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Research and Practice on the Construction of Professional Cluster in Application-Oriented Local Undergraduate Universities: Taking Environmental Chemical Engineering Professional Cluster in Pingdingshan University as an Example

Yanjiao LI[1*], Jiafei SU[1], Xiaonan HU[2], Hongsheng QIAN[1], Weishuang TONG[1], Shiping CHENG[1], Lihua XIE[1], Zhilu ZHANG[1]

1. School of Chemical and Environmental Engineering, Pingdingshan University, Pingdingshan 467000, China; 2. Henan Jingtong Glass Co., Ltd., Pingdingshan 467000, China

Abstract Based on the analysis of the importance of professional cluster construction by ecological theory, with the change of social demand for talents, this paper explores the practice of environmental chemical professional cluster construction in Pingdingshan University, including gradually perfecting teaching conditions and reforming teaching mode, breaking through the limitations of resources, integrating the boundaries of colleges and departments, integrating multiple resources, innovating systems and mechanisms, reconstructing professional clusters, deconstructing professional connotations, reorganizing curriculum systems, *etc.*, in order to better build the ecological chain network of education in application-oriented colleges and universities, realize the deep integration of industry and education, train future-oriented interdisciplinary applied talents of new engineering, and realize the construction of characteristic professional cluster in application-oriented colleges.

Key words Professional cluster, Industrial cluster, Talent demand, Resource integration, Structural adjustment, Undergraduate universities

1 Introduction

In 2006, the *Opinions of the Ministry of Education and the Ministry of Finance on Implementing the National Model Higher Vocational College Construction Plan and Accelerating the Reform and Development of Higher Vocational Education* put forward that "about 500 characteristic professional clusters with wide industrial coverage, good school-running conditions, close integration of production and education and high quality of talent training should be built". Higher vocational colleges pay more and more attention to the construction of professional clusters, and the research results involve the concept, significance, construction principles and methods, construction contents and other aspects of professional clusters.

The theory and practice of professional cluster have been popularized and promoted in higher vocational colleges. Influenced by it, some local ordinary undergraduate colleges are also actively carrying out professional cluster construction. In 2015, the Ministry of Education, the National Development and Reform Commission, and the Ministry of Finance issued the *pinions on Guiding Some Local Undergraduate Universities to Change to Application-oriented Universities*, which proposed that it is necessary to establish a platform for cooperative development of industrial enterprises, establish a cooperative school-running and cooperative governance mechanism involving schools, localities, industries, enterprises and communities, achieve full coverage of professional clusters by school-enterprise cooperation, establish a professional system that closely connects the industrial chain and innovation chain, and reorganize talents as needed. In 2016, the *Notice of the National Development and Reform Commission, the Ministry of Education and the Ministry of Human Resources and Social Security on Compiling the Construction Plan of the Planning Project of the Integration of Production and Education in the* 13th *Five-Year Plan* clearly stated that "professional construction" was an important part of the transformation and development plan. In 2017, *Several Opinions of the General Office of the State Council on Deepening the Integration of Production and Education* pointed out that the supply side of talent training and the demand side of industry cannot fully adapt in terms of structure, quality and level, and deepening the integration of production and education and promoting the organic connection between education chain, talent chain, industrial chain and innovation chain is the urgent requirement for promoting the structural reform of the supply side of human resources at present. During the "14th Five-Year Plan" period, the state will arrange investment in the central budget to support the construction of 100 high-level, professional and open training bases for the integration of production and education, giving priority to advanced manufacturing, new energy, new materials, biotechnology, artifi-

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* Corresponding author. Yanjiao LI, PhD., associate professor, research fields: restoration ecology.

cial intelligence and other fields as well as nursing, health care, childcare, housekeeping and other fields, so as to promote internship training, staff training, product pilot test, process improvement, technology research and development in related industries, further deepen the integration of industry and education, give full play to the role of enterprises as the main body of innovation, and closely link up with the economic and social demand for talents.

Therefore, one of the main ways for local universities to deepen the application-oriented transformation and development and strengthen professional construction is to build professional clusters, and the core is to connect with the development of local industrial clusters. Pingdingshan University, as an exemplary undergraduate university of applied technology type in Henan Province, aims to significantly improve the training ability and quality of applied talents and the ability and level of serving regional economic and social development, and has accumulated some practice in the construction of professional clusters[1].

2 Analysis of the necessity of professional cluster construction based on ecological theory

Based on the plant community theory of ecology, the professional cluster is compared with the plant community in natural ecosystem. Plant community is constructed by several species, and there are dominant species in the community, which play a decisive role in the characteristics of the community. According to the method of plant community allocation, taking the core majors (with advantages and characteristics) with high correlation with the main disciplines as the leader, by fully integrating a number of disciplines with the same or similar engineering objects and intrinsically related disciplines in the field of technology, the organic collection formed is the professional cluster. The majors in the group form an organic whole, and various majors support each other and are indispensable. Compared with a single major, professional clusters can respond quickly to the development of science and technology and market changes, and the talents trained can better meet the needs of social development. Professional clusters have stronger competitiveness and adaptability, and can better adapt to the complex and changeable situation of science and technology development and market[2].

In addition, species in the ecosystem carry out material circulation, energy flow and information transmission through the food chain network, so as to realize the stability of the system structure and the exertion of its function, and professional clusters should also form a similar structure and function chain network. Moreover, the logical starting point of professional cluster is industrial cluster, and the construction of professional cluster is put forward with the development of industrial cluster, which breaks the traditional construction mode, and adopts a new construction mode of industry and major. It is the result of modern industrial development requirements with relatively high knowledge and technical requirements, and the professional cluster chain network should correspond to the needs of posts (groups) in the same industrial chain and innovation chain in industrial clusters[3]. However, due to the limitation of resources or the single closed management, universities and industries often develop in their own independent systems, which leads to the fact that the major setting of universities often lags behind the development and changes of social industries. In fact, the traditional route of professional construction in colleges and universities is usually closed, respects discipline logic rather than application logic, and pays more attention to the systematicness of knowledge rather than the application value of knowledge. Professional construction is relatively inconsistent with market demand logic and industrial development logic. Colleges and universities pay insufficient attention to the specific requirements of industry on specialized talents, but pay more attention to knowledge transfer. Usually, college graduates can adapt to the needs of industrial development as long as they have solid professional basic knowledge, but industrial development is often guided by technological development. When the professional cluster organization and its operation mechanism are rigid and lack sensitivity to the development of science and technology and market changes, its advantages will turn into disadvantages. The talent training mode in colleges and universities obviously lags behind the industrial development and changes, and will not be able to provide suitable talents with both knowledge and technology for the industrial development with new technologies emerging one after another[4].

Therefore, the application-oriented undergraduate colleges need to shift the focus of talent training to the training of interdisciplinary application-oriented talents, form professional clusters around the industrial chain and talent demand specifications, and then adopt powerful management mechanisms and organization methods to realize the cooperation among various majors, so that scattered majors become professional clusters around certain core and leading majors. Such a professional cluster can be a system with perfect structure, stable function and common information exchange, and the trained talents will not become the burden of the system at the input and output ends of the system.

3 Exploration on the construction of environmental chemical engineering professional cluster in Pingdingshan University

3.1 Optimization of integration logic of professional clusters

As a resource-based city constantly exploring transformation and development, Pingdingshan is faced with the shortcomings of talent "structure" in industrial transformation and regional competition-the matching degree and fit degree between talent introduction and industrial system are not high enough, and the shortage of applied technical talents is obvious. Pingdingshan University, as a local undergraduate college, the transformation and development

and the guidance of social needs, focuses on the training of applied talents, implements the professional construction of new engineering, new liberal arts, new medical science and new agricultural science, and the development strategy of Made in China 2025, actively serves the national strategy and regional economic and social development, actively meets the talent needs of regional industries, follows the principles of total amount control and cluster development, relies on existing disciplines and majors, promotes the cross-integration of basic disciplines and applied disciplines, supports the construction of disciplines that meet the development needs of traditional advantageous industries and strategic emerging industries in the region, continuously optimizes the professional structure, and combines several majors with the same or closely related professional and technical foundations in a certain technical field to form a cluster. These majors are not simply piled up, merged, superimposed or integrated and utilized, and they have the internal logic of integration, which is closely connected with industrial clusters, takes serving industry chain as the core link, and has high compatibility and internal closeness with the post groups in the industrial chain[5-6].

It is in line with the integration and exchange activities of "10 000 students entering thousands of enterprises and 100 enterprises entering campus" carried out by Pingdingshan City. Pingdingshan University and industrial enterprises jointly build an innovation platform for the integration of production and education or jointly build and manage secondary industrial colleges, and jointly carry out key core technical talent training, scientific and technological innovation and discipline construction. By signing strategic agreements, it regularly holds communication meetings, cooperation talks, and other forms of activities to establish a regular contact mechanism, to strengthen the "two connections" between the supply side and the demand side, and to establish a precise supply and demand matching mechanism. If enterprises need technical and applied talents, Pingdingshan University will focus on training; if Pingdingshan University needs employment security, enterprises will go to the university for recruitment. In addition, it links basic research, application development, achievement transfer and industrialization, promotes the "two fusions" of the industrial chain and the talent chain, realizes the co-cultivation of talents, explores the "joint training of two teachers" between schools and enterprises, and the "dual identity" education model of students and apprenticeships, implements the cooperation between school and enterprise, and provides college students with "one-stop" services on registration, policy consultation, employment recommendation and so on. It promotes the compatibility of practical training, adopts the mode of joint construction of government, school and enterprise, and builds a characteristic industry-education integration training base and public training base around the advantageous industries such as nylon new materials, electrical equipment manufacturing, coal coke chemical industry, and ceramics. It establishes collaborative innovation centers with local enterprises to promote technological breakthroughs. Pingdingshan University organizes scientific research groups to focus on tackling key problems in industrial upgrading technology, so as to ensure that disciplines follow industries and majors turn around needs, realize common solutions to problems, promote project co-construction, and incorporate school-enterprise cooperation and industrial college construction into the evaluation index system of university construction. In addition, the education quality evaluation system oriented by the integration of production and education has been established, and the participation of industrial enterprises in the evaluation has been expanded. Graduates have been transformed into potential talents, and scientific research achievements have been transformed into technical products, giving full play to the respective advantages of universities and enterprises, and achieving win-win cooperation between the two sides.

3.2 Practice of environmental chemical engineering professional cluster construction At present, the environmental chemical engineering professional cluster of Pingdingshan University integrates resources across industries, disciplines and majors, and builds a cross-applied discipline professional cluster, which is composed of interdisciplinary chemical engineering and technology, environmental ecological engineering, materials science and engineering, and urban and rural planning majors. The School of Chemical and Environmental Engineering, which has the three majors of chemical engineering and technology, environmental ecological engineering and materials science and engineering, once had three provincial key disciplines of chemical engineering, environmental science and ecology, and four undergraduate majors of chemistry, chemical engineering and technology, environmental ecological engineering and materials science and engineering.

Chemical engineering and technology is the first-class major in Henan Province and the construction point of characteristic major in Henan Province, and it is the first batch of majors having passed the national engineering education certification. The School of Nylon New Materials, which relies on chemical engineering and technology major and materials science and engineering major, is one of the first batch of key industrial colleges in Henan Province. The college has a number of strong scientific research institutions and technology development bases, and has built provincial and municipal discipline research platforms such as Henan Key Laboratory of Ecological and Economic Woody Plant Germplasm Innovation and Utilization, Henan Nylon New Material Engineering Research Center, Henan Engineering Laboratory of Special Graphite Functional Materials, Henan Funiu Mountain Endangered Plant Breeding Engineering Technology Research Center, Pingdingshan Advanced Nylon Composite Material Engineering Technology Research Center, Pingdingshan Key Laboratory of Coal Salt Chemical New Functional Material, Pingdingshan Characteristic Economic Plant Breeding Collaborative Innovation Research Center, *etc.* It has an academician workstation in Henan Province and a postdoctoral R&D base in Henan Province, which focuses on the needs of

industries and enterprises, carries out collaborative innovation, enhances the ability to serve local economy and society, and serves the government and enterprises. It has successively established one of the first batch of key industrial colleges in Henan Province – "School of Nylon New Materials" with Pingdingshan Municipal People's Government and China Pingmei Shenma Group, jointly established a training base for graduate students in Henan Province with China Pingmei Shenma Group Nylon Technology Co., Ltd., and established a pilot base for public welfare projects in forestry industry of the State Forestry Administration. It joined the China Forest Biodiversity Monitoring Network funded by the Biodiversity Committee of Chinese Academy of Sciences, and completed a series of major national, provincial and municipal projects, contributing to the ecological environment protection, rational utilization of resources and sustainable development of Henan Province.

It innovatively proposes of including the talent training mode of industry curriculum into the program, industry experts into the team, industry cases into the classroom, teachers' practice into the enterprise, students' practice into the workshop, and graduation design into the front line. However, the major of urban and rural planning in the environmental chemical engineering cluster of Pingdingshan University belongs to the College of Tourism and Planning, and there are three undergraduate majors: urban and rural planning, geographical science and tourism management. The college has professional laboratories such as surveying and mapping and geographic information laboratory, physical geography laboratory, urban and rural planning laboratory and tourism virtual simulation training center. It has cooperated with Henan Urban and Rural Planning and Design Research Institute, Pingdingshan Urban Planning and Design Research Institute and other units to build a large number of off-campus practical teaching bases. It has jointly established "Research Institute for Transformation and Development of Resource-based Cities" with Henan Provincial Government Development Research Center and Pingdingshan Municipal Government. It cooperated with Pingdingshan Culture, Radio, Film and Tourism Bureau to set up "Pingdingshan Cultural Tourism Commodity R&D Center", and cooperated with Huazhu Group to set up "Huazhu Talent Class" to jointly train students.

The key problem is how to position itself and realize the prominent characteristics of environmental chemical professional cluster in application-oriented undergraduate colleges. The environmental chemical professional cluster of Pingdingshan University is characterized as an engineering professional cluster, which connects with the core links of nylon new materials in the green chemical industry and environmental protection industry chain. In terms of organizational structure, it breaks down the barriers of disciplines and majors among the four majors in the cluster, dismantles the barriers of secondary colleges, breaks through the vertical management boundary of schools, colleges, departments and majors, and explores the construction of a "matrix" organizational structure of professional clusters. According to the teaching module unit, the heads of curriculum modules are set up in the professional cluster, and they work together to help the construction of professional clusters. It explores the establishment of a structured and multi-functional cross-border work team in terms of personnel structure. Team members are appointed by the school (secondary college) or voluntarily formed by individuals according to their interests, energy and subject background, and enterprise personnel are included into the professional cluster construction team. It reforms the organization mode of the original teaching and research department, and relies on professional clusters to activate grassroots academic organizations. At present, it has formed the sharing of scientific research platform, the co-construction of teaching staff, the sharing of equipment resources, the co-research of science and technology, and the co-cultivation of industry talents, which strongly supports the training of applied talents.

4 Conclusion

The professional cluster is a kind of professional structure in the modern governance system of colleges and universities, an important strategy for higher education to optimize the allocation of professional resources, innovate service mode and promote the interdisciplinary development of majors, and also a growth point for the accumulation and innovation of technical skills. The thinking of "Internet plus", "Made in China 2025" and "Industry 4.0" gave birth to a new round of industrial revolution. The profound changes in national economic growth mode and production mode, the strategic adjustment of regional economic structure and the transformation of development mode led by innovation have given birth to the differentiation of traditional posts and the emergence of new posts. The demand for talents has changed from the demand for talents facing upstream and downstream industries and vertical and horizontal industrial chains to innovative, interdisciplinary and applied ones. The professional cluster has gradually become an important means for application-oriented undergraduate universities to cope with the changes of many internal and external factors, such as social and economic development, industrial demand, talent training, hierarchical development of universities, *etc.* It is also a realistic choice for the development and professional construction of application-oriented undergraduate universities.

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and daring to innovate, and train applied talents who are willing to stay, go to rural areas, and are practical.

3.2 Establishing a local red culture teaching resource library in Zunyi Zunyi Normal University, guided by the outcome of "inheriting the red gene and telling well the story of Zunyi", has organized a team of experts to compile the special textbooks such as *Long March Spirit* and *Long March Spirit and Contemporary College Students*" through excavating and inheriting the red cultural resources of Zunyi, and has compiled classical cases of red cultural education, thus providing professional teachers. Different teaching cases can be selected according to different courses.

3.3 Improving the ideological and political ability of teachers of specialized courses (i) It is necessary to cultivate the ideological and political consciousness of teachers of specialized courses. The course of ideological and political education is an important part of the cultivation of applied talents. (ii) It is necessary to strengthen the red culture training for teachers of specialized courses. Zunyi Normal University makes full use of the school's high-level scientific research platform, the college's key research base of humanities and social sciences of the Ministry of Education (the base of the Research Center for the Revolutionary Spirit and Cultural Resources of the Communist Party of China), the red classic art education demonstration base and other platforms, to improve the ideological and political ability of teachers of specialized courses by carrying out regular red culture teaching and related activities. (iii) Innovative teaching methods. Teachers explain through micro-video, Super Star (Chaoxing), rain classroom, *etc.*, using VR technology, combining virtual and reality, so that students can make PPT combined with red culture to publicize, so as to achieve full ideological and political coverage of the courses.

3.4 Promoting the organic integration of environmental discipline teaching and red culture Firstly, according to the characteristics of environmental discipline courses and the goal of educating people, it is recommended to systematically classify the specialized courses, deeply excavate the ideological and political elements in different types of courses, and integrate the red culture. The second is to guide students to participate in the "Innovation, Creativity and Entrepreneurship" Challenge, Challenge Cup and other activities, so that students can flexibly use their professional knowledge, organically integrate the red culture, and combine theory with practice.

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