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Exploration of Multi-Dimensional Collaborative Practice and Education Path for Electrical Engineering and Automation Major under the Background of "Dual Carbon"

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Abstract: Driven by the strategic goal of "dual carbon," the electric power industry is entering a critical period of transformation and upgrading, and there is a growing demand for composite and applied talents who are both proficient in professional technology and good at management. Taking the electrical engineering and automation major of Liupanshui Normal University as an example, this study addresses existing challenges in current talent cultivation practices. By emphasizing the deep integration of theory and practice and aligning closely with industry needs, the study aims to ensure that the talent cultivation system is both forward-looking and practical. Focusing on key aspects such as the practical teaching system, practice platforms, teaching content, instructional methods, assessment and evaluation strategies, and resource optimization, a series of targeted measures are proposed. These measures aim to construct a comprehensive, multi-dimensional practice education system that enhances students' practical innovation abilities and overall competencies. This approach not only improves the quality of talent cultivation but also serves as a valuable reference for the development of electrical engineering education in similar local colleges and universities.

Keywords: Dual carbon goals; Industry demand; Composite applied talents; Practical education; Reform and innovation

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1. Introduction

The implementation of the "dual carbon" strategy is an important initiative for China to respond to climate change, accelerate the construction of ecological civilization, and achieve green, low-carbon, and high-quality development [1]. To this end, the Ministry of Education of China released the Carbon Neutral Science and Technology Innovation Action Plan for Higher Education in 2021, which integrates the concept and practice of carbon neutrality into the talent cultivation system, supports the innovation of industry-teaching integration in carbon neutrality-related majors, and strengthens the construction of practice resources and platforms [2]. The "Work Plan for Strengthening the Construction of Carbon-neutral Higher Education Talent Training System" released in 2022 also emphasizes a series of practical initiatives aimed at promoting green and low-carbon awareness. These initiatives include optimizing the curriculum system, enhancing professional practice, deepening industry-academia collaboration, improving the construction of industry-education integration platforms and operational mechanisms, and collaborating on knowledge mapping and experimentation [3]. As a key sector in achieving the "dual carbon" goals, the power industry faces complex challenges in transitioning to a new energy-dominated system. This system emphasizes multi-energy complementary power supplies and the synergistic operation of generation, grid, storage, and load. Addressing these challenges requires cultivating a substantial number of composite, application-oriented talents who possess not only technical expertise but also strong management skills, knowledge, critical thinking, and high-quality professional capabilities. These talents will provide essential technical and personnel support to drive the transformation and upgrading of the industry [4,5].

In order to strengthen the quality of practical education for electrical engineering and automation majors (hereinafter referred to as electrical majors), in recent years, many domestic universities have carried out reform research on the practical teaching system of electrical major talent cultivation based on the background of "dual carbon." For example, Shenyang University of Engineering focuses on the combination of theory and engineering practice, establishes a separate integrated innovation laboratory and virtual experimental platform, and develops practical simulation experiments and intensive training programs covering both in-course and after-course, so as to strengthen the cultivation of engineering practical ability [6]; Northwest Agriculture and Forestry University integrates the concept of "dual carbon" into practical teaching, optimizes the practical course system according to the idea of "reducing traditional thermal power and increasing new energy power generation," and strengthens the practical platform through the introduction and development of practical teaching equipment in cooperation with enterprises [7]; China University of Mining and Technology, on the other hand, has built a multi-dimensional practical teaching mode by adopting the "two main bodies and three links" and building various kinds of platforms for science and innovation and competitions, so as to emphasize on the cultivation of students' practical skills and innovation ability [8]; Huazhong University of Science and Technology focuses on "electrification +," relying on the engineering practice platform, and builds an integrated engineering practice teaching system with synergy of "knowledge, skills, and awareness," realizing the transformation and upgrading of students' practical ability cultivation mode from "fragmentation" to "systematization" [9]; Shanghai Jiao Tong University has cross-fertilized theoretical and ideological elements in its practical courses, and constructed a four-phase progressive practical teaching system of diversified innovations: "engineering foundation-professional quality-designing ability-researching and creating ability" [10]; Xi'an University of Posts and Telecommunications focuses on the goal of "dual carbon," improves the construction of practical teaching platform, and promotes the quality of practical education from the dimensions of in-class experiments, fusion of science and education, combination of science and competition, and engineering application [11]; Suzhou University of Science and Technology has explored the institutional mechanism, methods, and strategies for cultivating innovative talents in electrical engineering from the ecological chain of university-enterprise collaborative education, practical platform of industry-teaching fusion, "dual-teacher, dual-competence" teaching team, and the four-dimensional construction of curricular resources [12].

Based on their own talent training goals, foundations, and conditions, the above-mentioned colleges and universities have carried out reforms from the aspects of strengthening the construction of a practical platform, building a practical teaching system, and innovating practical teaching models, while less is involved in ensuring the teaching content, teachers, and resources of practical teaching, and the results achieved have certain limitations in the implementation of colleges and universities in other regions. For this reason, this paper takes Liupanshui Normal University as an example and explores the path of practical education for cultivating composite applied talents in the electrical profession, which provides certain references for the cultivation of talents in this profession in similar local universities.

2. Analysis of professional background and current situation of practice teaching

The electrical majors of Liupanshui Normal University were established in 2013, and after more than a decade of development, the program was awarded the project of first-class undergraduate program construction at the university level and provincial level in 2020 and 2021, respectively. As of 2024, it has trained more than 540 graduates for the electric power, manufacturing, mining, and other industries in the province and abroad. There are seven full-time teachers, including five master's degree holders, three senior titles, less than 30% of teachers with more than five years of teaching experience and engineering practice experience and industry background, 30.24% of practice credits, and few teaching resources for practice courses. At present, there are still the following problems in the practice education of this major.

2.1. Unreasonable system of practical class courses

To enhance students' sense of social responsibility and mission, as well as to develop teamwork, communication, critical thinking, and innovative problem-solving skills for complex engineering challenges, practical courses have been designed to meet or exceed the requirements of the National Standard for Quality of Undergraduate Teaching of Electrical Specialties and the engineering certification standards. However, limitations in faculty expertise and platform resources have resulted in outdated courses that lack systematic organization and cutting-edge content. These courses often fail to align with the talent cultivation objectives and the evolving demands of industry positions, leading to delays in curriculum updates. Additionally, issues such as "person-centered course design" have contributed to a focus on quantity rather than quality in course offerings. The arrangement and credit allocation of some practical courses are poorly planned, with limited integration between theoretical and practical studies or between sequential courses. This disconnect results in a separation of theory and practice, diminishing the effectiveness of practical training. For example, an imbalance exists in the scheduling of practical courses, with more courses concentrated in the third semester and fewer in the fifth. Furthermore, experiments in mathematics and electrical engineering are conducted during the same semester as their theoretical courses, while other courses, such as Electrometer Science and Power Electronic Technology, lack corresponding experiments or practical training projects entirely.

2.2. Insufficient practical teaching platforms and resources

Rich and diverse practical teaching platforms and resources are essential for ensuring the quality of practical education. However, due to insufficient capital investment, there are significant challenges in maintaining the quantity and quality of both on-campus experimental training equipment and off-campus practice bases. Existing experimental equipment has a low average number and utilization rate, is not updated promptly, and supports only a limited number of training projects. Moreover, the content of these projects does not align with the latest technological advancements in the industry. The number of off-campus practice bases is also insufficient, and their degree of alignment with professional fields is relatively low. In addition, there are shortcomings in teaching personnel and resources. The number of qualified instructors is inadequate, and the available teaching materials and experimental training projects lack richness and fail to effectively integrate with professional training objectives and characteristics. Furthermore, the mechanisms for supporting discipline-specific competitions and extracurricular innovative practice activities—such as training platforms, funding guarantees, and organizational and management systems—are insufficient, further hindering the development of comprehensive practical teaching.

2.3. Lack of scientific practical assessment and evaluation

The scientific design of assessment and evaluation is a critical factor in ensuring the effectiveness of teaching outcomes. However, the current assessment and evaluation methods for practical courses are overly simplistic and lack a balanced focus on both results and processes. The evaluation mechanisms are neither sufficiently systematic nor process-oriented. For instance, in independent experimental courses, the assessment primarily consists of two components: pre-testing and the experimental report. This approach neglects the evaluation of the experimental process itself, which is essential for cultivating students' practical skills and innovative abilities. Similarly, in practical training courses, grades are typically composed of process performance and the practical training report. However, there is inadequate monitoring of the practical training process, making it difficult to effectively evaluate students' teamwork skills, innovative thinking, and ability to analyze and solve problems. Moreover, the current evaluation methods lack scientific rigor and do not incorporate a comprehensive feedback mechanism. As a result, the real impact of course teaching cannot be accurately assessed in a timely manner, limiting opportunities for continuous improvement.

2.4. Weak engineering practice capacity of faculty members

The teaching staff forms the foundation for ensuring the quality of practical courses. However, challenges such as teacher shortages and high turnover rates, combined with regional and platform constraints, significantly impact this major. On one hand, recruiting and retaining qualified teachers remains difficult. The existing faculty structure is unbalanced in terms of educational background, age, and professional titles. There is a notable shortage of "double-qualified" teachers and those with industrial engineering practice experience, resulting in insufficient expertise in integrating teaching with engineering practice. On the other hand, due to limited engineering practice ability and experience, the depth and breadth of practical course content fail to meet the market demands of industries aligned with the "dual carbon" goals. The knowledge system is updated slowly, leading to overly simplistic content in independent experimental courses and a low proportion of design-based and comprehensive projects. This inadequacy hinders students' deeper understanding and application of theoretical knowledge and limits their ability to think critically, analyze, and solve problems independently. Additionally, curriculum design and comprehensive training projects are disconnected from real-world engineering practices. The teaching content lacks a forward-looking perspective, which diminishes its capacity to foster students' innovative practical skills and comprehensive quality effectively.

2.5. Insufficient depth of industry-teaching integration and school-enterprise cooperation

Industry-teaching integration and school-enterprise cooperation are crucial for enhancing students' professional skills and overall quality. However, challenges persist due to insufficient mutual understanding between schools and enterprises regarding the integration of industry and education. The concept of collaborative education is not aligned, and a cohesive "system-platform-team" synergy model has yet to be established to facilitate seamless, mutually beneficial cooperation. As a result, the integration of industry and education lacks alignment, and school-enterprise collaboration remains superficial and ineffective, manifesting in the following issues:

(1) Differences in nature and institutional barriers: Universities and enterprises have fundamentally different natures and objectives, which create barriers to effective collaboration. For example, there is often no clear agreement on who should invest in and manage joint practice platforms. The lack of alignment in interests between the two parties makes it challenging to advance meaningful cooperation.

(2) Superficial level of collaboration: The content of school-enterprise cooperation tends to remain at a relatively shallow level. While the program may have signed industry-academia-research cooperation agreements with local enterprises, in practice, these enterprises often serve merely as venues for student internships rather than active collaborators in research and development, technological innovation, talent cultivation, or curriculum development.

(3) Misaligned management and insufficient incentives: The differing management and assessment mechanisms between schools and enterprises, coupled with an inadequate incentive system for cooperation, reduce the motivation of teachers to engage in scientific and technological research for enterprises. Consequently, the research projects undertaken by universities often fail to align with the actual needs of the industry.

3. Multi-dimensional synergistic practical education path exploration

In response to the strategic goal of "dual carbon" and the demand for electrical talent in the development of new engineering disciplines, the electrical engineering program, rooted in Guizhou and serving the central and western regions of China, adheres to the principles of moral education, student-centered learning, and the training philosophy of "strong foundation, broad scope, interdisciplinary focus, and robust skills." By embracing innovative thinking, bold reforms, seizing opportunities, and staying in step with the times, the program has built a multi-dimensional professional practice teaching system. This system is developed through initiatives such as "establishing frameworks, strengthening platforms and faculty, driving reform, enriching resources, and ensuring support," aiming to improve students' practical skills, innovative capabilities, and overall quality. These efforts aim to cultivate versatile and application-oriented talent to meet the demands of the "dual carbon" strategy.

3.1. Top-level design and construction of "3, 3, 4, 1" progressive practical teaching system

Practical teaching is a vital component in the training of electrical engineering students. To strengthen their grasp of theoretical knowledge, enhance their innovative thinking and application skills, and cultivate the practical innovation ability and engineering literacy required to solve complex engineering problems in the "dual-carbon" context, it is essential to design modularized practical courses. Based on the professional training objectives and practical course teaching principles, and adhering to the approach of "simple to complex, component to system, and strong-weak power integration," a "three combinations, three levels, four modules, and one classroom" (3, 3, 4, 1) practical teaching system has been developed.

The "three combinations" refer to the integration of theoretical and experimental teaching, the blending of basic training with skill development, and the fusion of innovative training with ability enhancement. The "three levels" include general practice and basic experiments, comprehensive and design-oriented experiments or practical training, and innovative research internship training. The "four modules" consist of public practice, basic practice, professional practice, and comprehensive and innovative practice, while "one classroom" refers to the second classroom. Guided by the principles of “cognitive inspiration, verification and design, specialized training, comprehensive application, and research innovation,” we have developed practical courses and second-classroom activities spanning all eight semesters. These activities are designed to complement theoretical courses, ensuring a progressive learning pathway from “engineering awareness” to “basic skills,” “comprehensive ability,” and ultimately, “innovative ability.”

3.2. Multi-dimensional synergism to consolidate the “four platforms” for practical education

The practice platform is the foundation of practical teaching. With a focus on the fundamental task of cultivating both character and expertise, and guided by the construction of the “Sanquan education” system and mechanism, we emphasize aligning with industry needs, career development, and relevant positions. Based on the characteristics of the specialty, we aim to integrate and expand various resources both within and outside the school, strengthening the development of the “four platforms.” The construction of these platforms ensures the effective implementation of the “3, 3, 4, 1” progressive teaching system. The “four platforms” include the professional experimental training platform, on- and off-campus internship practice platform, innovation practice training platform, and comprehensive quality training platform, all of which support the four-module curriculum and the second classroom, as shown in **Figure 1**.

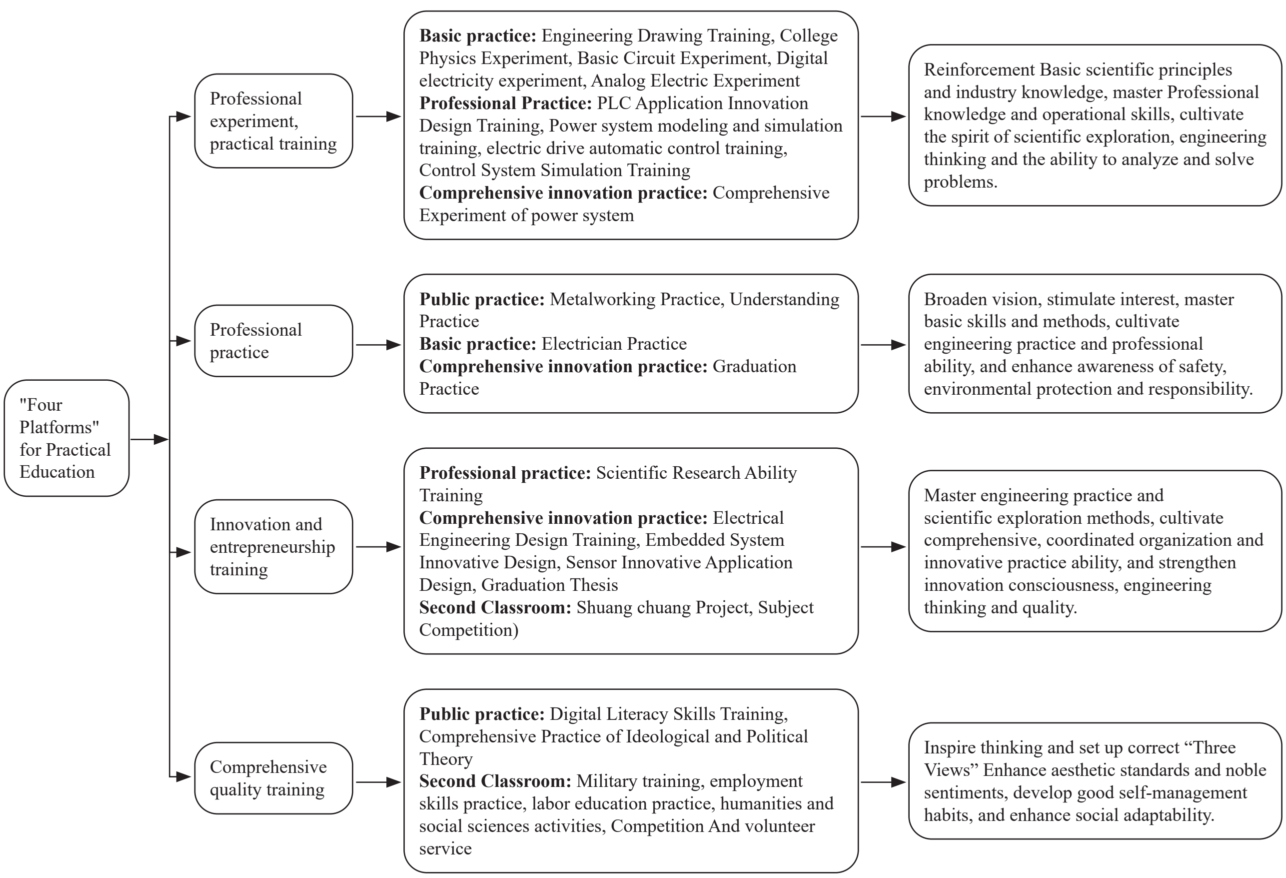

Figure 1. Supporting relationship between practice platform and course module

3.2.1. Platforms for specialized experiments, training, or internships

To align with industry needs and job requirements, we aim to integrate professional talent training objectives by updating and upgrading experimental and practical training equipment and technology. This includes introducing advanced experimental equipment and enhancing the technological content of internship training. Additionally, we will optimize the internship system for metalworking and electrician practices, develop experimental and practical training projects in depth, refine laboratory management mechanisms, and innovate the modes of experimental and practical training to ensure the platform is scientifically advanced, sophisticated, standardized, and well-utilized. In line with professional characteristics and service orientation, we will improve the school-enterprise cooperation management mechanism by establishing three key systems: organization, system, and guarantee. This will deepen cooperation in resource sharing, talent co-cultivation, technology co-research, and achievement sharing, ultimately enhancing the off-campus internship bases' capacity to educate students both quantitatively and qualitatively. Furthermore, leveraging modern information technology, we will establish an online management system for internships that integrates the release, application, matching, process tracking, results submission, and evaluation of internships, improving efficiency and transparency in resource utilization and internship management.

3.2.2. Innovative practical training platform

By combining platforms, faculty, and academic resources, we aim to highlight the integration of theory with engineering practice. Utilizing the school's online learning platform, we will build basic resources and project cases for innovation practice training, addressing the gaps in basic knowledge, tool usage, and skills that are not fully covered in the current talent training curriculum. This includes resolving issues related to outdated or missing course content. Additionally, we will integrate existing laboratory resources, instrumentation, and faculty expertise. Strengthening the undergraduate tutoring system will support electrical professional discipline competitions and dual-creation project training. This will focus on applied research and the development of physical devices in fields such as intelligent control, modeling and simulation, electronic equipment, mechanical structure, and instrumentation. The initiative will also involve the establishment of several innovative practice training studios. We will organize competitions in areas like embedded chip and system design, electrical and electronic engineering innovation, and other disciplines, encouraging every student to participate. These competitions will serve as a platform to enhance students' innovation and practical abilities.

3.2.3. Comprehensive quality training platform

We will integrate and explore cultural resources both on campus and within the surrounding urban area, such as the "Three Lines" Museum, the Party History Education Base, and the relief wall, to enhance the quality of general practice courses in national defense, ideology and politics, humanities, art, and career development. Additionally, we will enrich the university's series of student associations, social practice initiatives, and volunteer services, including activities like monthly matches, "My Weekend, My Troupe," the "Science and Technology Minghu Rhythm of Autumn," and the "Three Trips to the Countryside" during holidays. In alignment with professional characteristics, we will emphasize multidisciplinary integration and strengthen the development of activities that align with the unique qualities of each college, such as "one college with one characteristic" and "one professional with one event or activity." This approach will ensure a deeper and more engaging experience for students, fostering both personal and professional growth.

3.3. Social demand-oriented to comprehensively promote the reform of practical courses

Driven by the goals of the dual carbon strategy, China's electric power, manufacturing, transportation, and other industries have entered a new era. As a result, the demand for electrical professionals in society has undergone significant changes. Reforming the teaching content of practical courses, teaching methods, and assessment and evaluation systems is crucial for effectively improving the quality of practical education. These reforms play a key role in cultivating versatile, applied talents with broad foundational knowledge, strong professional skills, high comprehensive quality, and a sense of responsibility.

3.3.1. Optimizing and integrating practical teaching content

Based on the needs of the industry, positions and career development, the teaching contents of various practical courses are sorted out, optimized and integrated, focusing on the organic connection of each module, highlighting the actual engineering in the industry and reflecting the "three-step progression."

(1) The public practice courses are designed in line with the current situation and trends in the development of electric power, industry, and other sectors under the dual carbon strategy. The teaching content is broadened to cover both general knowledge and cutting-edge developments. For instance, the metalworking practice course aligns with professional characteristics, supports industry needs, and integrates new processes and technologies that meet the demands of the new era, offering diverse internship projects. The cognition practice course focuses on expanding into emerging fields such as smart grids, renewable energy, and electric vehicles, while also incorporating enterprise operations, job roles, product development, and equipment management into the curriculum.

(2) The independent experiment and practice courses in basic subjects discard outdated experimental projects, shifting from confirmatory experiments to a focus on interconnecting courses. The experimental content is reorganized to integrate modern science, interdisciplinary knowledge, and the latest experimental equipment, tools, and methods. The proportion of comprehensive, designed, and innovative experimental projects is increased. For example, the basic circuit experimental courses now include experiments related to current electronic technologies, design applications, and practical implementations, while the analog electronic technology courses incorporate integrated circuit performance testing, analysis, and the integration of virtual and real-world design and testing scenarios.

(3) Professional skills, comprehensive, and innovative practical courses are designed around industry technology and integrate scientific research, engineering, and social applications. Practical training equipment is enhanced, and teaching content is updated to ensure it is both practical and relevant. These courses also incorporate cross-disciplinary elements. For example, courses integrate the latest industry technologies, research results, and real-world applications into the curriculum. Students work on comprehensive and innovative projects such as designing small distributed photovoltaic power systems, power supply and distribution for 10kV factories, 110kV power system simulations, and electrical equipment control programs.

(4) Social practice is aimed at enhancing professional ethics and literacy. Students are screened, guided, and encouraged to engage in social practice activities that are closely aligned with the career development needs of this major.

3.3.2. Reforming and innovating teaching models

Reform and innovation of teaching mode is the key to cope with the changes in the development of the industry and improve the quality of the course and teaching effect.

(1) A reasonable division of course content, combined with online and offline learning, allows both students and teachers to make full use of fragmented time. Online learning is used to complete pre-study, homework, and report corrections, while offline sessions focus on hands-on practice. Teachers

guide students through pre-study and practice problems, providing Q&A sessions to enhance learning efficiency and quality. This approach also optimizes the use of experimental equipment.

(2) The introduction of modern educational technologies and information resources addresses the challenges posed by limited practical equipment, venues, and funding for electrical specialties. Virtual simulation tools and software create an integrated teaching mode—combining theory, virtual practice, and real-world application. This approach helps alleviate the complexity and abstraction of theoretical knowledge, improving students' engagement and understanding by simulating practice in a virtual environment.

(3) Digital empowerment expands the teaching space by incorporating generative AI technologies, such as ChatGPT, into practical courses. This creates a personalized learning system that addresses the limitations of traditional teaching methods—such as fixed content, limited interactive activities, and single evaluation approaches. By personalizing the teaching content and allowing for a flexible learning process, the system provides a more traceable and effective teaching experience.

(4) The project-driven approach integrates position-specific courses with competition certificates. By strengthening interactions with enterprises and tailoring course content to meet industry needs, the curriculum is aligned with real-world projects and vocational qualification training. Technical challenges faced by enterprises are transformed into topics for innovation and entrepreneurship practice. School-enterprise cooperation in student-driven double-creation projects and competitions helps bridge the gap between teaching content and engineering practice, enhancing students' innovation, practical skills, and employability.

(5) Promoting the deep integration of "Ideological and Professional Education" is key to optimizing practical courses. By incorporating ideological and political elements into professional teaching, the objectives of practical courses are refined. Ideological and political education is integrated into all aspects of teaching, forming a multidimensional teaching model. This integration enhances the educational value of practical courses, shaping the overall quality of education.

3.3.3. Reconstructing the assessment and evaluation system

Following the principle of "diversified, objective, scientific, and accurate," we monitor and evaluate all aspects of practical course teaching.

First, combining quantitative evaluation with summative evaluation to construct diversified evaluation methods. Diversified assessment items are set to quantitatively evaluate students' learning attitude, knowledge mastery, problem-solving ability, and value improvement in the whole process, the final questionnaire surveys the summative evaluation course content, teaching mode, three-dimensional goal achievement, and learning resources. For example, the quantitative assessment items of independent experimental courses are designed as preview performance, pre-test of experimental operation, virtual imitation operation, offline operation, and experimental report; the quantitative assessment items of practical training courses are designed as classroom performance, theoretical test, practical training operation, practical training report, and defense; and the quantitative assessment items of the thesis (design) are designed as attitude and specification requirements, literature reading, amount of work, technical level, theoretical foundation of the research results and professional knowledge, logical structure and written expression, and answer [13].

Second, the evaluation subject is diversified, and the multi-agent evaluation method of "teacher + X" is adopted, in which "X" flexibly selects students, school experts, enterprise experts, and other subjects according to the characteristics of the course and the evaluation items, and evaluates the teaching effect from the perspective of different subjects, making up for the limitations of the evaluation perspective of teachers, and improving the comprehensiveness and scientifically of the evaluation. For example, “teacher + student self-evaluation and mutual evaluation” is adopted for electrician and metalworking practice courses, “school leader teacher + internship unit instructor and management department + student self-evaluation and mutual evaluation” is adopted for graduation internship, and “teacher + school expert (Defense) + student group self-evaluation and mutual evaluation” is adopted for training courses.

Third, the evaluation content is extended to not only focus on the mastery of students’ knowledge and skills, but also pay more attention to the enhancement of professional ability and value literacy, such as analysis and problem-solving ability, innovation and practical skills, organization and coordination, communication, dialectical thinking, professional ethics, engineering literacy, teamwork, self-development consciousness, sense of responsibility, and so on.

3.4. Application of both hardware and software to strengthen the construction of practical teaching resources

3.4.1. Improvement of hardware facilities for practical teaching on and off campus

The practice base is the foundation for effective practical teaching. Following the principle of “new, eliminate, update, expand,” continuous improvements are made to both on-campus and off-campus practice bases:

(1) New equipment and tools: Advanced practical teaching equipment such as electrical test tools (oscilloscopes, multimeters, power analyzers, etc.) helps students better understand electrical principles and circuit characteristics, master measurement methods for electrical parameters, and enhance operational skills. Simulation software (e.g., Keil, Proteus, Multisim, PLECS, MATLAB/Simulink, PSCAD, PLCSIM) allows students to simulate the operation and characteristics of electrical systems, improving their problem-solving abilities. Electrical design software (e.g., EPLAN, LT Designer, PLS CAD) enhances students’ electrical design capabilities and technical drawing skills.

(2) Eliminating outdated equipment: Equipment that lacks performance, fails to meet experimental accuracy standards, is unstable, and does not provide reliable data is phased out. Additionally, outdated, single-function, inefficient, and costly-to-maintain equipment is replaced, particularly when frequent failures and limited maintenance options hinder its use.

(3) Incorporating current industrial technology: Experimental equipment related to smart microgrids, power systems, power electronics, new energy, and energy storage is introduced, aligning with the latest trends in industrial technology. This improves the relevance of practical training and ensures better alignment with industry needs.

(4) Expanding practice bases: By leveraging the engineering training center and on-campus resources, the focus is on interdisciplinary integration and the expansion of on-campus practice bases. Strengthening ties with local power supply bureaus, power plants, electrical equipment manufacturers, and industries such as manufacturing and mining enables the establishment of long-term, stable partnerships. This approach expands the number of off-campus practice bases and broadens industrial coverage, providing more hands-on learning opportunities for students.

3.4.2. Creating a high-quality practical teaching faculty

Teaching staff is fundamental to guarantee the quality of practical teaching, thus we make efforts in multiple directions from “introduction, training, hiring, and evaluation” to build a team of high-quality teaching staff.

First, according to the professional development planning and practical teaching needs, taking into account the academic qualifications, professional background, practical work experience, professional qualifications, etc., we introduce PhDs or excellent masters with strong practical ability from colleges and universities and scientific research institutes; and introduce engineers and technologists who are familiar with the latest technology in the industry and possess rich experience in engineering practice and excellent professional skills from enterprises.

Secondly, we regularly carry out demonstration classes, seminars, experience exchanges, professional lectures, etc. in the form of teaching and research activities to strengthen internal training, prompting the updating of the knowledge system of practical teaching, innovating teaching methods, and improving teaching skills; we encourage participation in academic conferences, special trainings and seminars, etc., to learn about the latest industry news and cutting-edge technologies, to broaden the horizons, and to improve the professionalism. We also encourage teachers to communicate with the industry and the enterprises through research and exchanges, attachment and training, cooperative research and development, etc. to establish interaction and improve practical ability.

Thirdly, strengthening cooperation with industrial enterprises us important. Combining with the actual demand of practical courses, we employ external engineers with firm political stance, profound theory, excellent skills, and rich practical experience to teach independently or participate in part of the practical courses.

Fourthly, we establish a scientific assessment and evaluation system to comprehensively evaluate the teaching work of teachers undertaking practical courses from multiple perspectives of students, peers, and supervisors. The aspects assessed include teaching content, teaching attitude, teaching methods, teaching effect, practical guidance ability, etc. Feedback is given to motivate teachers to make continuous improvement in terms of qualities and teaching level.

3.4.3. Enrichment of resources for practice-based courses

Teaching materials: In line with the specialty's characteristics and the needs of practical teaching, applied or innovative practical course materials are developed. These materials are tailored to highlight the practical, advanced, and operable nature of the course, covering fundamental theories, practical content, real-world cases, guidance for practice, tool resources, and opportunities for reflection and discussion. This approach addresses challenges such as insufficient practical course resources, disconnect from industry trends, and lack of prominence in the specialty's unique features.

Practical cases: Teachers develop representative and practical cases from various fields, including electric power systems, automatic control, new energy, and intelligent equipment. These cases are sourced from teachers' vertical research projects, horizontal collaborations with enterprises, and dual-creation projects led by college students. Technical achievements from these endeavors are transformed into practical cases. Additionally, students are encouraged to gather and organize cases during internships, course designs, and disciplinary competitions, summarizing their practical experiences into meaningful case studies.

Other resources: To support practical teaching, an online platform is created for resource sharing and exchange. This platform collects a wide range of materials, including standard specifications, technical manuals, engineering cases, simulation software, guidebooks, and the latest technological advancements, making these resources easily accessible for both teachers and students to enhance the learning experience.

4. Conclusion

Under the dual carbon strategy, undergraduate education for electrical majors has entered a new era, addressing key challenges in practical education related to curriculum systems, platforms, resources, and faculty, with a focus on the specific context of Liupanshui Normal University. Through a series of initiatives, including the development of a progressive practice teaching system ("3, 3, 4, 1"), strengthening the "four platforms" for practical education, optimizing course content, innovating teaching methods, reconstructing the evaluation system, and enhancing practice teaching resources, the goal is to build an education system that effectively cultivates versatile, applied talents to meet the demands of industries such as power, manufacturing, and mining in the new era. This approach aims to enhance students' practical, innovative, and comprehensive abilities, driving the high-quality development of the electrical major. However, building a robust practical education system is a long-term process that requires continuous exploration, practice, and refinement. Moving forward, we will remain committed to monitoring industry developments, assessing our successes and shortcomings in practice, and supporting further optimization of the practical education system.

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