Check for updates

Research on the Teaching Reform of Electronic Technology Courses by Combining Virtual and Real, Integrating Multiple-Class Types

Dongqiu Xing[a], Lihua Qi[b], Jingna Cui[c*], Luya Zhang[d]

Department of Optical Communication Network, Information Support Forces Engineering University, Wuhan, China

[a]xingdongqiu17@nudt.edu.cn, [b]qilihua17@nudt.edu.cn, [c*]cuijingna17@nudt.edu.cn, [d]zhangluya17@nudt.edu.cn

Abstract. To address existing issues in electronic technology courses, this study proposes a teaching reform model integrating virtual and entity with multi-classroom collaboration. First of all, combining virtual and entity carried out content reconstruction and digital empowerment resource construction is carried out to support the establishment of teaching mode. Secondly, it constructed a new teaching model based on three dimensions: establishing task chains that bridged virtual and entitative contexts, designing multi-class collaborative activities, and reconfiguring teaching and learning roles. Finally, it established an evaluation scheme for teaching effectiveness. Evidence from instructional practice and surveys reveals that the new teaching model and implementation strategies significantly enhanced student engagement, markedly improving the teaching effectiveness of electrical engineering courses. The new teaching model provides reference value for similar course reforms.

Keywords: Combination of virtual and entity, multi classroom interaction, teaching reform

1 Introduction

The report of the 20th National Congress of the Communist Party of China made an important deployment for running a good teaching that the people are satisfied with, emphasizing the need to “promote education digital” [1]. Subsequently, the Ministry of Education issued documents one after another, clearly proposing to further promote education digital, promote the deep integration of information technology and education and teaching, and accurately enable high-quality teaching and learning; In April 2025, the Ministry of education and other nine departments issued a document to accelerate the promotion of digitalization [2].

From the spirit of a series of policies of the Ministry of education on digital empowerment to improve the quality of teaching, it can be seen that under the digital background, it is essential to deepen the reform of curriculum teaching, build a new teaching

A. Y. M. A. Islam et al. (eds.), *Proceedings of the 2025 International Conference on Educational Technology and Management Information Systems (ETMIS 2025)*, Advances in Computer Science Research 129,
https://doi.org/10.2991/978-94-6239-630-2_42

mode from the perspective of digital empowerment, and help the quality and efficiency of efficient teaching.

1.1 Original Intention of Teaching Reform of Electrical Courses

Electrical courses are known as “three electrical courses” in engineering electronic information and related majors, specifically covering fundamentals of circuit analysis, analog electronic technology and digital electronic technology. As the core pillar of electrical disciplines, they are not only the cornerstone of the follow-up comprehensive courses, but also the basic support for professional course learning and post ability training, and their importance is self-evident. There is a clear internal logic between the three courses - if the foundation is not strong, the earth will shake, and if the connection is not smooth, the previous achievements will be wasted. However, with the rapid development of times and technology, the teaching problems of such courses are increasingly prominent.

Single Teaching Mode. The current teaching mode of electrical courses still takes theory teaching as the core, relying on the rain classroom to carry out pre class preview and consolidation of after-school homework, and the experimental links are mostly carried out in the physical classroom, dominated by confirmatory experiments, and the knowledge consolidation is completed through the experimental report after class. Because electrical engineering courses are naturally abstract and highly applied, students tend to be afraid of difficulties and weariness, and their learning interest and teaching effect are significantly affected. The teaching content of the experimental course is still based on confirmatory experiments, and the proportion of comprehensive and designed experiments is insufficient. The students' experiments are mostly operated according to the circuit connection given by the teacher, and the imitative tasks dominate. The link of independent thinking and exploration is greatly compressed, and the space for cultivating innovative ability is severely limited.

Outdated Teaching Methods. The traditional mode of “ppt+blackboard writing”, “onsite demonstration and individual guidance” is still the dominant mode in the theoretical and experimental teaching of electrical courses. Although the introduction of simulation technology to assist teaching has been attempted in recent years, the reform mostly focuses on the surface application of teachers' classroom presentations, and students lack the exploration process of specific participation. The problem of cognitive gap between physical construction and abstract principles is prominent. This situation directly causes students' understanding of the core principles to remain at the surface level, hindering the improvement of practical ability, and making it more difficult to stimulate innovative thinking and systematically cultivate engineering innovation ability.

The solution of the above problems is imminent. It is urgent to open up a new path for the improvement of teaching effect and the breakthrough of talent training quality through the collaborative support of new models and methods. Combined with the reform direction of “combination of virtual and real, multi hall linkage”, it needs to be systematically promoted from the five dimensions of content remodeling, resource construction, mode innovation, task design and role reconstruction.

1.2 Analysis of Curriculum Characteristics and Formation of Curriculum Reform Ideas

As the cornerstone of electronic information specialty, the core courses of electrical engineering can be systematically developed from three dimensions of theory, practice and engineering. At the theoretical level, the logic of evolution is “ abstract → concrete” and “mathematics → Engineering”. At the practical level, it generally presents the progressive characteristics of “verification → design” and “operation → thinking”.

Combined with the characteristics of the course, the current teaching of electrical courses is facing practical challenges, and peers have carried out many attempts. Building on a comprehensive “combination of virtual and real” reform implemented across all experimental content in Reference [3], further innovations have been explored in subsequent studies. Reference [4] focuses on a single course, where teaching reform was carried out by utilizing the Rain Classroom platform and Multisim software. Meanwhile, the approach in Literature [5] adopts extended reality (XR) and AI-powered virtual assistants to mitigate learning barriers. Positive outcomes from applying new technologies in electrical engineering courses are demonstrated in Literature [6]. Beyond specific implementations, Literature [7] advocates for a structural revision of course content along with the active integration of digital technologies into the educational process. However, most of the above studies focus on a single course, a single platform or a single technology application, showing fragmentation in the form of organization, and lack of systematic reconstruction from the perspective of curriculum system. Under the background of the rapid development of digital technology, how to go beyond the scattered improvement, systematically and integrally design the content of "virtual reality combination" and the teaching organization form of "multi classroom collaboration", and build a new teaching mode of continuity and complementarity is an important direction worthy of in-depth exploration and practice.

2 Teaching Reform and Experience

2.1 Content Reshaping through Integration of Virtual and Real

Basic Layer Content. Problem-driven, integration of virtual and real, lowering barriers to stimulate interest. For the basic layer content of foundational electronic technology courses, the core basic knowledge points are organized, and a “problem-driven, integration of virtual and real” teaching model is designed[3]. Aiming to “lower the abstraction barrier and stimulate exploration interest,” a closed loop of “problem chain-driven — virtual visualization — physical verification — interest extension” is employed to help students shift from “passive reception” to “active construction.” The concept of content reshaping is illustrated in Fig. 1.

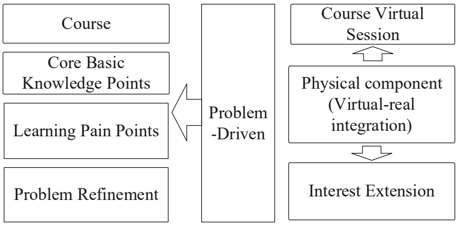

Fig. 1. Reshaping of basic layer content.

Specifically, the entire teaching system revolves around three core courses: “Circuit Analysis,” “Fundamentals of Analog Electronics,” and “Fundamentals of Digital Electronics.” For the “Circuit Analysis” course, in response to the difficulty students have in understanding abstract concepts such as transient processes, exploratory questions derived from everyday life are designed, such as “When you press the switch, does the light bulb turn on 'instantly' or gradually?” Through virtual simulations using software like Multisim, students can intuitively observe the transient response curves of RC circuits [4]; they are then guided to build real circuits on experimental kits and use oscilloscopes to capture the actual voltage and current waveforms, thereby deeply understanding the physical meaning of the time constant through a combination of virtual and real-world verification. In the “Fundamentals of Analog Electronics” course, to address the challenge of “why amplifier circuits produce distortion,” the teaching design guides students starting from the core task of “how to set an appropriate quiescent operating point.” Students first scan circuit parameters in a simulation environment to observe the conditions and waveform characteristics of nonlinear distortion; they then adjust the bias resistors in physical experiments, measure and compare real distortion waveforms, thereby mastering the engineering methods to keep amplifiers operating in the linear region. For “Fundamentals of Digital Electronics,” the teaching focus is on cultivating students' design abilities from logic functions to timing systems. Using typical projects like “designing a 10-second timer,” students first use Verilog HDL for behavioral description and functional simulation to verify logical correctness; they then download the code onto an FPGA development board and use a logic analyzer to measure timing waveforms, troubleshoot real-world issues such as race conditions, completing the full process from virtual design to physical implementation.

This content system connects the knowledge points of three courses through an interlinked “problem chain,” forming a full-process training from device characteristics to system design. Virtual simulation serves as a cognitive guide and solution rehearsal, reducing the cost of trial and error; hands-on practice, on the other hand, strengthens engineering practical skills and awareness of error analysis. The two verify and complement each other, together forming a closed-loop learning system of “problem-driven, virtual and real mutual verification, and spiral progression,” effectively laying the foundation for students' comprehensive ability to solve complex engineering problems.

Integrated Experimental Layer. Virtual-Real collaborative experiments integrating multiple knowledge points. After completing the reconstruction of virtual and physical content in the foundational layer, the integrated experimental layer and the innovation development layer focus on the integration of multiple knowledge points and the advancement of engineering capabilities. Through the iterative process of “virtual rehearsal - physical verification - iterative innovation” , they enable the leap from “single-skill training” to “system-level innovation”. The content construction model of the experimental integrated layer is shown in Fig.2.

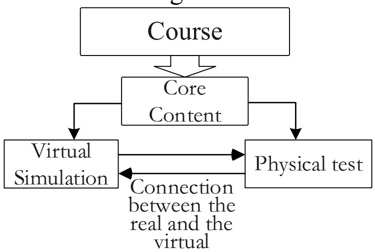

Fig. 2. Experimental integrated layer content construction model

In the circuit analysis integrated experimental layer, the content focuses on the Thevenin/Norton theorems and the transient and frequency response analysis of RLC series circuits. Students first build complex circuits with controlled sources in Multisim software. By simulating output voltages under different loads and plotting characteristic curves, they can preliminarily explore the applicable conditions of the theorems. Simultaneously, they simulate the step response and sweep frequency characteristics of the RLC circuit, visually observing the effect of the damping ratio (ζ) on the system's dynamic behavior. During the physical verification stage, students must replicate the circuits on the experimental board, actually measure equivalent parameters and frequency response curves, and calculate engineering errors. The connection between virtual and physical components lies in using virtual simulation to predict key parameters (such as equivalent resistance ranges and critical damping points) to guide targeted measurements during physical operation; the data and waveforms obtained from the physical experiment then feedback into the simulation model for correction and error analysis, completing the full cognitive cycle from “simulation prediction” to “empirical correction”.

The comprehensive course in analog electronics technology progresses from “single-stage amplifier circuit debugging” to “multi-stage amplification/feedback system design,” aiming to cultivate the ability to “optimize the overall performance of amplifier circuits” . The teaching content focuses on setting the DC operating point and suppressing distortion in common-emitter amplifier circuits, as well as optimizing the performance of integrated operational amplifier feedback circuits. In the virtual simulation phase, students use Multisim to adjust bias resistors, observe how DC operating point drift can lead to clipping distortion in output waveforms, and simulate the effects of negative feedback on amplifier gain, bandwidth expansion, and distortion suppression. In the practical verification phase, students are required to physically build and debug these circuits, use oscilloscopes to measure the actual operating points, observe distortion waveforms, and verify the actual performance parameters of the negative feedback circuits. The integration of virtual and physical experiments is reflected in that simulations quickly identify the reasonable range for the operating point and the boundary conditions for stable circuit operation, enabling students to be more targeted in their physical debugging; by overlaying and comparing measured distortion waveforms and frequency response curves with simulation results, students can intuitively understand the fundamental impact of device nonlinearity, parasitic parameters, and other engineering factors on circuit performance .

Digital electronic technology progresses from “single logic circuit design” to “sequential system integration” , cultivating the ability for “modular design and collaborative verification of digital systems”. The teaching approach enhances students' system design and software-hardware collaboration abilities through comprehensive projects such as synchronous counter design and real-time audio noise reduction systems. In the virtual environment, students write counter code using Verilog HDL and perform timing simulations in ModelSim to verify logic functions and analyze critical timing parameters such as setup and hold times; simultaneously, utilizing the MATLAB software described in reference [6], implement adaptive filtering algorithms such as the Least Mean Squares (LMS) method to assess their noise reduction performance and the enhancement of the signal-to-noise ratio (SNR) on speech signals contaminated by noise. In the physical verification stage, students download counter code onto FPGA development boards and use logic analyzers to capture actual signals to verify functionality and timing; they also build a complete hardware audio processing system to collect real audio and test noise reduction performance. The key to linking virtual and physical environments is that timing simulations pre-validate the digital system's logic correctness and timing margin, guiding focus on clock quality and signal stability during physical debugging; algorithm simulations optimize noise reduction parameters, while physical debugging challenges students to address practical engineering issues like noise and delay in mixed-signal circuits, achieving cross-level integration from “algorithm design” to “system implementation” .

Through the carefully designed experimental integration layers, a closed loop of 'virtual research, physical verification, and comparative feedback' is formed, deeply integrating the theoretical knowledge of the three courses into engineering practice, effectively cultivating students' systematic thinking and innovative abilities in solving complex engineering problems.

Innovation and Development Layer. Cross-curricular integration of virtual-physical driven Innovation Practice. The innovation and development layer is guided by “real engineering problems” or “projects with a military background” , emphasizing students' full-process practice of “independently defining requirements → integrating cross-curricular knowledge → virtual-physical collaborative innovation.” Virtual simulation addresses the high cost and high risk of prototype verification, while physical operations focus on engineering implementation and performance optimization, ultimately achieving the transformation from “learner” to “developer” . Three main directions are set: hardware innovation development, energy conversion device development, and digital signal processing system development.

Practical Hardware Innovation Development. Addressing real-world needs such as "sensor signal processing", this integrates knowledge of circuits, analog electronics, and digital electronics to cultivate full-chain innovation capabilities in "hardware design - signal conditioning - data processing". The knowledge involved includes resistive sensors (temperature sensors), operational amplifiers, comparators, and relay control. In the virtual stage, Multisim is used to simulate the output voltage of the temperature sensor, while in the physical stage, PCB design is completed using domestic EDA software, and core modules are soldered. A temperature generator is used to simulate different temperature environments, verify whether the system accurately displays temperature, and optimize the circuit. Innovative outputs include a physical "sensor signal processing" prototype, design report, and algorithm code, which can be further optimized into an "IoT front-end prototype".

Development of Energy Conversion Devices. Relying on the requirements for portable power supplies for individual soldiers, this focuses on engineering problems such as "small inverters," cultivating innovative abilities in "power electronics design - control algorithm implementation - system stability verification." Relevant knowledge points include photovoltaic cell characteristics, small wind turbines, DC-DC converters, and battery charging management. In the virtual stage, simulate the efficiency of Boost/Buck converters and analyze the matching between the open-circuit voltage of photovoltaic cells and the output power of wind turbines. In the physical stage, build a wind-solar hybrid circuit board connecting photovoltaic cells, wind turbines, and batteries; measure the battery charging time, and if the wind turbine efficiency is low, adjust the duty cycle of the Buck converter to enhance power transfer.

Real-Time Audio Noise-Canceling Headphones Production. Focusing on consumer electronics requirements, this cultivates innovative abilities in "digital algorithm design - hardware acceleration - real-time system implementation" . Design knowledge points include filter algorithms, establishing algorithm models on FPGA, and DAC debugging. In the virtual stage, use Python/ MATLAB to design an "adaptive filtering noise reduction algorithm" , simulate the signal-to-noise ratio improvement between "input signal" and "noise-reduced signal" , and optimize parameters to balance convergence speed and steady-state error. In the physical stage, design the core board based on MCU and FPGA, solder audio codec chips, microphones, and headphone interfaces, completing the full hardware setup for "audio input, acquisition, PGA processing, MCU control, and headphone output" . During joint virtual-physical debugging, use an audio analyzer to capture audio waveforms "before and after noise reduction" , compare with the virtual simulation "SNR improvement curve" , adjust the "filter order" and "LMS step size" in FPGA to enhance noise reduction; use a logic analyzer to verify the "MCU-FPGA communication timing" to ensure no data loss . The innovative output includes a "real-time audio noise-canceling headphone" prototype, algorithm code, and hardware design report, which can be further optimized to provide a solution for battlefield voice communication noise-canceling headphones.

2.2 Digital Resource Development Empowered by Technology

In the context of digital empowerment for blended virtual and physical multi-class collaborative teaching reform, the development of technology-empowered digital resources is a core infrastructure that supports “virtual-physical integration and multi-class collaboration” . It should focus on two main directions: “multi-platform collaborative tools” and a “virtual-physical integrated resource repository,” while taking into account the characteristics of electronics courses, namely “abstractness, practicality, and engineering orientation” , to build a digital resource system that is “usable, easy to use, and effective” .

Multi-platform collaborative Tools. Multi-platform collaborative tools need to cover the entire process from “teacher lesson preparation → student learning → lab operations → evaluation feedback”, addressing the issues of “disconnected tools and data silos” present in traditional teaching, achieving “one-time development, multi-terminal reuse, and data interoperability”. The design and selection of core tools mainly include: Simulation and virtual lab platforms, which support the “virtual” component, addressing pain points such as “invisible abstract principles and inaccurate complex processes” , and providing high-fidelity, interactive virtual simulation environments. Collaboration and interaction tools to support “multi-class collaboration,” primarily aiming to break the physical boundaries between “theory classes — lab classes — project classes” and “pre-class guided learning — in-class flipped learning — post-class expansion,” achieving “collaborative learning across time, space, and roles.” Virtual collaborative labs create “multi-user collaborative virtual lab spaces,” supporting student group collaboration and real-time monitoring of peers' operations and simulation results. Development of a “AI Teaching Assistant & Human Q&A” hybrid system, where the AI assistant automatically identifies student questions and pushes explanatory videos on relevant knowledge points. Multi-terminal teaching management platforms, supporting “teaching-learning-management” collaboration, integrating course resources, student data, and teaching workflows, enabling “one-click publishing for teachers, multi-terminal learning for students, and real-time data tracking.” This includes mobile learning platforms that allow students to enter virtual labs via QR codes, review preparation materials, and submit lab data, as well as teacher assessment platforms that display student learning progress, lab grade distribution, and common problem statistics in real-time to assist teachers in dynamically adjusting teaching strategies.

Developing a Resource Library Integrating Virtual and Physical Elements. Develop “short, simple, and fast” micro-lessons focusing on core knowledge points of electronic technology to address the issues of traditional classrooms such as “high information density and unclear key points”, supporting students' fragmented learning needs of “previewing, reviewing, and identifying gaps.” For the microscopic processes in electronic technology that are “invisible and intangible”, develop interactive and visually representable animations to transform abstract principles into intuitive phenomena, reducing the cognitive threshold. Develop a simulation library to achieve high-fidelity “virtual laboratories” , supporting real “trial-error, verification, and optimization” in “engineering scenarios,” cultivating “problem-solving” abilities and cross-disciplinary “comprehensive practice,” and promoting the advancement of “innovation ability.”

2.3 Establishment of Teaching Model

Establishment of Virtual-real Task Chain. The establishment of a virtual-real task chain is the core link of the multi-class interconnected teaching model that integrates virtual and real elements under digital empowerment. Its essence is to focus on the development of students' abilities, constructing a spiral progression path of abilities through the sequential design of “virtual tasks, physical tasks, and collaborative tasks”, which follows the progression of “knowledge comprehension—skill training—thinking enhancement—innovative breakthroughs ”. The design of the virtual-real task chain should revolve around “student ability development”, and the corresponding relationship between specific implementation objectives and levels is shown in Table 1.

Multi-class Collaborative Design. Based on the time dimensions of “before class - during class - after class”, it links the four main types of classes to achieve full-process coverage of “knowledge delivery → practical verification → immersive exploration → outcome production”. Integrated Design of Multi-Type Class as shown in Table 2.

Table 1. Establishment of Virtual-Real Task Chain

Ability hierarchy	Target Description	Task Chain Design
Basic Task Chain	Master core knowledge points and establish the “abstract-concrete” connection	Closed-loop validation from formulas to phenomena
Integrated Task Chain	Integrate multiple knowledge points, cultivate the ability of “system analysis and parameter optimization,” and solve “complex engineering problems”	From device characteristics to overall system performance
Innovation Task Chain	Integrate knowledge across courses to cultivate the abilities of “needs analysis, innovative design, and output of results”, achieving the leap from “learner to developer”	Integrated Application of Cross-Curricular Knowledge

Table 2. Design of Multi-Type Class Interaction

Time Dimension	Class Type	Core Features	Linked Design
Before class (Study guide session)	Theoretical class preparation	Convey the core knowledge of rehearsal	The teacher publishes “task chain micro-lesson virtual animation,” and students complete the micro-lesson test.

During class (flipped, deepened)	Laboratory Class Virtual Simulation Class	Strengthen “hand-brain coordination” and verify theories through physical operations; virtual environments overcome equipment limitations and support trial-and-error without cost	Students use Multisim for simulation, and build physical circuits on breadboards during circuit lab classes to compare the “ideal waveform' with the 'actual waveform.” Teachers can monitor students' operation data in real time through the backend and provide targeted guidance.
	Project Course (Preliminary Design)	Integrate knowledge from multiple courses and carry out “micro-project” practices to develop “requirement analysis-design” skills	Integrate knowledge from multiple courses and carry out “micro-project” practices to develop 'requirement analysis-design' skills.
After-class (extended class)	Extracurricular Activities (Innovation)	Extend classroom learning, engage in practical exercises with “real engineering problems,” and cultivate the ability to “implement systematically”	Address practical problems, optimize in-class projects, or complete small club projects and participate in innovation and entrepreneurship competitions.

Reconstruction of Teaching and Learning Roles. Break away from the traditional “teacher lectures, students listen” relationship, and build a bidirectional interactive ecosystem where “teachers are learning ecosystem builders and students are active constructors,” driving the implementation of the model. Firstly, the teacher's role shifts from “knowledge authority” to “learning ecosystem builder”. Teachers are responsible for designing the top-level task chains, as well as integrating, maintaining, and updating course resources such as micro-lessons, animations, simulation libraries, and case libraries. They plan multi-lesson workflows and key nodes, and must also take on the role of process guides—for example, stimulating students' learning interest before class by posing questions, and addressing learning obstacles during class through collaborative platforms. Secondly, students' roles transform from “passive recipients of knowledge” to “active constructors of knowledge and skills”. Before class, students engage in self-directed learning through the micro-lessons and simulations, and independently complete tests. During class, the flipped and deepening sessions turn them into collaborative innovators, communicating and working together to optimize solutions while gradually building innovative thinking. After class, in extension sessions, students complete full projects from design to implementation, and by presenting or sharing their work, they cultivate various abilities and become producers of tangible outcomes.

Teaching Effectiveness Assessment.

Diversified Evaluation Types. According to the assessment philosophy of “strengthening the process, emphasizing abilities, quantifying virtual achievements, and guiding practical creation," the entire learning process of students is included in the evaluation. It organically combines "virtual" (simulation, online) and "practical" (experiments, hands-on) performance, and assigns value to participation and contribution across "multiple sessions" (such as online pre-class sessions, offline practical sessions, and post-class extension sessions).

The evaluation types include diagnostic evaluation, formative evaluation, and summative evaluation for online pre-class teaching. The diagnostic evaluation methods include online pre-knowledge tests, surveys, pre-class mini-projects, or simulation tasks. Formative evaluation runs through all teaching stages, such as online self-study, virtual simulation, classroom discussion, and experimental operation. The evaluation methods include the completion of online tasks, completion and quality of virtual simulation projects, classroom interaction and questioning, contributions to group discussions, adherence to experimental operation procedures, and periodic quizzes. Summative evaluation occurs at the end of the course, with methods including final exams or final comprehensive project/work assessment and defense.

Diversified Evaluation Content and Weight Allocation. The evaluation content needs to be one-to-one corresponding to the "content remodeling" and "multi hall linkage" modes, which can be divided into the following five modules, and the evaluation content is weighted according to the corresponding dimensions:

$$A\ (15\%)+B\ (20\%)+C\ (25\%)+D\ (25\%)+E\ (15\%) = 100\%.$$

- A stands for online learning, including checking the completion, the time spent, the accuracy of the pre class test and the quality of the online forum question and answer.
- B stands for virtual simulation practice, including standardization of simulation model construction, rationality of parameter setting, and ability to analyze and reflect on simulation results.
- C stands for offline core links, including proficient and standardized instrument operation, circuit debugging and troubleshooting skills, scientific recording and processing of experimental data, team cooperation.
- D stands for project-based learning, and evaluates students' innovative thinking, project management ability, including design planning and innovation ability, project planning and execution skills, project report/document writing skills, and final presentation and defense performance.
- E stands for discipline competition, which measures students' innovative and practical achievements in applying knowledge in high-level competitions..

3 Practical Investigation and Data Analysis

In order to deeply explore the application status of the subject and students' needs, this study carried out a special questionnaire survey. A total of 149 valid questionnaires were collected in this survey, mainly focusing on the use of students' digital learning platform, the application experience of virtual simulation experiment, the attitude towards the "combination of virtual and real" teaching method, as well as the challenges and expected effects of the "multi class linkage" mode. The purpose is to provide data support and decision-making reference for optimizing the teaching mode of electrical courses and improving the teaching quality, and select several groups of data for analysis.

Most students believe that digital teaching platform is helpful for learning. As shown in Fig. 3, the proportion of students who choose " very helpful" and " relatively helpful" is 32.89% and 44.3% respectively, and the total of the two is 77.19%, more than three quarters. This data comes from Q5, "How helpful do you think the digital teaching platform (including online videos, materials, assignments and other functions) is to your learning? "

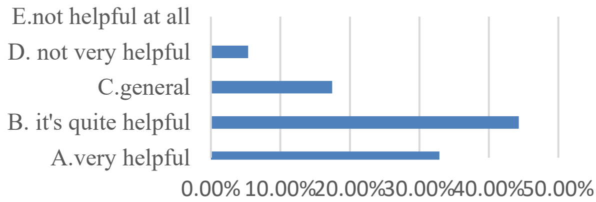

Fig. 3. Use approval of digital platform

Most of the respondents held a positive attitude towards the " virtual reality combination" teaching method. As shown in Fig. 4, more than 90% of the respondents agreed with the teaching method, nearly half of them thought it should be vigorously promoted, and more than 40% thought it was worth trying. This conclusion comes from Q10, "In general, what is your attitude towards the teaching method of 'combination of emptiness and reality'? "

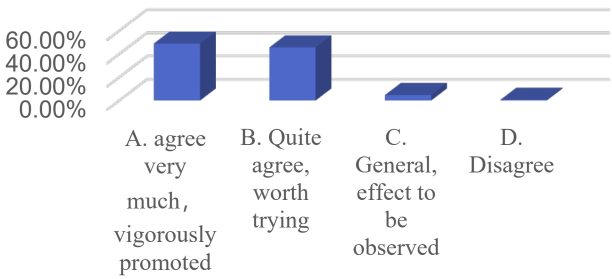

Fig. 4. Recognition of teaching methods

The "multi hall interaction" mode is considered to have a positive effect on the improvement of a variety of abilities, among which the combination of theory and practice and autonomous learning ability are highly recognized, as shown in Fig. 5, More than two-thirds of the respondents believe that this mode can improve the combination of theory and practice ability (69.8%) and autonomous learning ability (67.79%), The data comes from Q13, "What do you think can be improved by the multi hall linkage 'mode? ".

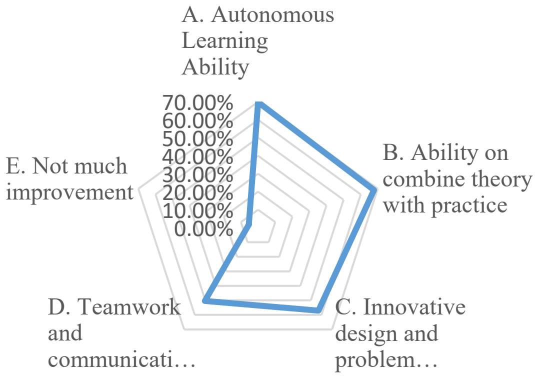

Fig. 5. Recognition analysis of linkage mode

4 Conclusion

The survey results indicate that students in electrical courses highly accept and expect the "virtual-real integration and multi-classroom linkage" teaching reform. They widely recognize the value of digital teaching platforms, particularly showing strong demand for high-quality resources such as key knowledge points, intensive lectures, and instructional videos. Students hold a positive attitude toward the "virtual-real integration" approach and prefer practical, project-based integrated curricula, hoping to achieve deep integration of theory, simulation, and practice through project-driven methods. The "multi-classroom interaction" model is considered highly potential in enhancing the ability to integrate theory with practice and fostering self-directed learning. However, the adoption of virtual simulation software remains limited, and concerns exist regarding self-discipline and learning burden under the "multi-classroom linkage" mode. These findings highlight clear directions for teaching reform: it should be student-centered, enhance the development of high-quality resources, deepen and broaden the application of virtual simulation, and fully leverage the complementary advantages of "virtual-real integration" to effectively develop students' comprehensive abilities. Since most respondents are sophomores—a stage where core electrical courses are typically offered—the survey results hold significant reference value.

Acknowledgment

This thesis would not have been completed without the guidance and support of many team instructors. Special thanks to Associate Professor Cui Jingna for her precise guidance throughout the thesis, from topic selection, framework construction to instructional design. Her rigorous academic attitude and deep insights into teaching greatly benefited the research. Thanks are also due to Professor Qi Lihua and Professor Zhang Luya for their valuable suggestions, which helped clarify the research ideas, improve the research and practice, enhance core methods, and facilitate the smooth progress of the study, and also wish to express our gratitude to the experts and reviewers for their insightful comments, which have been instrumental in correcting errors and enhancing the overall quality of this work.

Military Officers Joint Conference Educational Reform Project: SL2025111.

Hubei Province Educational Reform Project: 202401000266.

2025 University-Level Teaching Achievement Project.

References

1. Provide education that satisfies the people (Earnestly study, publicize, and implement the spirit of the 20th National Congress of the Communist Party of China) china.huanqiu.com/article/4AOns0zvhxj.
2. "Opinions of the Ministry of Education and Eight Other Departments on Accelerating the Digitalization of Education" (Jiaoban [2025] No. 3) www.gov.cn/zhengce/zhengceku/202504/content_7019045.html.
3. XIAO Jin, ZHAO Chengtao, HU Xiaoguang, ZHANG Xiulei, FAN Changbo, WU Xingming, "Reform and practice on inquiry teaching of 'Combination of virtuality and reality' in course of 'Experiment electrical technology'",Experimental Technology and Management. Vol.38 ,pp.219-224, China,Mar. 2021.
4. LIANG Zhanhong, LIAO Xiao hui,HU Yuxia,SU Kai,LUO Yong, "Exploration and Practice of the Blended Teaching for Circuit Experiment Based on the Combination of Virtualization and Reality", Experiment Science ndTechnology . Vol.20,pp.89-92, China, Dec.2022.
5. Aryanto, M. H. Pratama and N. U. Putri, "Increasing The Effectiveness of Electronic Physics Learning by Utilizing Extended Reality and Smart Virtual Technology Assistant as Interactive Media," 2023 International Conference on Networking, Electrical Engineering, Computer Science, and Technology (IConNECT), Bandar Lampung, Indonesia, 2023, pp. 127-131, doi: 10.1109/IConNECT56593.2023.10326769.
6. E. D. Grigorieva, V. B. Kreindelin and V. V. Frisk, "Application of New Technologies and Software in the Development of a New Laboratory Stand for Studying the Discipline of Electrical Engineering," 2022 Systems of Signals Generating and Processing in the Field of on Board Communications, Moscow, Russian Federation, 2022, pp. 1-5, doi: 10.1109/IEEECONF53456.2022.9744319.
7. T. B. Lemeshko, E. V. Gnezdilova and T. V. Ostapchuk, "Digital Technologies as the Basis of Teaching Special Training Courses at Universities," 2021 International Conference on Quality Management, Transport and Information Security, Information Technologies (IT&QM&IS), Yaroslavl, Russian Federation, 2021, pp. 682-685, doi: 10.1109/ITQMIS53292.2021.9642917.