable, experiential, and demonstrable real-life tasks, providing students with more hands-on opportunities, enhancing their sense of achievement, significantly improving their classroom participation and learning initiative, and significantly reducing their fear of difficulties.

5.2 Practical Skills and Engineering Capabilities have been Significantly Enhanced

Through progressive project training, students' core skills such as component identification, instrument usage, circuit construction, and debugging and troubleshooting have been significantly improved. They are now able to analyze circuit phenomena and solve practical problems using theoretical knowledge, gradually developing engineering thinking and professional qualities.

5.3 Continuous Improvement in Teaching Quality and Course Satisfaction

The diversified evaluation mechanism promotes the comprehensive development of students, with a steady increase in the pass rate and excellence rate of courses. Students' satisfaction with teaching modes, teaching content, and teaching methods has significantly improved, laying a solid foundation for subsequent professional course learning.

5.4 Promote the Improvement of Teachers' Teaching Ability and Curriculum Construction Level

The reform urges teachers to continuously update their teaching concepts, optimize their teaching methods, and enhance their practical guidance abilities. It promotes the transformation of courses from traditional lectures to project-based, integrated, and information-based formats, resulting in reproducible and scalable teaching models and resource outcomes.

6. Existing Issues and Improvement Directions

6.1 Existing Problems
Due to limitations in class hours and equipment, the implementation depth of some complex circuit projects is insufficient; there are significant differences in students' foundations, and layered teaching and personalized guidance still need to be strengthened; there is still room for improvement in the depth and breadth of project alignment with industry positions; the integration of information technology teaching methods with projects needs to be further deepened [10].

6.2 Direction for Improvement
In the future, we will further optimize the project system, incorporating more real-world projects and typical cases from enterprises; promote tiered teaching and personalized task design to meet the needs of students at different levels; deepen the integration of industry and education, introducing industry standards and job specifications; strengthen the application of virtual simulation and blended teaching methods, both online and offline, to enrich teaching forms; continuously improve the evaluation system, emphasizing competency-oriented and innovation ability evaluations, and continuously enhance the implementation effect of project-based integrated teaching.

7. Conclusion
Implementing a project-based integrated teaching reform for the "Fundamentals of Computer Circuits" course, both theoretical and practical, is an inevitable choice to adapt to the cultivation of computer-related professionals in the new era. It also serves as an effective approach to address traditional teaching pain points and enhance course quality. Through goal integration, project-based content, synchronized processes, diversified evaluations, and systematic support, the reform achieves a deep integration of theory and practice, simultaneous improvement of knowledge and skills, and effective alignment between teaching and job requirements. This approach effectively cultivates students' circuit application abilities, engineering practical abilities, and comprehensive professional qualities.

Amidst the ever-deepening reform of vocational education, curriculum teaching reform is always on the road. In the future, we will continue to adhere to student development as the center and ability cultivation as the core, continuously optimize project design, innovate teaching modes, enhance teaching connotation, and promote the development of the "Computer Circuit Foundation" course towards a more practical, efficient, and industry-oriented direction, providing stronger support for cultivating high-quality computer technology talents.

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