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TEACHING MODE OF "FUNDAMENTALS OF ELECTRICAL TECHNOLOGY" COURSE BASED ON VIRTUAL-REAL INTEGRATION

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Abstract: This study innovatively developed a "Three Integrations, Three Stages, Six Steps" teaching model for the "Fundamentals of Electrical Technology" course through virtual-real integration technology. The framework systematically addresses critical challenges in traditional education such as insufficient practical opportunities, fragmented resources, and unscientific evaluation mechanisms. By advancing through five dimensions—foundational analysis, environment construction, model innovation, resource support, and evaluation assurance — the model establishes a comprehensive educational reform framework with a closed-loop implementation path. Practical evidence demonstrates that this approach significantly enhances student engagement, practical skills, and teaching quality. It provides a replicable paradigm for deepening the integration of information technology and pedagogical instruction in vocational education, offering valuable reference for similar technical course reforms.
Keywords: Virtual-real integration; Fundamentals of Electrical Technology; Teaching mode; Teaching evaluation

1 INTRODUCTION

With the rapid advancement of information technology, particularly the emergence of virtual reality (VR) and augmented reality (AR), new possibilities have been created for innovative educational models. The "Education Informatization 2.0 Action Plan" highlights that educational informatization possesses unique advantages such as breaking time-space constraints, rapid replication and dissemination, and diverse presentation methods, making it a crucial tool to enhance educational quality. It emphasizes strengthening the construction of virtual simulation training environments in vocational colleges and universities to meet the needs of digital teaching[1]. The "Vocational Education Quality Improvement Action Plan (2020-2023)" advocates deep integration of information technology with education, encouraging vocational schools to leverage modern IT to reform talent cultivation models, address students' diverse learning needs, and vigorously promote new forms of "Internet+" and "Intelligent+" education, driving transformative innovations in teaching practices[2].

"Fundamentals of Electrical Technology" serves as a cornerstone course for electrical engineering majors, equipping students with essential theoretical knowledge and practical skills to prepare them for advanced studies and real-world applications. However, traditional teaching methods often overemphasize theoretical instruction while neglecting hands-on experiments and practical training. This imbalance frequently prevents students from effectively integrating theory with practice, hindering their deep understanding of electrical engineering principles and development of application capabilities. By adopting a blended learning approach that combines virtual and real-world simulations, this course not only addresses these limitations but also enhances student engagement, motivation, and ultimately cultivates innovative thinking and practical problem-solving skills[3].

Therefore, this paper aims to explore the teaching mode of "Fundamentals of Electrical Technology" based on virtual-real integration. Through building a virtual-real integrated teaching environment, optimizing teaching content and methods, developing rational-real integrated teaching resources, establishing a diversified evaluation system and other measures, the teaching quality and learning effect of the "Fundamentals of Electrical Technology" course can be comprehensively improved.

2 THE KEY PROBLEMS TO BE SOLVED

2.1 Solve the Problem of Lack of System and Integrity in the Integration of Virtual Simulation and Teaching Mode

Currently, the application of virtual simulation technology in the "Fundamentals of Electrical Technology" course remains fragmented. Virtual simulation experiments often operate independently from theoretical instruction, lacking coherence in integrating virtual and real-world elements and failing to be embedded within a complete teaching process. To address this issue, this paper proposes a "Three Integrations, Three Stages, Six Steps" teaching model that incorporates virtual simulation throughout the entire learning cycle—before, during, and after class. By categorically

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designing application scenarios for virtual simulations, the approach enhances the systematic integration and holistic coherence of the educational framework.

2.2 Solve the Problem of Lack of Pertinence and Practicability in the Development of Virtual Simulation Teaching Resources

The current virtual simulation teaching resources for courses lack sufficient alignment with core knowledge points, making it difficult to effectively address key teaching challenges. Moreover, the simulated scenarios are disconnected from real-world engineering contexts. To address this issue, this paper proposes a layered design of virtual tasks centered on core competencies. Furthermore, we collaborate with enterprises to develop simulation resources featuring authentic engineering cases, thereby enhancing the practicality and career-oriented relevance of these resources.

2.3 Solve the Problem that the Virtual Simulation Teaching Evaluation System Lacks Scientificity and Objectivity

Traditional evaluation methods predominantly rely on summative assessments, overemphasizing one-time test results while neglecting behavioral data from the learning process. This single-dimensional approach fails to comprehensively and authentically reflect students' academic achievements and skill development, leading to biased evaluation outcomes that hinder effective teaching optimization and learning improvement. To address this issue, this paper proposes a data-driven dynamic evaluation system that incorporates multi-dimensional assessment indicators to dynamically evaluate learning performance.

3 THE INTEGRATION OF VIRTUAL AND REAL TEACHING MODE

The integration of virtual and real-world teaching practices focuses on creating simulated authentic learning environments for students. This approach fulfills the expected practical objectives of course instruction while achieving pedagogical outcomes through immersive simulations. By deeply integrating embodied experiential learning with interactive engagement, it fosters students' immersion in the educational process and cultivates their application capabilities[4].

This project advances systematically through five dimensions: "foundational analysis, environmental construction, model innovation, resource support, and evaluation assurance". It establishes a comprehensive framework for teaching reform research. By conducting student needs assessments, optimizing curriculum standards, and setting objectives (foundational analysis), the project creates a blended virtual-real teaching environment (environmental construction). The innovative "Three Integrations, Three Stages, and Six Steps" teaching model (model innovation) is developed, complemented by a multidimensional teaching resource system (resource support). Ultimately, a dynamic, diversified evaluation mechanism (evaluation assurance) is established, forming a closed-loop teaching reform pathway. The overall idea is shown in Figure 1.

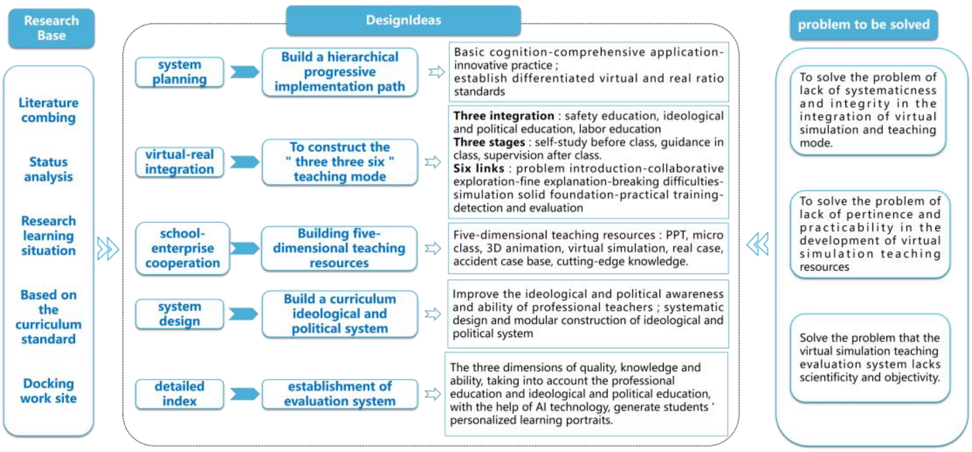

Figure 1 Overall Idea

3.1 Research and Analysis, Sorting out and Summarizing the Collected Data to Consolidate the Foundation of Virtual-Real Integration Teaching

"Fundamentals of Electrical Technology" is a core required course for electrical engineering majors, serving as a crucial program to develop students' professional competencies and ethical standards. As the primary participants in classroom activities, students should actively engage in curriculum research to identify individual differences and comprehensively address their learning needs. This approach ensures teaching resources effectively meet student requirements, enabling them to utilize learning materials appropriately and enhance their academic outcomes.

Through questionnaire survey and interview quantitative analysis, students' basic knowledge of electrical engineering, cognitive style and technical acceptance were quantified; industry enterprises were combined to sort out typical work tasks and extract core competency modules; existing training conditions were sorted out and the current situation of virtual simulation application was analyzed, so as to provide data support for the innovation of teaching mode and resource development in the future.

3.2 System Planning, Build a Hierarchical Implementation Path, and Form a Virtual and Real Integrated Teaching Environment

To address the current deficiency in deep integration of virtual and real-world elements in teaching, we have developed a tiered "basic cognition-comprehensive application-innovative practice" teaching pathway that combines virtual and physical environments, establishing virtual simulation and practical training platforms. ① The foundational layer focuses on virtual simulations, using software like Multisim for basic circuit theory training. ② The comprehensive application layer employs a hybrid approach, simulating complex system operations in virtual environments before conducting physical equipment verification. ③ The innovative layer utilizes real-world projects as carriers, leveraging virtual-real platforms to collaboratively solve open engineering challenges. We also established differentiated virtual-real integration standards, implementing progressive implementation plans for theoretical foundations, comprehensive training, and innovative projects through varying degrees of virtual-real integration, providing environmental support for subsequent teaching model implementations[5].

3.3 Build a Teaching Mode of "Three Integrations, Three Stages, and Six Steps" to Improve the System of Integration

Centered on students, aiming at the improvement of quality, knowledge and ability, and taking project tasks as the carrier, we build a teaching mode of "Three Integration, Three Stages and Six Steps".

The "Three Integrations" initiative integrates three educational dimensions throughout the teaching process: labor education, ideological-political education, and safety education. Specifically, labor education empowers students to master practical skills like electrical tool usage and wiring installation through hands-on practice, while cultivating their work ethic and dedication. Ideological-political education leverages China's world-leading achievements in ultra-high voltage power transmission technology to foster technological confidence, and showcases exemplary stories of power industry workers to instill professional values of diligence and commitment. Safety education employs VR simulations of electric shock and short-circuit scenarios to reinforce the principle of "safety first." This integrated approach creates a tripartite educational framework combining technical skills, moral cultivation, and value orientation.

The "Three Stages" framework comprises three phases: pre-class self-study, in-class guided learning, and post-class supervision. During the pre-class self-study phase, students prepare materials through preparatory work. The in-class guided learning phase employs six instructional modules: problem introduction, collaborative inquiry, detailed explanation of key concepts, simulation-based foundation reinforcement, practical skill development, and assessment evaluation. Utilizing virtual simulation technology to replicate real-world scenarios, students perform circuit assembly and fault diagnosis operations within a virtual environment. Through hands-on practice, they apply skills learned from simulations to actual equipment operation, enhancing both practical skills and engineering competencies. The post-class supervision phase involves reviewing previously acquired knowledge and completing extended learning tasks[6].

The "Six Steps" integrates virtual simulation technology throughout the entire learning process − from pre-class preparation to in-class exploration and post-class extension − forming a closed-loop learning path of "theory − virtual practice − real operation − reflection and optimization". By organically combining theoretical instruction, virtual simulations, and hands-on training, this framework establishes an integrated teaching system that seamlessly blends theoretical knowledge with practical application.

Through "Three Integration, Three Stages and Six Steps", the organic unity of knowledge transmission, ability cultivation and value guidance is realized.

3.4 School-enterprise Cooperation, Build a Five-Dimensional Teaching Resource Platform, and Form a Virtual and Real Integrated Resource Base

We have established a specialized curriculum team combining full-time and part-time faculty members from universities and enterprises. By integrating electrical and electronic training laboratories and utilizing virtual simulation software for experiments, we have developed high-quality digital teaching resources that form a five-dimensional educational framework: "Initiation, Learning, Practice, Operation, and Expansion" with clear application scenarios[7]. ① Pre-class Self-study: Develop pre-class learning resource packages to support students 'pre-class exploration and stimulate critical thinking. ② Course Platform: Leverage Shandong Electric College's digital learning platform advantages through micro-lectures, 3D animations, and virtual simulations to create personalized courses for principle-based learning. ③ Virtual Simulation: Utilize experimental simulation software to develop course-specific virtual resources focused on technical skill development. ④ Practical Training: Establish standardized real-world work environments in electrical training laboratories and create hands-on demonstration course materials for student practice.

⑤ Post-class Expansion: Develop extended learning resources based on real-world case studies and emerging electrical technology advancements to enhance knowledge retention and skill enhancement.

3.5 Taking Teachers as the Basis, the Ideological and Political Education System is Systematically Designed and Modularly Constructed to Realize Ideological and Political Education

① Enhance professional teachers 'ideological and political awareness and capabilities to build solid ideological education expertise. Strengthen course instructors' primary role in integrating ideological education into teaching, reinforce their dual focus on instruction and student development, improve teachers' political literacy, and elevate their ideological education capabilities[8]. ② Systematically design and modularize the ideological education framework. Construct a resource repository encompassing industry pioneers, contemporary role models, historical contexts, disciplinary frontiers, and national engineering projects. This repository will incorporate diverse teaching methods and concrete case studies, with layered integration according to course modules. Through multi-level ideological education integration points from modules to tasks, achieve comprehensive coverage across all dimensions[9].

3.6 Refine Indicators and Build a "Diverse, Multidimensional, Dynamic" Evaluation System to Achieve Scientific Evaluation

The assessment system evaluates students across three dimensions－quality, knowledge, and competence－while integrating professional education with ideological-political education. It establishes evaluation metrics through a combination of online learning assessments, process evaluations, and outcome-based assessments. The ideological-political assessment is embedded throughout the learning process in both implicit and explicit ways, focusing on students 'developmental changes during the learning journey and exploring value-added assessment methods. By leveraging AI to analyze massive student data collected from learning platforms, personalized learning profiles are generated to more accurately assess students' learning capabilities. This enables the provision of tailored learning recommendations, fostering self-directed learning and holistic student development.

4 RESULT AND EFFECT

4.1 The Teaching Quality has been Significantly Improved

By developing a blended teaching model for the "Fundamentals of Electrical Engineering" course featuring "Three Integrations, Three Stages, and Six Steps", we organically integrate labor education, ideological-political education, and safety education into three instructional phases: pre-class, in-class, and post-class. During the in-class phase, we employ a six-step pedagogical approach: problem introduction, collaborative inquiry, focused explanation, simulation reinforcement, practical training, and assessment evaluation, with virtual simulation technology integrated throughout the entire teaching process. This blended teaching method that combines theoretical knowledge with practical application not only enhances students' hands-on skills but also significantly improves overall teaching quality and learning outcomes.

4.2 The Teaching Resource System is More Perfect

The curriculum development has established a multidimensional teaching resource repository encompassing theoretical instructional videos, virtual simulation resources, practical demonstration materials, and interactive learning modules. Leveraging electrical and electronic simulation software alongside laboratory hardware facilities, a dual-environment teaching platform integrating virtual and real-world components has been developed. This integrated theoretical-practical-physical educational resource system provides students with enhanced learning experiences, effectively boosting both academic efficiency and engagement.

4.3 The Teaching Evaluation System is More Scientific

We have innovatively developed a comprehensive evaluation system that is diversified, multidimensional, varied, and dynamic. By integrating multi-source data from virtual platforms, we fully leverage the guiding, motivating, diagnostic, and improvement functions of evaluations. The established dynamic evaluation mechanism provides real-time feedback on teaching information, offering data-driven support for instructional optimization and student development. This approach achieves scientific precision in educational assessment.

5 CONCLUSION

This study develops a "Three Integrations, Three Stages, and Six Steps" teaching model for the Electrical Engineering Fundamentals course through virtual-real integration technology. By implementing systematic instructional design, multidimensional resource development, and dynamic evaluation systems, the model has significantly enhanced both teaching quality and student learning outcomes. Practical results demonstrate that this blended approach not only addresses shortcomings in traditional teaching's practical components but also significantly improves students' theoretical comprehension, hands-on skills, and innovative thinking through immersive, interactive learning experiences. The virtual-real integration model provides fresh perspectives for curriculum reform in Electrical Engineering Fundamentals while injecting new momentum into the digital transformation of vocational education. Moving forward, we will continue refining this model to contribute to cultivating highly skilled technical professionals.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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