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Research on Practical Training Mode of Chemical Engineering Specialty from the Perspective of City-Wide Industry-Education Consortium

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Abstract: This paper focuses on the construction of an industry-education consortium in Pingdingshan, Henan Province, analyzing the difficulties in practical training for chemical engineering majors under this background. It initially outlines the "learning site" practical training curriculum system. Building upon this system, it proposes methods for constructing training modules, setting training objectives, enhancing training content, designing training methods, and establishing evaluation criteria. It then summarizes the significance of research on the training model for chemical majors from the perspective of urban-industrial-educational consortiums.

Keywords: City-level industry-education consortium; Chemical engineering specialty; Practical training mode

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1. Introduction

The purpose of the city-level industry-education consortium is to realize the effective docking of industrial needs with education and training through collaboration and to provide vocational education and training that meets market needs [1]. The establishment and development of the city-level industry-education consortium is conducive to improving the teaching quality and employment rate of vocational education, promoting regional industrial upgrading and economic development, and realizing the positive interaction between vocational education and regional economic industries [2].

As a basic industry related to the national economy and people's livelihood, the chemical industry integrates the government, industries, schools, and enterprises through the industry-education consortium. This integration aims to enhance asset operational efficiency through production management, supply chain collaboration, and equipment optimization. Planning and operations are streamlined to optimize resource allocation, ensuring safety and environmental protection while reducing costs and increasing efficiency. In the context of industry-education consortium, new demands are placed on the educational models of school-enterprise cooperation, with particular emphasis on the construction of practical teaching systems [3]. Currently, there are several issues present in the practical training models for chemical engineering majors.

(1) Training base planning does not align with industrial transformation and upgrading.

(2) The design of practical training projects does not meet the needs for high-quality development of vocational education.

(3) Lack of the utilization of "big data" and "mobile Internet" technologies are embedded.

In view of the above problems, our institute has explored and implemented a new modern apprenticeship talent training model of "dual education and stage rotation." We have established a practical training course system named "learning field," which is closely aligned with the high-quality development of Pingdingshan's industrial chain. Specifically, we have developed chemical technology professional groups corresponding to various links within the industrial chain, such as industrial Internet, cloud computing, and big data. This innovative training model serves to support the industrial cluster and foster the development of skilled professionals.

2. Constructing practical training modules in the nearby development zones

The practical courses in chemical engineering should encompass the development of systematic thinking throughout the labor transformation process. To achieve this, a progressive learning module should be established, beginning with cultivating fundamental qualities in chemical engineering through a module tailored for factory workers, transitioning to strengthening practical operations and specialized skills in chemical production to form an advanced skills module [4]. Building upon this foundation, emphasis should be placed on practical operation, equipment maintenance capabilities, and the introduction of interdisciplinary knowledge to students, incorporating the concept of intelligent chemical engineering to create a comprehensive module. Finally, using this comprehensive module as a base, innovative thinking should be stimulated through innovative project practice training and competitions, thus fostering teaching innovation and the creation of an innovation module [5].

3. Formulating practical training objectives from the perspective of target taxonomy

Objective classification is an important basis for comprehensively quantifying students' cognitive knowledge, skill acquisition, and emotional internalization [6,7]. It plays a pivotal role in examining the similarity of categories during the process of achieving objectives in various fields, delineating teaching gradients, and establishing target positions that correspond to actual training modules effectively [8].

3.1. General objectives

The general education module requires students to engage in creative activities within engineering contexts, actively participating in psychological inclination and cognitive action processes. Students can demonstrate their initiative by accepting and responding to emotional contexts during this process. Additionally, students get to understand the tools used in cognitive domains through memory recall.

3.2. Advanced goals

The advanced module will build upon students' current levels and the logical progression of practical teaching. Knowledge enhancement will be based on individual practice, broadening the cognitive scope using concepts from the general education module. Skill enhancement will prioritize mastering student actions and visibility, fostering intrinsic motivation during practice, thus enabling students to feel a sense of accomplishment. Emotional reinforcement will deepen students' understanding of the production process.

3.3. Comprehensive goals

Taking the special skills created by students as the current level of the module, students are required to independently choose technical support projects according to their own interests. Team members often brainstorm during collaboration to achieve consistent "organizational values".

3.4. Innovative goals

The innovative goals serve to cultivate innovative thinking and effectively assess innovative factors, ensuring that novel approaches are applied to address challenges in chemical production processes, leading to optimal solutions. Students will engage in independent thinking, developing their own value systems, and thereby enhancing their personal qualities and abilities.

3.5. Strengthening the content of practical training from the perspective of literacy

3.5.1. General knowledge: Experiencing primary projects

The general knowledge module aims to immerse students in real production processes, fostering an understanding of chemical production concepts and technical interests, while instilling a problem-solving mindset [9,10]. At the experiential level, smart factories and cloud data are seamlessly integrated into the classroom, allowing students to witness firsthand the industrial transformations driven by advancements in science and technology. Emphasizing problem orientation, the focus is on using production as a conduit, identifying experiential projects, and cultivating the awareness of identifying, analyzing, and resolving issues.

3.5.2. Advanced: Deepening the advanced project

The advanced module builds upon the foundation laid by the general education module, providing comprehensive support for students to further develop their skills and engage in micro-control cognition alongside macro-level understanding. Within this framework, students gain a deep appreciation for the essence of chemical enterprise survival, enabling them to prioritize reliability, efficiency, and cost consciousness in the chemical production process. Moreover, the advanced module takes into account the impact of ideological and political education as well as characteristic education, honoring students' preferences by allowing them to choose projects and work types aligned with their interests. This approach ensures that the basic requirements of compulsory practical teaching projects are met while being driven by students' passions.

3.5.3. Comprehensive: Cross-elevating projects

Solving practical problems in chemical production requires expertise from various fields. When issues arise in the production line or central control system, it is essential to investigate the root causes across disciplines like chemical engineering, electronics, and the internet. During practical training, students can promptly identify these problems, foster the concept of interdisciplinary collaboration in chemistry, develop initial problem-solving abilities in chemical manufacturing, and promote the cross-fertilization of professional knowledge and thinking. This process establishes effective support conditions for the development of innovative modules.

3.5.4. Innovation: Entrepreneurship competition project

The innovation and entrepreneurship competition serves as an organic platform where innovative elements are highly concentrated. By guiding students to prepare adequately during practical training, they develop cognitive approaches to product structure, production methods, and functional realization. This process enables them to formulate preliminary plans and acquire the ability to continuously optimize and analyze problems, as well as to solve them through ongoing refinement and transformation.

4. Design practical training methods from the perspective of project teaching

4.1. Characteristics of project-based teaching

(1) Achieving both students' subjectivity and teachers' leadership

As knowledge processors, students should proactively showcase their initiative throughout the teaching process, enabling the sublimation of their knowledge, abilities, practical skills, and emotions. On the other hand, as guides in practical teaching, teachers should lead students in problem exploration, knowledge system establishment, and the full utilization of students' comprehensive qualities.

(2) Synchronization of processes at the macro and micro levels

Scholars such as Kilpatrick and Fury summarized project learning in four phases: theme development, plan development, task implementation, and experience summarization [11]. This approach emphasizes not only the guidance provided by teachers but also begins with the central role of students, synchronizing both macro and micro-level processes. This synchronization facilitates teachers' monitoring of progress and provides a clear direction for advancement.

(3) Social relevance

Project-based teaching seeks to socialize students by immersing them in realistic work environments, authentic tasks, and production processes. This approach enables students to adapt to the evolving landscape of social development with cohesive productivity and production relationships. It also allows them to experience the process, functions, and societal impacts of project activities. Consequently, project-based teaching aims to cultivate students' ability to solve practical production problems intertwined with social life.

4.2. Project-based process design

The project is identified as the central focus, and the project process is designed at the macro level. This encompasses stages such as perception and selection, information gathering and preparation, planning and decision-making, implementation and monitoring, and evaluation and feedback. Each main process is then broken down into separate micro-processes to provide a detailed framework for project execution and management [12].

(1) Perception and selection

Project selection should prioritize two key factors: Firstly, based on the production situation, students should proactively investigate production challenges and identify viable projects that address these needs effectively. Secondly, characteristic projects should be established according to the specific requirements of the regional economy served by the school. Students can then select projects aligned with their interests from this pool of options.

(2) Information and preparation

Under the guidance of the teacher, students collaborate in a division of labor to gather information, conduct checks, and demonstrate their findings. The teacher oversees the process, ensuring the comprehensiveness of data collection.

(3) Planning and decision making

The instructor will integrate the real project, focusing on potential issues that may arise during actual operations, and guide students in analyzing and resolving these challenges. Additionally, team members should provide detailed explanations of the process design and operational procedures, developing a preliminary plan based on production concepts. The teacher then facilitates a discussion to confirm the plan's suitability, guiding students to identify any shortcomings and devise the optimal plan.

(4) Implementation and inspection

Following the plan, the designated leader will coordinate and plan the production training for the team members, assigning tasks and addressing any challenges encountered during the practical training process. Supervising teachers oversee the entire practical training process, offering guidance to ensure students gain production experience and successfully complete training operations while maintaining high standards of quality and quantity.

(5) Evaluation and feedback

After students complete the practical training operation, the instructor will organize project evaluation, summary, and reflection. Project evaluation encompasses the entire training process, with assessments based on actual performance. Subsequently, the teacher will summarize the project based on the evaluation findings and iteratively improve it through reflection and refinement.

5. Creating evaluation criteria from the perspective of individual intelligence

Individual intelligence manifests in various forms, highlighting that intelligence is an individual's capacity to solve problems. It encompasses eight categories: language, mathematics, spatial reasoning, music, interpersonal communication, physical movement, nature observation, and self-awareness [13]. When evaluating educational attainment, it is essential to acknowledge students' individual differences and intelligence and encourage them to leverage their unique strengths within a team setting [14]. The evaluation criteria for individual intelligence are shown in **Table 2**.

Table 2. Apprenticeship evaluation criteria

Type of intelligence	Evaluation metrics	Proportioning %	Self-rating	Peer review	Teacher review
Emotional intelligence	Safety awareness, code of conduct	5			
Interpersonal skills	Group work, research projects	10			
Linguistic skills	Expressing ideas and clarifying goals	10			
Logical/Mathematical intelligence	Logical reasoning, plan execution	10			
Spatial intelligence	Presenting patterns and arguing ideas	10			
Motor skills	Equipment operation and hands-on skills	10			
Innovation skills	Functional innovation	10			
	Practical innovation	10			
	Structural innovation	10			
	Aesthetic innovation	10			
Self-awareness	Aware of personal advantages and shortcomings	5			
	Total	100			

Under the joint efforts of both the university and the enterprise, the chemical engineering students are trained with general modules, advanced modules, comprehensive modules, and innovative modules. Furthermore, practical projects are integrated into the relevant knowledge system to form a good practice cycle and systematic training.

Studying the practical training mode of chemical majors from the perspective of a city-wide industry-education consortium holds significant practical importance. This approach can effectively enhance students' practical skills, interdisciplinary application abilities, innovation capabilities, and employment competitiveness [15]. It fosters closer collaboration between educational institutions and enterprises, facilitating the provision of high-quality, skilled talents essential for the local industrial economy's development. Additionally, insights gained from this approach can serve as valuable references for talent cultivation across other professional fields.

Disclosure statement

The author declares no conflict of interest.

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