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Research and Practice of Industry-Education Integration for Talent Development in the New Energy Industry

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Abstract: *The rapid development of the new energy industry necessitates a workforce equipped with specialized skills and knowledge. This paper explores the research and practice of industry-education integration for talent development in the new energy sector, focusing on the initiatives undertaken at Tianjin Urban Construction Management and Vocation Technology College. By analyzing the collaborative efforts between educational institutions and industry stakeholders, this study highlights the importance of curriculum design, practical training, and industry partnerships in fostering a skilled workforce. The findings suggest that a well-structured industry-education integration model can significantly enhance the employability and competency of graduates, thereby contributing to the sustainable growth of the new energy industry.*

Keywords: *Industry-Education Integration, Talent Development, New Energy Industry, Vocational Education, Curriculum Design, Practical Training, Industry Partnerships*

1. Introduction

With the changing global economic landscape and the advancement of the strategy for building a technologically strong nation, the demand for talent has steadily increased, presenting new challenges and opportunities for university students in employment and entrepreneurship. Industry-education integration, as an effective model for talent development, has gained widespread attention. Zhu (2024) emphasizes that universities should focus on addressing employment and entrepreneurship challenges for college students by aligning with national demands and enhancing students' capabilities[1]. Wang et al. (2024) propose strategies for curriculum reform in new energy materials, including modular content restructuring and multidimensional integration of teaching resources[2]. Hu et al. (2024) identify issues in new energy industry talent cultivation and offer targeted solutions[3].

The integration of science, education, and industry has also proven to be crucial for talent development in the new energy sector. Liu et al. (2024) suggest that integrating scientific research and educational resources can create new pathways for talent cultivation in the new energy industry[4]. Chen et al. (2024) explore the practical teaching system for new energy majors under the industry-education integration model, highlighting the importance of rational curriculum design and industry-university collaborative teaching to enhance students' practical skills[5].

The battery industry, as an important component of the new energy sector, faces a disconnect between talent cultivation and industry demands. Duan (2024) proposes the application of the "science-industry-education" integration theory to optimize teaching content and cultivate high-quality, applied talents[6]. Wang (2023) constructs a curriculum system for photovoltaic engineering technology, including general education modules, specialized courses, and integrated application modules[7].

Industry-university-research collaboration is another vital approach for talent cultivation in new energy majors. Zhou (2023) analyzes the roles of enterprises, universities, and research institutions in new energy talent development from an industry-university-research integration perspective[8]. Liu et al. (2023) examine the pathways for industry-education integration in solar energy industry talent cultivation, noting the gap between university-trained professionals and industry needs due to the relatively slow development of solar energy programs[9].

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Regarding specific talent cultivation models, Huang et al. (2021) explore strategies for applied talent cultivation under the industry-education integration model[10]. Xu (2021) investigates industry-education integration talent cultivation models, emphasizing the provision of more practical training bases through integrated curriculum design and multi-level courses[11]. Liu (2021) proposes talent cultivation suggestions for e-commerce under the industry-education integration framework[12].

Wang et al. (2020) analyze the construction of a talent support system for technological innovation in the new energy industry in Jiangsu Province[13]. Zhang et al. (2020) explore undergraduate talent cultivation models under the industry-education integration framework, including "3+1" and "2+1+1" models[14].

In summary, existing studies have explored the application of industry-education integration in new energy industry talent cultivation from various perspectives, providing a theoretical and practical foundation for this research. This paper further investigates industry-education integration talent cultivation models for the new energy industry, combining case studies to propose targeted and actionable suggestions.

2. Analysis of Talent Demand Characteristics in the New Energy Industry

2.1. Industry Structure and Job Group Analysis

2.1.1. New Energy Industry Structure

With the rapid development of the new energy industry, the industrial chain has gradually expanded from a single energy production field to multiple related areas, forming a multi-level, comprehensive industrial structure. In China, the new energy industry has formed a "vertical industrial chain + horizontal support layer" three-dimensional structure, covering all links from energy production to terminal applications.

The vertical industrial chain includes core areas such as photovoltaic power generation, wind power generation, energy storage technology, and hydrogen energy applications. It spans the entire process from raw material extraction, equipment manufacturing, system integration, to operation and maintenance. In the photovoltaic industry, various links in the industrial chain involve silicon material purification, silicon wafer production, photovoltaic module manufacturing, and power plant design and operations. As technology continuously progresses, the division of labor in these links has become increasingly detailed, and technical requirements have also gradually increased. Similarly, the industrial chain of wind power generation and energy storage technologies has shown multi-dimensional expansion, especially in wind turbine operation and maintenance (O&M) technologies and the integration and optimization of energy storage systems, which have become key focuses of the industry’s development each year. Additionally, the hydrogen energy industry is gradually promoting the widespread application and industrialization of hydrogen energy through the production of electrolyzers, the development of storage and transportation equipment, and the construction of hydrogen refueling stations.

The horizontal support layer mainly includes areas such as digital services, testing and certification, and financial services. In terms of digital services, with the increasing demand for intelligent management and remote O&M in the new energy industry, digital twin technology and smart O&M platforms have become crucial supports for industrial development. Simultaneously, with the continuous advancement of new energy technologies, the demand for testing and certification institutions has been rising to ensure the quality and reliability of products and technologies in the market. In financial services, the emergence of new financial instruments such as green finance and carbon finance has provided robust funding support and risk management tools for the new energy industry.

2.1.2. Job Group Classification Matrix

To gain a deeper understanding of talent demands at various stages of the new energy industry, this study constructed a three-dimensional job classification matrix of job groups and skill requirements based on a survey of 48 new energy companies in the Beijing-Tianjin-Hebei region, as shown in Table 1. This matrix covers various types of positions including technology R&D, production and maintenance, digital services, and cross-disciplinary technical skills, analyzing the core capabilities and skills required for each role. In technology R&D positions, photovoltaic system designers and energy storage system engineers require high proficiency in technical tools, with photovoltaic system designers needing to be familiar with PVsyst simulations, shading analysis, and economic evaluation techniques. In production and maintenance roles, wind farm O&M technicians and hydrogen refueling station operators are

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required to have strong on-site operation and fault diagnosis capabilities, particularly in areas such as high-altitude work and pressure vessel management, skills crucial for ensuring safety and improving work efficiency. Digital service roles demand strong digital skills, with new energy data analysts required to proficiently use Python, Pandas, and Tableau for forecasting energy production and data analysis. As intelligent O&M and robotics technology become more widespread, cross-disciplinary technical roles are also increasing, especially for those needing both technical expertise and practical skills, such as in the fields of electric vehicles and smart O&M.

Table 1: Job Groups and Skill Requirements in the New Energy Industry

Job Category	Typical Positions	Core Skill Requirements	Skill Gap Rate
Technology Research and Development	Photovoltaic System Designer	PVsyst simulation, shading analysis, economic evaluation	34%
	Energy Storage Systems Engineer	Battery thermal management, EMS strategy optimization	41%
Production and Maintenance	Wind Farm O&M Technician	SCADA system operation, gearbox fault diagnosis	62%
	Hydrogen Refueling Station Operator	Pressure vessel management, leak detection	57%
Digital Services	New Energy Data Analyst	Python, Pandas, Tableau for energy forecasting	68%
	Virtual Power Plant Dispatcher	Demand-side response, electricity market trading	73%
Cross-Disciplinary Skills	Smart O&M Robot Operator	PLC programming, equipment maintenance	85%

2.1.3. Structural Features of Skill Demand

The job demands in the new energy industry exhibit several notable structural characteristics. Firstly, the skill demand for talent in the new energy sector is increasingly interdisciplinary and composite. Many positions require employees to not only master traditional new energy technologies but also possess the ability to use digital tools. For example, photovoltaic O&M positions require workers to not only have traditional maintenance skills for photovoltaic modules but also to be able to use drones for inspections and employ AI technology for fault diagnosis. This cross-disciplinary composite ability is evident in multiple positions, particularly in wind power, energy storage, and other technology sectors. Secondly, with the rapid iteration of technology, the skill demands in the new energy industry exhibit strong sensitivity to change. For example, the knowledge half-life for energy storage system integration positions has been reduced to 1.8 years, while the half-life for traditional electromechanical positions is still 5.2 years. This characteristic indicates that talent cultivation and skill enhancement in the new energy sector must be more flexible and efficient to adapt to the rapid updates in technology. Finally, the skill demand in the new energy industry also shows strong regional adaptability. In Tianjin, for instance, enterprises have particularly urgent demands for certain skills, such as offshore wind power anti-corrosion technology, integrated photovoltaic building design capabilities, and hydrogen energy storage and transportation safety operations. These regional demands reflect the combination of local industry characteristics and technological requirements, emphasizing the importance of aligning talent cultivation with the unique features of regional industrial clusters.

By analyzing the job groups and skill requirements in the new energy industry, it is evident that the diversified demand for talent at various stages of the industrial chain is not only reflected in the technical depth but also in the cross-disciplinary integration and innovation of technologies. Especially in the application stage, the integration of traditional technologies with emerging digital skills is gradually becoming mainstream. Therefore, constructing an educational training system that matches the various stages of the industrial chain is of vital importance for improving the quality of talent supply in the new energy industry and promoting industrial upgrading.

2.2. Evolution of Skill Demand Trends

2.2.1. Accelerating Technological Iteration Drives Composite Skill Needs

The rapid development of the new energy industry and continuous technological innovation have led to an urgent demand for composite talents. As new energy technologies progress, especially in areas such as photovoltaics, energy storage, and wind power, the speed of technological iteration has accelerated, significantly changing the skill requirements of enterprises. This accelerated technological update not

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only requires practitioners to quickly master the operation of new membrane deposition equipment but also to understand and solve issues such as Light-Induced Degradation (LID) and to proficiently use intelligent EL defect detection systems. The energy storage sector has similarly experienced rapid technological development. The early commercialization of sodium-ion batteries has posed challenges to traditional lithium-ion battery technologies, requiring practitioners to master new material synthesis methods, low-voltage system safety management, and multi-type energy storage system coordination. These changes indicate that the technological advancements in the new energy industry have greatly compressed the skill update cycle, requiring practitioners to continually adapt to rapidly developing new technologies, acquire interdisciplinary skills, and thus driving the demand for composite abilities.

2.2.2. Digital Capabilities Become Core Incremental Skills

With the deeper application of digital technologies, the skill demand in the new energy industry is gradually shifting from traditional technical operations to digital capabilities. Based on text mining (Python+NLP analysis) of job demands from new energy companies in the Beijing-Tianjin-Hebei region, as shown in Table 2, we can clearly see that the evolution of key skill demand keywords reflects the trend of digital transformation. These changes indicate that, as digital technologies continue to penetrate, the skill requirements in the new energy industry are shifting from traditional equipment operation to more complex digital system analysis, intelligent diagnostics, and data processing capabilities, further emphasizing the central role of digital capabilities in future skill demands.

Table 2: Skill Demand Evolution in Digital Transformation

Year	High-Frequency Skills (Weight ≥ 0.8)	Emerging Skill Demand (Annual Growth Rate)
2019	Component cleaning, combiner box repair	SCADA system operation (+18%)
2021	Drone inspection, IV curve analysis	Digital twin modeling (+215%)
2023	AI fault diagnosis, virtual power plant dispatch	Generative AI-assisted design (+347%)

2.2.3. Regional Industrial Clusters Shape Skill Features

The development of the new energy industry exhibits significant regional differences, which in turn shape the unique skill characteristics of local industrial clusters. For example, in the Beijing-Tianjin-Hebei region, Tianjin Binhai New Area, as a hydrogen energy demonstration hub, places particular emphasis on cultivating hydrogen energy safety operation skills, requiring related positions to have high-end skills such as hydrogen refueling station operation and pressure vessel management, with 70% of positions requiring a TSG 08 certificate. Additionally, the offshore wind power industry in the region also has specific skill demands, particularly in offshore wind power anti-corrosion technology and subsea cable fault location. In the Zhangjiakou renewable energy industrial cluster, skills such as wind-solar-storage-hydrogen coordinated dispatching and green hydrogen production economic analysis are more prominent. These regional skill demand differences reflect the close integration of the new energy industry with local resource endowments and policy directions, also emphasizing that talent cultivation in different regions must consider the characteristics and demands of local industrial clusters.

2.2.4. Challenges for Vocational Education

The evolution of skill demand in the new energy industry presents three notable characteristics, which pose significant challenges to the vocational education system. Firstly, the window for skill migration is shrinking. With the rapid advancement of technology, the skill update cycle for positions has significantly shortened. For example, the knowledge half-life for energy storage system integration positions has been reduced to 1.8 years, while for traditional electromechanical positions, it remains at 5.2 years. This means that vocational education must be more flexible and efficient in adjusting course content and teaching methods to meet the rapidly changing technological demands. Secondly, the cost of skill acquisition is rising. For instance, in the photovoltaic O&M sector, the investment cost for virtual simulation systems is 3.2 times higher than traditional training equipment, which undoubtedly poses significant financial pressure on educational institutions. Finally, the trend of fragmented skill certifications is becoming more pronounced. Many companies have launched specialized certifications, such as the "Smart Energy Manager" certification from Sungrow Power Supply, but these certifications are not yet fully integrated with the national 1+X certification system. This phenomenon indicates that the vocational education system urgently needs to improve the unity and adaptability of skill certifications to ensure seamless alignment between talent development and industry needs.

These trends in skill demand not only reflect the rapid technological advancement in the new energy

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industry but also highlight the challenges faced by the vocational education system in training adaptable talent. Against this backdrop, constructing a flexible and dynamic educational system that can adapt to rapid technological changes, and cultivate high-quality talent with interdisciplinary composite skills, digital capabilities, and regional-specific skills, has become the key to driving the sustainable and healthy development of the new energy industry.

3. Construction of the Industry-Education Integration Talent Development Mechanism

3.1. Collaborative Talent Cultivation Mechanism

3.1.1. "Six Joint Efforts and Three Integrated Chains" School-Enterprise Collaboration Model

Against the backdrop of the rapid development of the new energy industry, the integration of industry and education has become a key pathway for cultivating high-quality technical talents that meet industry demands. To achieve in-depth alignment between educational supply and industrial demand, this study proposes the "Six Joint Efforts and Three Integrated Chains" school-enterprise collaboration model. This model promotes comprehensive cooperation between education and the industry through the collaborative operation of six core elements and the deep integration of three chains, thereby realizing a positive interaction among technological innovation, talent cultivation, and industrial development.

The "Six Joint Efforts" refer to jointly defining standards, jointly building courses, jointly training teachers, jointly researching technology, jointly sharing responsibilities, and jointly sharing outcomes. Among these, jointly defining standards and jointly building courses ensure that talent cultivation goals are synchronized with industry technical demands; jointly researching technology and jointly training teachers effectively connect educational resources with industry technical demands; jointly sharing responsibilities and jointly sharing outcomes ensure the balance of interests among all parties, achieving win-win cooperation. Through this model, schools can adjust curriculum content and teaching methods under the guidance of enterprises, while enterprises can also enhance their technological and innovative capabilities by participating in the educational process.

The "Three Integrated Chains" refer to the organic combination of the industry chain, innovation chain, and education chain. The industry chain refers to the entire industrial process from raw material supply to product manufacturing and final application. Schools should work with enterprises to analyze the technical development needs of the industry chain and promote timely updates to educational content. The innovation chain refers to the entire process from technological research and development to application. Schools and enterprises jointly carry out scientific research projects, integrating the latest technologies into the education system to ensure that students can master cutting-edge industry technologies. The education chain refers to the entire process from talent cultivation to employment. Schools should deepen cooperation with enterprises to ensure that the cultivated students meet enterprise needs and provide students with valuable practical experience through practice platforms provided by enterprises.

Through the deep collaboration of these "Three Integrated Chains", schools can not only better provide technical talent support for enterprises but also promote rapid technological innovation and industrial upgrading through the deep integration of industry and education. The implementation of this model effectively enhances the quality of education and students' employment competitiveness, while providing strong talent support for the development of the new energy industry.

3.1.2. Modern Apprenticeship System

In practice, the innovative application of the modern apprenticeship system provides a new path for implementing the collaborative talent cultivation mechanism. As shown in Table 3, the "three-stage progressive" apprenticeship training model is implemented in the wind power O&M field, allowing students to gradually improve their skill level from basic operations to advanced technical applications during their enterprise practice. In the awareness stage, apprentices focus on mastering work safety and basic skills; in the proficiency stage, apprentices gradually take on more technical tasks by participating in actual project tasks; in the innovation stage, apprentices participate in R&D and innovation projects, developing the ability to independently solve complex problems. This training model not only enhances students' practical abilities but also promotes technological interaction and knowledge sharing between enterprises and educational institutions, fully reflecting the advantages of industry-education integration.

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Table 3: Wind Power O&M Apprentice Training Stages

Stage	Duration	Training Focus	Enterprise Mentor Participation	School Assessment Weight
Awareness	3 months	Safety regulations, tool use	40%	70%
Proficiency	6 months	Yaw system debugging, vibration analysis	60%	50%
Innovation	3 months	Fault prediction model construction	80%	30%

3.1.3. Multi-Stakeholder Collaborative Governance

To ensure the long-term effectiveness of the collaborative talent cultivation mechanism, it is crucial to establish a multi-stakeholder collaborative governance system. In this system, the government, industry associations, enterprises, and schools all play their respective roles to ensure the continuous and effective implementation of industry-education integration.

The government plays a key role in policy-making and financial support, providing necessary institutional guarantees and financial incentives for school-enterprise cooperation. Industry associations set industry standards and regulations, guiding the construction of educational and training systems to ensure that talent cultivation aligns with industry development needs. Enterprises, as the main body of technological innovation, not only participate in designing course content and training materials but also provide practical platforms for apprentices. Schools take a leading role in course development, teaching implementation, and talent cultivation. Through the collaboration of the government, enterprises, industry associations, and schools, a virtuous cycle of multi-party governance and collaborative talent cultivation is formed, effectively promoting the optimization of educational resources and the continuous advancement of technological innovation.

3.2. Curriculum System Reconstruction

3.2.1. "Four Horizontals and Four Verticals" Modular Curriculum System

With the rapid development of the new energy industry, the increasing frequency of technological updates, and the diversification of industry demands, traditional curriculum systems have gradually become insufficient to meet the needs for high-quality technical talents. Therefore, reconstructing the curriculum system is crucial to improving the quality of talent cultivation. Based on the analysis of job groups in the new energy industry, this study constructs a "Four Horizontals and Four Verticals" modular curriculum system, aimed at precisely aligning with industry job demands and enhancing students' professional skills and comprehensive abilities.

Horizontal Dimensions:

▪ Basic Competency Level: Basics of new energy technology, engineering mathematics application

▪ Job Skills Level: Photovoltaic system design, energy storage power station O&M

▪ Digital Empowerment Level: Python energy data analysis, digital twin technology

▪ Professional Literacy Level: Basics of green finance, interpretation of dual carbon policies

Vertical Modules:

▪ Photovoltaic Power Generation: Component processes → System design → Intelligent O&M → Recycling disposal

▪ Energy Storage Technology: Cell manufacturing → BMS development → System integration → Cascade utilization

▪ Wind Power Generation: Blade design → Complete machine manufacturing → Grid connection debugging → Offshore O&M

▪ Hydrogen Energy Applications: Hydrogen production technology → Storage and transportation equipment → Refueling systems → Fuel cells

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3.2.2. Project-Based Teaching Implementation

Project-based teaching enhances students' practical abilities through real-world tasks. Using a 50MW fish-solar power station in Tianjin as an example, a "three-tier" project system is proposed (see Table 4). This project-based teaching path not only enhances students' practical abilities through real-world project tasks but also helps them understand and master the latest technological developments and industry standards. More importantly, project-based teaching stimulates students' innovative thinking, enabling them to encounter real-world problems and propose effective solutions, which in turn leads to the internalization of knowledge and improvement of their abilities.

Table 4: Project-Based Teaching Implementation Matrix

Project Level	Typical Tasks	Skill Development Goal	Proportion of Class Hours
Unit Level	PV string MPPT optimization	DC/DC converter parameter adjustment	30%
System Level	Power station PR value enhancement	System efficiency diagnosis and optimization	50%
Comprehensive Level	Photovoltaic and energy storage economic evaluation	LCOE calculation, investment recovery analysis	20%

3.2.3. Integration of Virtual and Real Teaching Resources

To adapt to the rapid technological updates in the new energy industry, curriculum resource construction needs to stay up-to-date, particularly with innovations in teaching methods and tools. The integration of virtual and real teaching resources, combining virtual simulation technology with physical training equipment, is an essential means to enhance teaching effectiveness and students' practical abilities. Virtual simulation technology provides a highly realistic operational environment where students can engage in tasks like photovoltaic system design and energy storage system debugging on a virtual platform. This method not only simulates complex work scenarios but also allows multiple operation practices, reducing equipment damage rates and improving teaching efficiency. Meanwhile, physical training equipment provides students with real operational experiences, allowing them to perform technical operations and fault diagnosis on actual equipment, further consolidating their knowledge.

Additionally, the introduction of enterprise case resources plays a significant role in curriculum resource construction. By collaborating with enterprises, schools can transform real engineering cases from enterprises into teaching projects, allowing students to understand and master the cutting-edge technologies and developments of the industry while solving practical problems. The dynamic updating mechanism of curriculum resources ensures that teaching content keeps pace with industry technological advancements, allowing timely adjustments to the curriculum to address the rapid technological changes in the new energy industry.

3.2.4. Dynamic Curriculum Update Mechanism

The rapid pace of technological iteration in the new energy industry requires the educational system to be highly flexible to keep up with industry technological developments and changes in demand. Therefore, establishing a dynamic curriculum update mechanism is crucial. This study establishes a "dual-cycle" curriculum quality control mechanism, operating through both "external cycles" and "internal cycles," ensuring continuous updates to course content and ongoing improvement in quality. The external cycle mainly relies on changes in enterprise technology. Schools regularly collect notices of technological upgrades from enterprises, promptly adjusting course content to ensure it meets the latest industry standards. The internal cycle relies on teaching feedback, where schools track graduates' skills achievement and employment feedback to evaluate and revise the curriculum. In this process, schools and enterprises have established close communication channels, ensuring the timely and effective updating of courses.

Through this dual-cycle mechanism, the curriculum system can rapidly respond to technological changes while effectively enhancing students' employment competitiveness, ensuring that the skills they have acquired remain adaptable to the future workplace.

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3.3. Innovation in the Training System

3.3.1. Four-Layer Training Platform

To address the growing demand for skilled talent in the new energy industry, this study proposes a Four-Layer training platform, integrating hardware, digital, data, and management layers.

At the hardware level, the platform is equipped with advanced training equipment in the fields of photovoltaic, energy storage, wind energy, and hydrogen energy, such as the TOPCon/HJT module comparison testing platform and sodium-lithium hybrid storage intelligent microgrid system, providing students with a real operational environment. At the digital level, the platform introduces digital twin technology, building virtual simulation systems like photovoltaic station shadow analysis models and energy storage thermal runaway warning simulators, allowing students to practice in a simulated environment, thus reducing the risks of actual operations. The data layer connects to real-time enterprise data and constructs a big data platform for tracking students' training performance, providing personalized learning feedback and improvement suggestions. Finally, at the management level, the platform uses the MES system for training process management and monitors equipment utilization through OEE analysis to ensure efficient operation of the training platform.

The core advantage of this "four-dimensional interaction" model lies in its multi-level, multi-dimensional integration, which achieves seamless alignment between educational resources, technological platforms, and enterprise needs. On this platform, students can fully experience the entire process from theoretical learning to practical operations, enhancing the depth and breadth of their skill training and laying a solid foundation for their future careers.

3.3.2. Teaching Workshop Mode

This study proposes an innovative "teaching workshop" training mode, aiming to closely integrate teaching with actual production by introducing enterprise production work orders, thereby improving students' hands-on ability and problem-solving skills in real-world scenarios. Table 5 is an example of introducing a production work order from an enterprise in Tianjin to form a three-level advanced training project.

Table 5: Enterprise Work Order Transformation into Training Projects

Work Order Level	Typical Tasks	Teaching Transformation Method	Skill Development Focus
L1 Routine	Module EL testing	VR simulation training	Defect identification
L2 Complex	Inverter MPPT optimization	Virtual-real combined debugging	System efficiency
L3 Innovative	Photovoltaic-storage coordination	On-site enterprise guidance	Multi-energy system design

In this model, students directly participate in enterprise work orders, simulating the enterprise production process and completing the entire task from receiving work orders to handling and delivering results. The core of this model is to transform enterprise production tasks into teaching projects, enabling students to master the necessary skills through actual work experience. Specifically, in lower-level(L1) tasks, students practice equipment operation and fault diagnosis skills through VR simulation technology. In mid-level(L2) tasks, students participate in more complex tasks, such as inverter MPPT parameter optimization, to improve their system efficiency optimization abilities. In high-level(L3) tasks, students take on comprehensive projects like photovoltaic-storage system coordination control, developing the ability to independently manage multi-technology collaborative scheduling and optimization design.

This model not only effectively improves students' practical abilities but also helps them better understand enterprise demands and industry technical standards, thereby enhancing their competitiveness in the job market. By deeply cooperating with enterprises, the teaching workshop model breaks down the barriers between traditional education and enterprise production, achieving seamless integration between education and industry, and providing students with more practical opportunities and space for innovation.

3.3.3. "Dual-Loop" Quality Control System

To ensure the training system operates efficiently and teaching quality continuously improves, a robust quality control mechanism is essential. This study introduces a "dual-loop" quality control system, integrating two critical processes: the process control loop and the result improvement loop.

In the process control loop, the system monitors students' training activities and enterprise experts' operational workflows in real-time. This allows for immediate identification and correction of deviations,

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ensuring students adhere to standardized procedures and minimizing risks such as non-compliant operations or equipment damage.

In the result improvement loop, the system generates personalized skill development reports based on students' performance metrics, including operation accuracy and response speed. These reports provide actionable insights for refining training content and methods, establishing a continuous feedback loop for ongoing enhancement.

The "dual-loop" system ensures the training process is both scientific and systematic, enabling real-time tracking of students' progress and skill acquisition. This guarantees that each student meets industry standards during their training. Additionally, the active participation of enterprise experts ensures training quality, as their guidance and feedback further elevate the overall effectiveness of the training system.

3.3.4. "3R-3H" Training Standards

To ensure the standardization and efficiency of the training system, this study proposes the "3R-3H" training standards concept. The "3R" refer to real scenarios, real tasks, and real evaluations, emphasizing the introduction of real work environments and tasks into the training, allowing students to operate in conditions close to actual work. The training evaluation system should also be based on industry standards to ensure that students' learning outcomes are validated in a real-world context. The "3H" refer to high technical content, high collaboration requirements, and high safety standards. The training equipment should align with cutting-edge industry technologies, fostering students' teamwork spirit and cross-disciplinary collaboration abilities, while ensuring operations follow strict industry safety standards to guarantee students' safety during training.

By implementing the "3R-3H" standards, the training system not only improves students' technical level and practical abilities but also enhances their communication and collaboration skills in team settings, significantly enhancing their overall competence. The implementation of these standards provides scientific and systematic guidance for new energy industry talent development, ensuring that training quality closely aligns with industry demands.

4. Conclusion

In conclusion, the integration of industry and education is pivotal for the development of a competent workforce in the new energy sector. The research and practices at Tianjin Urban Construction Management and Vocation Technology College demonstrate that a collaborative approach involving curriculum alignment, hands-on training, and strong industry partnerships can effectively bridge the gap between academic knowledge and industry requirements. This model not only enhances the skill set of students but also ensures that they are well-prepared to meet the evolving demands of the new energy industry. Future efforts should focus on expanding these collaborative frameworks and continuously updating educational programs to keep pace with technological advancements and industry trends. By doing so, educational institutions can play a crucial role in driving the sustainable development of the new energy sector.

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