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Exploration and Practice of a Virtual Simulation Training Base for New Chemical Materials from the Perspective of Industry-Education Integration

Jie Zhao, Yubo Ma, Fangfang Jie, Chunyu Song, Deping Peng, Wenli Li, Yan Zou, Dong Lin

Chongqing Chemical Industry College, Chongqing, 400000, China

Abstract

Against the backdrop of vocational education system reform, deepening industry-education integration, and industrial transformation and upgrading, the "three highs and three difficulties" issues in traditional chemical engineering training have become increasingly prominent, making the construction of virtual simulation training bases an important direction for vocational education reform. From the perspective of industry-education integration, this article focuses on the field of new chemical materials and systematically elaborates on the "four combinations and six integrations" construction concept and the "1+1+3" training base architecture through a case study approach, including elements such as an intelligent management platform, teaching factory, and multi-functional centers. Practice demonstrates that the base has established a "four-level, integrated, open" training teaching system, formed a "virtual-real combination, school-enterprise co-construction" teaching resource and multi-directional service mechanism, and effectively enhanced the quality of talent cultivation. During the construction period, 88 municipal-level achievements were attained, 1,967 technical and skilled talents were trained, over 8,000 enterprise training person-times were completed, and significant results were achieved in curriculum construction, teacher training, and social services, providing a practical pathway for constructing virtual simulation training bases in similar institutions.

Keywords

Industry-Education Integration; New Chemical Materials; Virtual Simulation Training Base.

1. Introduction

With the deepening of vocational education system reform, industrial transformation and upgrading, the pervasive integration of the digital economy, and the shift of the global industrial chain toward high-end sectors, the topic of industry-education integration combined with virtual simulation technology has emerged as a core focus in educational and industrial research in recent years. Scholars generally agree that industry-education integration is a key pathway[1-3] to addressing the disconnection between the education chain, industrial chain, and innovation chain, thereby enhancing the quality of applied talent cultivation. To address the issues of "high investment, high loss, high risk" and "difficult implementation, difficult observation, difficult reproduction" in traditional chemical engineering and materials training, the construction of virtual simulation training bases is imperative. The Ministry of Education has identified the construction of exemplary virtual simulation training bases for vocational education as a key initiative, with plans to establish approximately 200 national demonstration bases by 2025 and promote the development of about 1,000 regional demonstration bases[4] across various regions.Meanwhile, the chemical industry is evolving into a strategic emerging

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sector focused on new chemical materials.It is projected that the market size of virtual simulation education in China will reach tens of billions of yuan by 2025, exhibiting significant potential for growth[5]. Driven by policy and market forces, virtual simulation training bases have become vital platforms for deepening industry-education integration and cultivating high-quality technical and skilled talents, with their construction holding considerable contemporary significance and urgency.However, translating macro policies into tangible educational outcomes hinges on exploring effective implementation pathways. This study aims to elucidate this exploration process through a case study of our institution's virtual simulation training base.

2. Base Construction Concept

2.1. Focusing on the Characteristics of the New Chemical Materials Industry to Build a Training Base

Based on the characteristics of the new chemical materials industry, we propose a training base construction concept characterized by "four combinations and six integrations."In line with the principle of "keeping pace with advanced levels, closely aligning with actual production, and facilitating on-the-job talent development," models such as inviting enterprises onto campus, embedding schools within enterprises, and school-enterprise integration are employed to attract high-quality enterprises to co-construct and share the training base.Adhering to the integration of old and new, virtual and real, dynamic and static, online and offline, a comprehensive training base is established that integrates teaching, practical training, research, competition, and popular science activities.A "four-level, integrated, open" practical teaching system is constructed, forming a progressive ability development pathway from basic skills and comprehensive skills to production skills and innovative practices. By combining real chemical operations with virtual simulations of hazardous processes, the development of "virtual-real integration, school-enterprise co-construction" teaching resources and "school-enterprise sharing, multi-directional services" practical projects has effectively enhanced the quality of technical and skilled talent cultivation in the chemical industry.

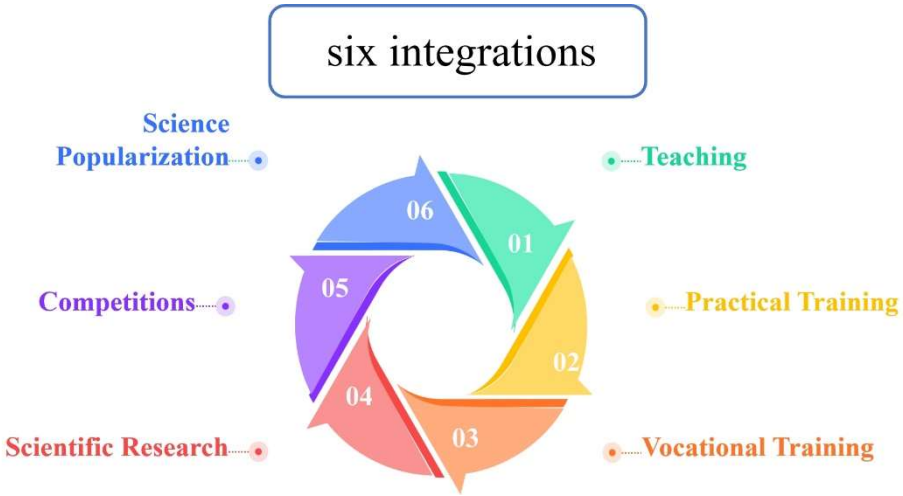

Figure 1. Design concept diagram of the virtual simulation training base

2.2. Serving Local Economic Development by Building Open Virtual Simulation Teaching Scenarios

Oriented toward social and market demands, the base deeply integrates industry and education to serve local economic development.Integrating the school's programs in applied chemical technology, fine chemical technology, petrochemical technology, industrial process automation,

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safety technology and management, analytical inspection technology, and others, modern technologies such as virtual reality and distributed interactive simulation are comprehensively utilized to construct multiple open 3D virtual simulation teaching scenarios. Through diverse equipment and resources, a realistic environment consistent with actual conditions is maximally replicated on computer systems, enabling students from various majors to experience and engage, thereby addressing practical training challenges in daily teaching such as invisibility, inaccessibility, high cost, and high risk.

2.3. Deepening School-Enterprise Cooperation for Joint Construction and Sharing of Virtual Simulation Training Bases

In accordance with the construction requirements outlined in the "Notice on the Construction of Demonstration Virtual Simulation Training Bases for Vocational Education" issued by the Department of Vocational and Adult Education of the Ministry of Education, and through long-term selection and practical research, the college has engaged in in-depth cooperation with several companies, including Chongqing Chemical and Pharmaceutical Group, Chongqing Changfeng Chemical, Chongqing Chuanwei, and simulation software technology firms. Based on the principle of "resource sharing, complementary advantages, mutual benefit, and common development," a new model of school-enterprise co-construction, co-management, and co-sharing has been established to jointly develop the virtual simulation training base for new chemical materials.

3. Implementation Path

3.1. Systematic Planning and Design for Building a New Chemical Materials Training Base

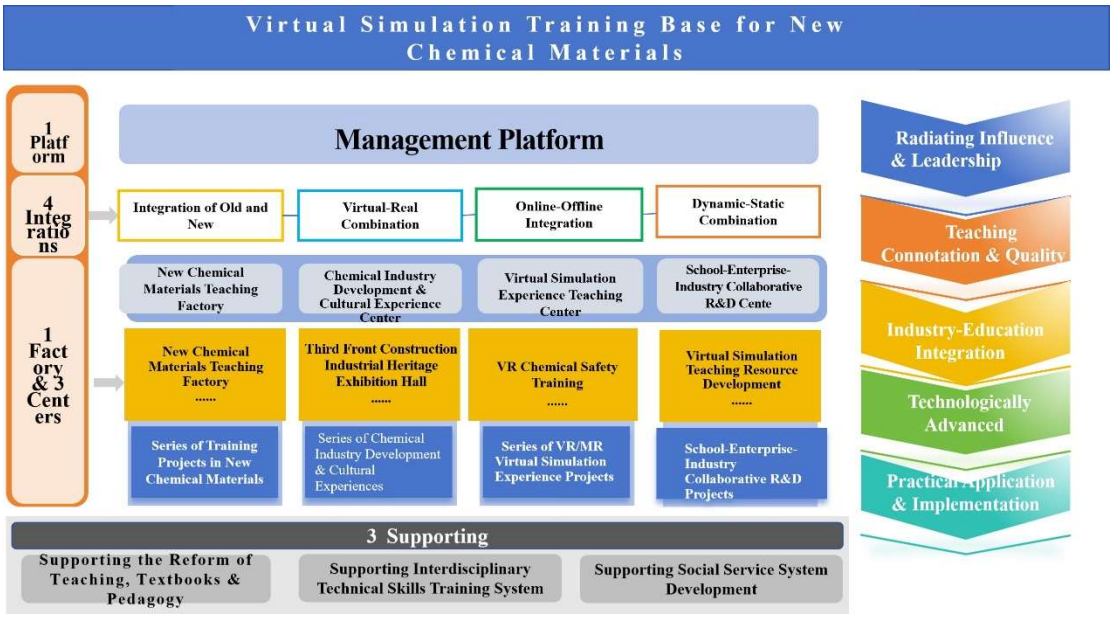

Figure 2. Virtual Simulation Training Base for New Chemical materials

Based in the field of new chemical materials, a high-level virtual simulation training base is jointly constructed with Changshou District, the National Economic Development Zone, and leading enterprises in the sector such as "SVW Chemical Co" and "Changfeng Chemical."In accordance with the overall requirements for the construction of the Applied Chemical Technology major, the government, industry, schools, and enterprises collaborate in building and operating the base, broadening the construction pathway. The construction plan is systematically designed based on the talent cultivation program for applied chemical

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technology, focusing on developing students' practical abilities, integrating training resources, and holistically planning the training base's space, functions, equipment, scale, and environment. This leads to the establishment of one management platform, one teaching factory, and three centers, collectively forming the new chemical materials training base.

3.2. Building a "1+1+3" Structure to Enhance Base Training Conditions

In accordance with the professional talent training program, national standards such as the "Teaching Standards for Vocational Education Specialties" and "Construction Standards for Professional Training Teaching Conditions in Vocational Schools (Specifications for Professional Instruments and Equipment in Vocational Schools)," as well as industry enterprise standards, are implemented. One intelligent practical teaching management cloud platform, one new chemical materials teaching factory, and three centers-the Virtual Simulation Experience Teaching Center, the Chemical Industry Development and Cultural Experience Center, and the School-Enterprise-Industry Collaborative Virtual Simulation Research and Innovation Center-are established. Industry enterprise technical requirements, process flows, and management norms are introduced. Teaching instruments, facilities, and equipment that integrate practical teaching, social training, real enterprise production, and social technical services are procured, comprehensively enhancing the training conditions of the base.

3.2.1. Intelligent Practical Teaching Management Cloud Platform

Guided by the policies of the Ministry of Education and centered on practical course teaching, the platform adheres to the integration of education and training. It incorporates the latest technologies, including cloud computing, the Internet of Things, big data, and artificial intelligence, and fully leverages the school's strengths in teaching, research, and innovation to align with professional construction goals. This assists the school in achieving efficient, centralized management of virtual simulation resources, establishes an online learning model integrating PC, APP, and WeChat endpoints, and builds an intelligent practical teaching management cloud platform, thereby enhancing the information management level of the training base.The platform primarily comprises six core functional modules: Training Resource Management (management module), Training Teaching Management (management module), Training Preview (learning and practice module), Training Organization and Process Monitoring (training module), Training Evaluation (assessment module), and Training Report Statistics Management (data center module).Through the data center, institutional leaders can gain a clear overview of the current base's training resource construction status and resource type allocation, thereby informing strategic guidance for future resource development directions.

3.2.2. New Chemical Materials Teaching Factory

Currently, there are very few virtual simulation training programs in China tailored to the new industrial characteristics of a chemical new materials teaching factory. Therefore, based on the development characteristics of Chongqing's new chemical materials industry and the existing processes and equipment of the old Changfeng Chemical plant, it is planned to be transformed into a modern, systematic teaching factory for new chemical materials.This facility will integrate chemical production and process training, chemical safety production and emergency response training, and firefighting and emergency rescue training drills.The teaching factory, situated within the old Changfeng plant area, authentically replicates the actual chemical production process. It utilizes adapted process simulation software as its core driver and incorporates various common industrial Distributed Control System (DCS) styles.Utilizing theoretical knowledge, simulation software systems, enterprise-level skill databases, and practical vocational skill course packages, it addresses the practical teaching needs of enrolled students, the training and skill enhancement requirements of on-the-job workers, and the needs of job transfer training.

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3.2.3. Virtual Simulation Experience Teaching Center

In the new era, adhering to innovation-driven development, intelligent transformation, foundational strengthening, and green development, and deeply integrating with the information industry to capture the commanding heights of future industrial competition, the center promotes the intelligent transformation and upgrading of the new chemical materials industry. It accelerates the establishment of an efficient, clean, low-carbon, and circular green system, building a new-era virtual simulation experience teaching center for the chemical new materials industry based on "Cloud, Mobile, Big Data, Internet of Things, and Artificial Intelligence" (CMBIA).The center digitizes real-world scenarios, employs virtual simulation technology to develop systems and content scenarios tailored to training or educational requirements, simulates diverse practical training projects to closely replicate real-world operations, and enables students to develop situational awareness within virtual environments.

3.2.4. Chemical Industry Development and Cultural Experience Cente

(1) Third Front Construction Industrial Heritage Exhibition Hall

BLeveraging the remarkable legacy of Changfeng Chemical-encompassing its "glorious history, fine traditions, hard work, selfless dedication, excellent quality, outstanding contributions, and bright future"-and utilizing modern technologies such as graphics, videos, touchscreens, motion-sensing interaction, VR, and AR, the hall showcases and disseminates the narrative of that illustrious period.

Utilizing preserved industrial equipment and production facilities, the exhibition explains the development of the Third Front industry and its selfless contributions to national defense and economic construction.Through demonstrations of chemical production lines and processes, visitors can appreciate the beauty of industry, the wonder of chemistry, and the meticulous nature of industrial work, which underpins the creation of diverse daily and industrial products, including cosmetics, perfumes, fabrics, plastics, and pharmaceuticals.The exhibition highlights how the seemingly enigmatic chemical industry is, in fact, inextricably linked to our daily lives.

(2) Chemical Industry Development Documentary Display Area

It aims to dispel public apprehension about chemicals and reinforce the conviction that "chemicals create a better life."Leveraging the collective strengths of the Chongqing Chemical and Medical Vocational Education Group and the Chengdu-Chongqing Twin-City Economic Circle Chemical Vocational Education Industry-Education Synergy Development Alliance, a series of initiatives are undertaken in collaboration with leading enterprises including Chongqing Chemical and Medical Holding (Group) Company and Sinopec Chuanwei Chemical Co., Ltd. These initiatives focus on integrating responsible care concepts, safety education, professional quality cultivation, labor education, and innovation and entrepreneurship education.Exhibition areas dedicated to innovation and entrepreneurship, petroleum culture, and corporate culture are established to strengthen cultural development.Model workers, master craftsmen, and skilled workers are invited into schools and classrooms to promote the chemical industry spirit and the spirit of craftsmanship.National and industry technical standards and norms are implemented, and advanced technologies, processes, and operating procedures from enterprises are introduced.Supported by the on-campus Chemical Industry Development and Cultural Experience Center currently under construction, chemical awareness among diverse audiences is enhanced.

(3)New Chemical Materials Comprehensive Experience Zone

The New Chemical Materials Comprehensive Experience Zone aims to showcase and archive the developmental history and significant achievements of China's new chemical materials industry, disseminate chemical industrial civilization, popularize scientific knowledge, and conduct patriotic education.

(4) China's Chemical Industry Landscape Display Area

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From the arduous entrepreneurship of early 20th-century national industrialists Fan Xudong and Wu Yunchu, to the pioneering efforts of the founders of New China's chemical industry in the early post-establishment period,and the multifaceted experiences-both challenges and successes-of contemporary socialist entrepreneurs striving during the reform and opening-up era;from the strategic deployment decisions made by successive ministers of the Ministry of Chemical Industry to the remarkable accomplishments of numerous grassroots cadres and workers in executing these decisions;and from the major inventions of scientific and technological experts to the quiet, selfless dedication of ordinary chemical workers—this display uncovers numerous moving and inspirational moments within these seemingly commonplace narratives.

3.2.5. School-Enterprise-Industry Collaborative Virtual Simulation Research and Innovation Center

The Research and Innovation Center focuses on studying the internship and practical training system, developing professional virtual simulation training projects, and facilitating the transition from theoretical teaching to scientific research and innovation. It also fosters the practical application of innovation and entrepreneurship outcomes, utilizing virtual reality (VR) development tools, digital modeling and scene development platforms, and innovation and entrepreneurship platforms.Equipped with VR simulation equipment, AR simulation equipment, panoramic acquisition devices, unmanned aerial vehicles (UAVs), and visualization screens, among others, the center enables the mastery, development, testing, optimization, and innovation of virtual simulation teaching resources.It supports colleges and universities in constructing virtual simulation training bases by integrating state-of-the-art hardware equipment and cutting-edge technologies, thereby forming a talent cultivation platform dedicated to scientific research, innovation, and entrepreneurship.

3.3. Promoting Educational Reform and Improving the Base's Practical Teaching System

Utilizing the school's existing infrastructure, professional equipment, and the newly constructed virtual simulation training base, a "school-enterprise cooperation, co-construction and co-management" practical teaching system is established. This system fosters the development of "virtual-real combination, school-enterprise co-construction" teaching resources and "school-enterprise sharing, multi-directional services" practical teaching projects, cultivates the spirit of craftsmanship, and enhances students' core competencies.

3.3.1. Deepening Industry-Education Integration to Build a "Four-Level, Integrated, Open" Practical Teaching System

Leveraging the school's existing infrastructure, professional equipment, and the newly built virtual simulation training base, the "basic training → professional skills training → production practice training → scientific and technological innovation training" four-level, integrated, open talent cultivation practical teaching system is explored and refined.Specifically, professional basic training focuses on foundational professional skills, aiming for students to master both basic professional skills and fundamental practical abilities.Professional skills training primarily involves specialized practical training, fostering students' professional competencies and initially developing their engineering thinking abilities.Production practice training, conducted through internships, enhances students' capability and proficiency in comprehensively applying professional knowledge and skills. This is achieved via production practice training conducted in on-campus and off-campus training bases, as well as virtual simulation internship bases.A school-enterprise co-construction and co-management mechanism is established to ensure the training center's orderly operation, safety, and standardized services.Schools and enterprises collaboratively develop the assessment and evaluation system, jointly formulate the training program, co-implement the cultivation

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process, co-develop teaching resources, and co-supervise teaching quality, constituting a "Four Co-s" whole-process evaluation system.

3.3.2. Joint Talent Cultivation and Development of "Virtual-Real Combination, School-Enterprise Co-construction" Teaching Resources

Fully utilizing existing on-campus basic resources-including chemical unit operation training devices, DOP simulation factory training devices, and HSE safety operation training devices-one new teaching factory and three centers are constructed. A comprehensive practical teaching management platform and a school-enterprise joint management system are established to enable the sharing and allocation of training resources.On this basis, the positions associated with each unit in the teaching factory are thoroughly analyzed. Based on unit-specific job responsibilities, job content is decomposed and work tasks are systematized. Knowledge and competency items across multiple modules-such as unit fundamentals, safety, equipment, process, operational skills, and case studies-are delineated, matched to respective positions, used to form job competency requirements, and ultimately build a unit-position-based curriculum system.Schools and enterprises collaboratively discuss the professional talent training program, jointly develop practical teaching courses, and co-create work manual-style and loose-leaf teaching materials. Enterprise experts and school teachers also collaboratively produce micro-lecture videos on typical new material processes.Grounded in the context of the new materials chemical industry, it is ensured that the practical training projects implemented are all derived from authentic job tasks, thereby achieving alignment between the teaching process and the work process.

3.3.3. Collaborative Project Design Forming "School-Enterprise Shared, Multi-directional Service" Practical Teaching Projects

Schools and enterprises jointly discuss and design practical training projects to ensure teaching is closely aligned with actual enterprise production.These projects cater to four distinct student cohorts:

i. Students within the school's professional group, for cognitive internships and practical training;

ii. New and existing employees of new materials enterprises within the park, for skill development related to specific processes and positions;

iii. Students from other higher vocational colleges and undergraduate institutions, requiring practical training on typical processes and specific positions in new materials;

iv. The general public, for science popularization activities related to "new materials chemical engineering."

Primary teaching and training programs include VR Emergency Response Training, VR Hazard Identification Training, VR Accident Experience Training, among others.

VR Emergency Response Training: The VR emergency response training system simulates typical chemical production units, focusing on team-level emergency response. It primarily addresses the activation of emergency response procedures and on-site mitigation actions when incidents such as leaks, fires, explosions, or personnel poisoning occur at chemical production sites. Operations are primarily conducted by operational teams, with support roles (e.g., firefighting and medical rescue) playing auxiliary functions.

VR Hazard Identification Training: The VR hazard identification training system comprises two subsystems: one for operational hazard identification and another for production hazard identification. The operational hazard identification subsystem involves inspecting, investigating, and confirming potential hazard points across eight types of special operations, including confined space entry, work at height, hot work, temporary electrical work, lifting operations, work on energized circuits, complex combined operations, among others. The

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production hazard identification subsystem focuses on hazard points inherent to the production process, configured according to different production types, encompassing issues such as pump leaks in tank farms, filter leaks, and foreign object intrusion in production areas.

VR accident experience training. The VR accident experience system provides immersive accident scene experiences through VR experience devices, allowing trainees to feel the impact and harm of accidents as if they were there, enhancing the warning effect of accidents, touching trainees from the bottom of their hearts to enhance their safety awareness and improve their safety emergency response capabilities. The VR accident experience system includes eight experience tasks, namely scaffolding collapse, fall from height, throwing from a height, slip and fall, escape from warehouse fire, forklift accident, mechanical injury, gas leak and explosion accident.

3.3.4. Cultivating the Spirit of Craftsmanship and Enhancing Students' Core Competencies

The spirit of craftsmanship embodies professional competence and ethics, representing a professional's value orientation and behavioral expression.Classroom discipline and behavioral norms for students can be established by mirroring how enterprises enforce compliance with operating procedures among employees. Precise reward points can be allocated for aspects such as attendance, work ethic, reporting accuracy, practical skill proficiency, and adherence to safety protocols. Furthermore, points can be assigned to students' learning behaviors during individual or team practical training sessions. This approach aims to stimulate student potential, foster the high-standard completion of production tasks, and ultimately enhance students' core professional competencies.

3.4. Implementing a Combination of Introduction and Cultivation to Build a Base Training Teacher Team

Adhering to the standards of "Four-Haves" good teachers, the base strengthens the development of teacher ethics and professional conduct. It emphasizes the cultivation and two-way exchange mechanisms for a dual-qualified teacher team deeply integrated with schools and enterprises. Through a strategy of targeted introduction and internal cultivation, the base strives to build a practical training teacher team distinguished by high ethical standards, superb skills, and strong school-enterprise integration, thereby enhancing the team's industry leadership capacity.

3.4.1. Upholding the "Four-Haves" Good Teacher Standard to Build a Team of Practicum Teachers with High Ethical Standards

Second, achieving dual integration and mutual promotion, the teachers' Party branch team is developed into a core force facilitating the integration and mutual reinforcement of Party building with teaching and research in higher education institutions in the new era.Third, implementing holistic education by enhancing the curriculum ideology and politics capabilities of practicum teachers.Training programs are conducted to enhance curriculum ideology and politics capabilities, thereby raising the overall level of ideological and political education within the training teacher team.

3.4.2. Enhancing Teaching and Research Capabilities to Build a Highly Skilled Practicum Teacher Team

Focusing on the reform of teaching models, educational approaches, and pedagogical research, high-level teaching innovation teams are cultivated.Using the implementation of the "Huang Danian-style" Teacher Team Cultivation Project as a catalyst, and leveraging the on-campus Skill Expert Studio and off-campus Teacher Practice Training Base, practicum teacher teams are formed with a focus on new chemical materials and intelligent chemical technology. These teams actively apply for provincial and ministerial-level teaching-research projects, elevate the

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standard of practical training instruction, and establish themselves as leading forces in teaching innovation.

3.4.3. Promoting Both Introduction and Cultivation to Build a School-Enterprise Integrated Practicum Teacher Team

Through deep school-enterprise integration and a strategy of recruitment and cultivation, plans for selecting and training practicum teachers are formulated. Measures include enterprise exchange programs, participation in technological innovation initiatives, and the appointment of renowned experts from the chemical new materials industry, such as Zhou Weiping, as part-time leaders. These actions enhance the industry leadership capabilities of the practicum teachers.Through school-park co-education and a system of dual appointments and dual hiring, a two-way flow and mutual part-time plan is implemented, involving industry experts, enterprise technicians, highly skilled talents, master craftsmen, and school backbone teachers. Enterprise technical experts recognized as "Ba-Yu Craftsmen," such as Huang Yong and Luo Li, are appointed as Skill Masters, contributing to the formation of a school-enterprise integrated practicum teacher team.

3.5. Joint Operation by Government, Industry, Enterprises, and Schools to Innovate the Base Operation Model

Adhering to the new operation model of "government guidance, industry support, enterprise participation, school management," scientifically sound and standardized management systems are formulated, continuously improving the management and service levels of the training base.The functions of the training base are expanded, focusing on enhancing its roles in practical training, production, skill assessment, competition hosting, and science popularization. Open sharing is promoted, including conducting labor and vocational enlightenment education for primary and secondary schools, and providing technical services, social training, and science popularization activities for the public.Government, industry, enterprises, and schools jointly establish a virtual simulation training base consortium, aiming to achieve open sharing and sustained utilization of high-quality virtual simulation training resources.

3.5.1. Improving the Management System to Enhance Base Management and Service Levels

The management system is established and refined, involving the formulation of regulations such as the "Management Measures for the Virtual Simulation Training Base of Chongqing Chemical Industry Vocational College" and the "Management Measures for Training Teachers of Chongqing Chemical Industry Vocational College." This enhances the base's management and service levels across various aspects, including base operation, administration, student management, teacher management, equipment management, and social services.

3.5.2. Expanding Training Base Functions and Promoting Open Sharing

In line with the development needs of the chemical new materials industry and socioeconomic development requirements, the development plan and functions of the training base are formulated. Considering industry characteristics and public perception, appropriate training projects, skills competition events, skills appraisal programs, and popular science activities are developed. This enhances the base's functions in practical training, production, appraisal, and competition, ensuring its functions are both comprehensive and robust.The base implements an open sharing mechanism, leveraging its advantages in teaching staff and equipment to provide technical services and social training for Changshou District, Chongqing Municipality, the broader Southwest region, and even nationwide. Concurrently, it collaborates with primary and secondary schools to deliver labor and vocational enlightenment education, thereby generating social benefits.

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3.5.3. Strengthening Performance Evaluation to Improve Equipment Utilization Efficiency and Base Service Contribution

A multi-stakeholder management platform is constructed, and a robust performance evaluation mechanism coupled with an information feedback system is established. With participation from government, industry, enterprises, and schools in the evaluation process, the utilization efficiency of base equipment is guided and maintained at a high level.The base actively seeks cooperation with government bodies and diverse research platforms, shares its functions and equipment across these platforms, and offers free access to universities, research institutes, and enterprises in Chongqing, Southwest China, and nationwide, thereby increasing its service contribution rate.

3.6. Utilizing New-Generation Information Technology to Enhance Training Base Efficiency

Relying on new-generation information technologies like virtual reality and artificial intelligence, and adhering to the principle of "prioritizing practical training, using virtual simulation as a supplement," the base addresses the "three highs and three difficulties" inherent in internships and practical training. It constructs virtual simulation training bases, reforms traditional teaching methods, focuses on resolving key challenges in teaching and learning, and promotes the innovation of talent cultivation models.A virtual simulation training system is established, equipped with corresponding virtual simulation equipment. A compatible practical teaching curriculum system is developed, training content is defined, teaching resources are created, talent cultivation programs and training methods are optimized, the operational efficiency of the training base is continuously enhanced, and local economic development is supported.

3.6.1. Utilizing VR for Training Projects

VR training excels at highly replicating real-world scenarios. Through 3D modeling, it digitizes actual environments and employs 3D virtual simulation technology to conduct chemical safety training and accident experience exercises. Systems and content scenarios are developed based on specific training or educational objectives, capable of simulating a wide range of accidents, disaster situations, and training projects. This strives to achieve operational fidelity comparable to the real world, enabling trainees to develop situational awareness within the virtual environment.Through VR hardware, users can experience multi-sensory scenario simulations encompassing visual, auditory, and tactile elements, akin to a 3D movie experience.Supported by the hardware equipment, trainees can achieve an immersive effect, "hearing" the roar of machinery on a construction site, "seeing" the forms of various engineering structures, and "manipulating" objects present within the scenario.Thus, VR virtual simulation exercises can leave trainees with a lasting impression and enduring memory, as if they had personally experienced the real scenario.

3.6.2. Applying MR Technology for Intelligent Production Operations

Mixed Reality (MR) technology facilitates the seamless integration of virtual and real-world scenes. It superimposes digital information-typically difficult to experience directly in the physical world-onto the real environment through virtualization techniques. Using MR technology, intelligent production operation training is conducted, enabling students to interact between the real world and virtual images and comprehend the production operational processes of new chemical materials.

3.6.3. Employing Immersive LED Screen Technology to Improve Training Effectiveness

High-definition LED screens are seeing increasingly widespread application. In recent years, declining costs and enhanced brightness have made LED screens more accessible. Their advantages-including low power consumption, long lifespan, wide viewing angles, and fast

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response times-have become increasingly prominent. They have emerged as a significant technology in virtual simulation. The adoption of immersive LED screens by the base is expected to substantially improve training outcomes.

4. Conclusion

4.1. Overall Situation

The Virtual Simulation Training Base for New Chemical Materials was established in May 2022. The school assembled a dedicated construction team that closely adhered to the construction plan, realized the "1+1+3" base structure, attained 88 municipal-level landmark achievements, trained 1,967 technical and skilled talents in the field of new chemical materials, and provided training to over 8,000 enterprise personnel, thereby achieving the anticipated objectives.

4.2. Venue Construction

The constructed venues include: the first floor of the school's First Training Building (approximately 1,000 m^2), two computer rooms on the third floor (approx. 200 m^2), the Third Front Construction Exhibition Hall at the old Changfeng Chemical factory (approx. 300 m^2), and the Aniline Production Workshop (approx. 1,000 m^2). Facilities developed encompass the Comprehensive Practical Teaching Management Platform, the New Chemical Materials Teaching Factory, the Chemical Production Scenario-based Interactive Center, the Virtual Simulation Experience Teaching Center, the Chemical Industry Development and Cultural Experience Center, the School-Enterprise-Industry Collaborative Virtual Simulation Research and Innovation Center (constituting the "1+1+3" core), the Hazardous Chemicals Special Operations Practical Training Base, the DOP Smart Simulation Factory, the Smart Chemical Engineering Command Center, the Third Front Construction Spirit Exhibition Hall, and the Party Spirit and Ideological and Political Education Base.

4.3. Construction Achievements

Since its establishment, the Virtual Simulation Training Base for New Chemical Materials has played a significant role in talent cultivation, teaching reform, and social services. It has achieved 88 landmark outcomes at or above the provincial/ministerial level, trained tens of thousands of individuals in the new chemical materials sector, and demonstrated strong construction results and social benefits. These achievements can be categorized into three main areas:

4.3.1. Foundation: Enhanced Practical Training System Facilitating Student Growth and Success

A "four-level, integrated, open" practical teaching system has been constructed. A progressive "three-module" curriculum system-comprising basic modules (professional ethics and foundational courses), core modules (professional core courses), and extension modules (professional elective courses)-was implemented. Practical training was completed for 1,967 students enrolled in Applied Chemical Technology and other chemical engineering programs. The pass rate for the 1+X (Chemical HAZOP) certification exceeded 96%. Student employment rates have consistently remained around 95% annually. Over 30% of graduates secured positions in leading chemical enterprises such as Wanhua Chemical, Zhenhai Refining & Chemical, Sinopec Chuanwei Chemical, and Sanning Chemical, with the highest annual salary reaching 340,000 RMB.

4.3.2. Objective: Social Service Innovation for Continuous Base Efficiency Enhancement

Utilizing the virtual simulation training base as the primary teaching facility, the project completed training for 1,220 workshop directors and team leaders under the city's hazardous chemical injury prevention capacity enhancement program, delivered nearly 7,000 training

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instances (over 100 sessions) on hazardous chemical special operations for enterprise employees, and provided science popularization experiences to more than 1,000 secondary school students. Consequently, the school's Chemical Green and Safe Production Science Popularization Base was designated a municipal-level science popularization base in 2023. Furthermore, students won 12 innovation and entrepreneurship awards at or above the municipal level.

4.3.3. Guideline: Establishing a Teacher Training System to Build a High-Level Dual-Qualified Team

A structured teacher training curriculum was developed, effectively enhancing teachers' engineering practice capabilities. The Applied Chemical Technology teacher team was recognized as a municipal-level "Huang Danian-style Teacher Team." The proportion of dual-qualified teachers reached 100%, and teachers secured 56 landmark achievements at or above the provincial/ministerial level.

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