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A Study on the Collaborative Innovation of School-Enterprise Talent Training Models for Water Conservancy Professionals in the Context of High-Quality Development in the Yellow River Basin

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Abstract: *The Yellow River Basin holds a crucial position in China's socio-economic development landscape. Its high-quality development not only entails the coordinated advancement of strategic goals such as rational water resource utilization, ecological protection, and economic transformation, but it has also achieved remarkable economic accomplishments in recent years. As key contributors to the construction of water conservancy infrastructure, water resource management, and water ecology protection in the Yellow River Basin, the innovation and optimization of water conservancy talent training models are of paramount importance. From the perspective of school-enterprise collaboration, this paper delves into the significance, current status, and challenges of integrating high-quality development in the Yellow River Basin with water conservancy talent training models. It also proposes innovative strategies and practical approaches to establish a new system of talent training that aligns with the developmental needs of the Yellow River Basin, thereby providing robust talent and intellectual support for ecological protection and high-quality development in the region.*

Keywords: *School-enterprise collaboration; Yellow River Basin; High-quality development; Water conservancy; Talent cultivation*

1. Introduction

The Yellow River Basin is China's second-largest river basin and represents a complex river system. Covering multiple provinces, the basin is not only rich in natural resources and characterized by a unique ecological environment but also has a profound historical and cultural heritage, offering immense potential for socio-economic and cultural development. It plays a critical role in promoting sustainable development, advancing ecological civilization, and enhancing ecological security[1]. The governance of the Yellow River has always been a major national priority. China has articulated a water management strategy emphasizing "water conservation first, spatial balance, systematic governance, and dual efforts"[2]. The ecological governance strategy for the Yellow River involves comprehensive control of soil erosion in the upper and middle reaches, integrated management of areas with high sediment concentration, and the construction of high-standard silt dams. Additionally, it requires strengthening ecological governance, continuously replenishing water in the estuarine delta, enhancing ecological protection and restoration in the estuarine area, and regulating ecological flows to ensure compliance with key river flow targets. High-quality development in the Yellow River Basin prioritizes ecological protection, with China emphasizing strict adherence to ecological protection and high-quality development strategies along the river basin, firmly pursuing a path of ecological priority and green development. Significant achievements have been made in recent years in ecological protection and high-quality development in the basin, with sustained improvements in the ecological environment, enhanced water security, and numerous highlights of high-quality development, laying a solid foundation for the region's sustainable development. Undoubtedly, the ecological protection and high-quality development of the Yellow River Basin is a major strategic initiative for China, encompassing complex tasks such as scientific allocation of water resources, construction and maintenance of water conservancy projects, protection and restoration of the aquatic ecosystem, and optimization and upgrading of the economic structure within the basin. Water conservancy professionals, as key elements for achieving these goals, play a critical role, and their training quality and models directly impact the success of the high-quality development strategy in the Yellow River Basin. The "school-enterprise collaboration" teaching model,

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which tightly integrates education with industry, offers new opportunities and a broad platform for cultivating water conservancy professionals in the basin[3]. Its core structure is shown in Figure 1. Implementing the school-enterprise collaboration model not only improves the mechanism for comprehensive participation of practice education bases in key aspects such as curriculum teaching, practical training, and thesis supervision for undergraduate education, but also ensures seamless alignment between talent training and industry demands. Moreover, it integrates educational resources of universities with the practical experience and technological strengths of enterprises, enabling water conservancy professionals to gain well-rounded training and significant enhancement in multiple dimensions, such as theoretical learning and practical application, technological innovation, and engineering practice, thus better meeting the diverse talent needs of high-quality development in the Yellow River Basin [4].

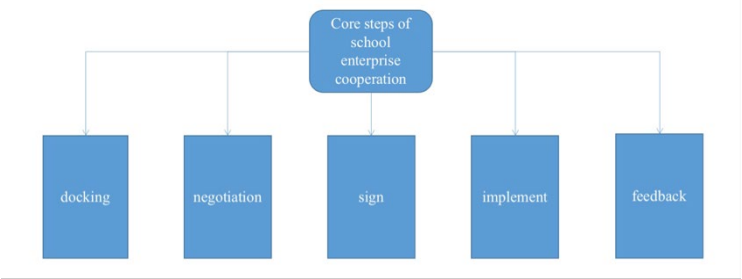

Fig 1. Core Steps of School Enterprise Cooperation

2. Characteristics of the Demand for Water Conservancy Professionals in the High-Quality Development of the Yellow River Basin

2.1 Comprehensive Knowledge and Skills

The high-quality development of the Yellow River Basin requires talent recruitment to safeguard ecological security and achieve economic high-quality development[5].

In the context of talent needs, water conservancy engineering exhibits notable distinctions from other engineering disciplines. The expertise required in design, project management, construction, and supervision in water conservancy projects is irreplaceable by other fields. Moreover, the high-quality development of the Yellow River Basin calls for water conservancy professionals to acquire a multidisciplinary and comprehensive knowledge framework. They should not only master conventional water conservancy engineering domains such as hydrology and water resources, hydraulic engineering, and irrigation technology but also familiarize themselves with allied fields like environmental science, ecology, economics, and information technology. Such knowledge enables them to address diverse challenges, including ecological conservation in water resource management, economic viability analyses in hydraulic engineering, and the integration of information technologies into smart water conservancy systems. For example, in projects ensuring ecological flow in the Yellow River Basin, water conservancy professionals need to combine hydrological expertise to determine optimal ecological flow, apply ecological theories to assess project impacts on ecosystems, and employ information technology to develop monitoring and regulatory systems for ecological flows[6]. A scientific assessment of water conservancy talent demand trends, coupled with the timely training of highly skilled professionals capable of ensuring ecological, flood, drinking water, and cultural security, empowers control over the high-quality development of the Yellow River Basin.

2.2 Cross-Regional Collaboration and Communication Skills

The Yellow River Basin encompasses multiple provinces and regions, characterized by strong interconnections and mutual dependencies in areas such as water resource distribution, coordinated operation of hydraulic projects, and water environment management[7].

Professionals in water conservancy must possess advanced cross-regional collaboration and communication expertise to harmonize stakeholder interests, collaboratively design a comprehensive development blueprint for the basin, and develop and implement strategic plans grounded in scientific principles. For example, during the unified water regulation processes in the Yellow River Basin, water conservancy experts must engage in efficient communication and cooperation with entities upstream,

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downstream, and across both banks to ensure the reasonable implementation and optimal adjustment of water distribution plans.

2.3 Ecological and environmental awareness

The management of the Yellow River has always been crucial for national governance. China has established comprehensive water management principles within its ecological civilization framework, emphasizing water conservation, spatial balance, systematic governance, and coordinated efforts. The ecological management strategy involves integrated solutions for upper and middle reaches, including erosion control in sandy regions, construction of advanced sediment retention structures, and ecological restoration in river estuaries[8]. This encompasses continuous water replenishment for delta ecosystems, ecological flow monitoring systems, and guaranteed water availability at key monitoring stations. Ecological preservation forms the cornerstone of high-quality development in the Yellow River Basin. Provincial authorities are mandated to implement strategic plans prioritizing ecological protection and sustainable growth, maintaining commitment to environmentally conscious modernization. Recent achievements demonstrate notable progress in ecological rehabilitation and water security enhancement. Continuous environmental improvements and innovative development models have established a solid foundation for sustainable basin management. Water management professionals bear critical environmental responsibilities throughout project lifecycles. This requires not only ecological awareness but also practical implementation of sustainable practices to minimize environmental impacts while ensuring project viability. From planning to operation, engineers must systematically assess ecological implications and adopt environmentally adaptive technologies to achieve harmonious coexistence between water infrastructure and natural ecosystems. Hydraulic engineering projects now incorporate ecological considerations, such as preserving fish migration routes and wetland ecosystems through targeted restoration measures. The Tianjiaotan Project maintains fish migration via a 2.3km fish passage, while Guangxi's Luojiao Project combines acoustic guidance with 1km-long channels to protect endangered species during upstream spawning migrations.

3. The Current Situation and Issues of School-Enterprise Cooperation in the Training of Water Conservancy Professionals

3.1 Insufficient Depth and Breadth of Cooperation

Although some universities and enterprises have explored school-enterprise cooperation in the training of water conservancy professionals, the cooperation remains limited to shallow levels such as student internships and part-time enterprise lecturers.

The cooperation has not yet extended to deeper aspects, such as setting talent development goals, constructing curriculum systems, developing teaching resources, and implementing teaching evaluation. For example, some enterprises only provide short-term internship positions during students graduation internships and do not participate in course design or the optimization of teaching content during students' academic years. This results in a disconnect between internships and theoretical learning, making it difficult for students to apply the knowledge they have acquired effectively in real-world work. Many universities and enterprises have signed school-enterprise cooperation agreements and established relevant training bases, but most enterprises have not established a sound talent practice and development system. The practical teaching, which should have been the responsibility of the enterprises, is entirely transferred to the universities, leading to a severe lack of practical experience for students. In terms of cooperation breadth, most collaborations are concentrated in a few large water conservancy enterprises or local enterprises, failing to expand a broad network of cooperation with enterprises of different sizes and types within the Yellow River Basin. This restricts students' comprehensive understanding and practical experience of the diversity of the water conservancy industry in the basin. Furthermore, there are shortcomings in the content of school-enterprise cooperation. Many collaborative projects fail to keep up with the latest technological developments and market demands in the water conservancy industry, leading to a gap between the skills students learn and the actual needs of the industry, making it difficult for them to meet the challenges of future work. Therefore, both parties in the cooperation need to continuously update the project content to ensure that the training of water conservancy professionals stays current and truly meets the practical needs of the high-quality development of the Yellow River Basin.

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3.2 Delay in Curriculum System and Practical Teaching

Currently, the curriculum system of the water conservancy program focuses on the delivery of traditional water conservancy theoretical knowledge but has failed to adequately integrate emerging technologies and interdisciplinary knowledge crucial for the high-quality development of the Yellow River Basin. Courses related to cutting-edge fields such as smart water conservancy and ecological water conservancy are relatively weak and lack systematic planning and forward-thinking arrangements. The practical teaching segment faces numerous challenges, including the underdeveloped construction of practical teaching bases, outdated facilities, and an inability to meet the urgent demands of real-world engineering applications. The content of practical teaching lacks innovation and comprehensiveness, mainly focusing on verification experiments and basic engineering internships, making it difficult to fully develop students' ability to address complex engineering problems in the Yellow River Basin. Furthermore, the assessment and evaluation system for practical teaching is incomplete, focusing mainly on the outcomes of practical operations while neglecting a comprehensive evaluation of students' innovative thinking, teamwork, and problem-solving abilities during the practical process.

3.3 Faculty Development Requires Enhancement

Current industry-academic collaboration reveals critical gaps in water engineering faculty development. While demonstrating strong theoretical competence, university instructors often lack practical experience in Yellow River projects. This disconnect between academic knowledge and real-world applications results in abstract teaching content that fails to engage students effectively. Industry mentors, though technically proficient, frequently lack pedagogical training. This skills gap leads to inconsistent teaching quality, overreliance on conventional methods, and suboptimal learning outcomes. Furthermore, insufficient institutional mechanisms for faculty exchange limit professional growth opportunities. Restricted access to corporate training for academics and academic development for industry practitioners impedes comprehensive competency improvement within the teaching force.

4. Innovation Strategies for Talent Training Models from the Perspective of University-Enterprise Collaboration

4.1 Constructing an Integrated Talent Training Plan

Universities and enterprises should closely align with the strategic goals of high-quality development in the Yellow River Basin, jointly formulating an integrated talent training plan for water conservancy professionals to meet the national strategic demands of ecological protection and high-quality development in the region. Starting from the top-level design of talent cultivation, the goals, teaching content, and practical training arrangements for each stage should be clearly defined. When setting training objectives, the comprehensive requirements of the Yellow River Basin for water conservancy talent in terms of knowledge, skills, and qualities must be fully considered, with a focus on fostering interdisciplinary thinking and comprehensive application abilities in students. For example, the practical needs of the Yellow River Basin in water resources management, ecological protection, and water conservancy engineering construction and management should be broken down into various teaching modules, allowing students to gradually establish a knowledge system and competency structure that align with the development of the basin throughout their studies. In terms of course content, the proportion of specialized courses and case-based teaching related to the Yellow River Basin should be increased, such as courses on the hydrological characteristics of the Yellow River, case studies on water conservancy engineering in the Yellow River Basin, and ecological restoration technologies for the Yellow River. This will enable students to gain a deeper understanding of the characteristics and development trends of the water conservancy sector in the Yellow River Basin. Furthermore, careful planning of practical teaching is essential to ensure its close integration with theoretical teaching, complementing each other. For example, students' internships and practical training should be carefully structured throughout the entire training cycle, from basic water conservancy engineering internships to more advanced professional skill internships and comprehensive practical internships, gradually enhancing students' practical skills and problem-solving abilities.

4.2 Innovative Practical Teaching System

Leveraging the abundant water conservancy engineering resources and enterprise practice platforms

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in the Yellow River Basin, a multi-level and diversified practical teaching system should be constructed. First, strengthen the development of on-campus practical teaching bases by introducing advanced water conservancy engineering simulation equipment and software, such as the Yellow River Basin Hydrological and Water Resources Simulation System and Virtual Simulation Platforms for Water Conservancy Engineering, allowing students to conduct experiments and simulations closely resembling real engineering scenarios on campus, thereby enhancing their understanding and mastery of theoretical knowledge. Second, expand the network of off-campus practical teaching bases, establishing extensive cooperation with water conservancy enterprises, research institutions, and water management departments in the Yellow River Basin to create long-term and stable internship and practical training bases. For example, collaboration with units under the Yellow River Conservancy Commission, large hydropower enterprises in the basin, and water conservancy planning and design institutes can provide students with diverse internship positions and practical projects. In the design of practical teaching content, emphasis should be placed on the development of comprehensive and innovative projects, encouraging students to participate in practical activities related to the planning, design, construction, and operation management of actual water conservancy projects in the Yellow River Basin, such as designing ecological restoration projects for tributaries of the Yellow River or construction organization design for small-scale water conservancy hubs. This will cultivate students' teamwork, innovative thinking, and engineering practice capabilities. At the same time, a sound practical teaching evaluation mechanism should be established, using diverse assessment methods to comprehensively evaluate students' abilities in knowledge application, operational skills, teamwork spirit, and innovative achievements in practical teaching, ensuring the effective improvement of practical teaching quality. In terms of curriculum innovation, specialized innovation-oriented practical courses can be enhanced by adding four practical modules: academic competition topics, innovation and entrepreneurship training, cutting-edge technology achievements, and scientific paper writing. On one hand, this should focus on competition-driven, innovation-oriented approaches to practical ability development. On the other hand, related BIM courses should also be added to help students master research and practical tools.

4.3 Developing Dual-Qualified Faculty

University faculty typically demonstrate strong theoretical expertise in teaching and research, yet often lack industrial experience. This practical knowledge gap limits their ability to address real-world challenges and meet industry demands for application-oriented professionals. Establishing reciprocal faculty exchange programs between academia and industry is essential for developing dual-qualified instructors. This initiative plays a pivotal role in enhancing water engineering education systems. Universities should actively deploy water engineering faculty to leading enterprises along the Yellow River for professional immersion. Through participation in actual projects, faculty can gain practical experience while staying current with industry trends and technical requirements. For instance, involving faculty in major Yellow River projects enables them to acquire construction techniques, management processes, and technical solutions, thereby enriching their teaching with practical case studies. Concurrently, enterprises should assign experienced professionals as adjunct faculty, contributing to course instruction, practical training, and thesis supervision. Universities should provide tailored pedagogical training to enhance industry instructors' teaching competencies, ensuring effective knowledge transfer and improved educational outcomes. Furthermore, collaborative faculty development programs and educational research initiatives should be established. Drawing from successful models like the Yellow River Conservancy Technical Institute, these partnerships can drive innovation in curriculum design, teaching methodologies, and talent development strategies, ultimately enhancing overall educational quality.

4.4 Enhancing Industry-Academia-Research Collaborative Education

Industry-academia-research collaboration serves as a vital platform for maintaining university-enterprise partnerships. Mutual benefits and shared progress are essential for sustainable development of such collaborations. Addressing critical technological needs and practical engineering challenges in the Yellow River Basin's development, this initiative strengthens collaborative education among universities, enterprises, and research institutions. Establishing collaborative alliances and innovation platforms integrates diverse resources. Notable examples include the joint innovation laboratory between Yunnan Water Resources Bureau and Huawei, and the talent development program by Loongson Technology and Hohai University, which collectively advance technological innovation and professional training in water engineering. Collaborative research projects in water resource optimization, ecological restoration, and smart water systems provide students with hands-on research opportunities, enhancing their innovative

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capabilities and scientific competencies. Jointly established research centers and laboratories enable cutting-edge technology development and knowledge transfer, exposing students to industry advancements and research outcomes. These collaborative platforms facilitate coordination with local governments and industry associations to establish professional standards and training benchmarks for water engineering talent in the Yellow River Basin. For instance, the Yellow River Conservancy University's curriculum cultivates well-rounded professionals with theoretical knowledge, technical skills, and comprehensive competencies to meet the basin's water management needs. Collaborative workforce assessments with provincial water authorities and industry associations inform curriculum updates, ensuring alignment with the basin's development requirements and industry trends.

5. Conclusion and Prospects

The integration of high-quality development in the Yellow River Basin and the talent training model for water conservancy professionals, viewed from the perspective of school-enterprise cooperation, represents an important task with far-reaching significance and systemic challenges. Over the past several decades, China's "school-enterprise cooperation" teaching model has essentially taken shape, and various models have been implemented within the water conservancy sector, yielding certain outcomes. Of course, we must also acknowledge the existing shortcomings within the "school-enterprise cooperation" teaching model, such as the need to deepen cooperation and the insufficient integration of resources. However, the reform and innovation of the school-enterprise cooperation talent development model is, after all, a long-term and complex process. Moving forward, in the reform and innovation of the "school-enterprise cooperation" teaching model, the government should further strengthen policy support, and universities and enterprises should actively refine their cooperation mechanisms to enhance the synergistic effects of the "school-enterprise cooperation" teaching model. This will promote close collaboration among enterprises, universities, and government agencies, continuously exploring and innovating collaborative teaching models, and jointly building a high-quality talent resource pool to serve socio-economic development. This approach will facilitate the effective application of students' theoretical knowledge to real-world practice. Through tripartite collaboration, the focus should be on cultivating a new generation of talent with independent research and innovation capabilities, an exploratory mindset, and creativity. This will establish a more open, shared, and dynamic technological innovation talent system, promoting free allocation of talent and injecting fresh energy into the development of water conservancy projects in the Yellow River Basin. In summary, with a focus on the future of the entire water conservancy industry and based on the needs for "great protection," "great governance," and high-quality development in the Yellow River Basin, it is essential to implement a top-level design for talent development. The goal is to create a large-scale, well-structured, well-coordinated, and high-quality team of builders for the Yellow River, which stands as the highest aspiration for universities in cultivating water conservancy professionals in the new era.

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