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# Research on the Combined with Discipline Competition and Scientific Research to Enhance The Path of Water Supply and Drainage Talent Cultivation

Jian Tang*, Haiyue Wang

School of Civil Engineering, Sichuan University of Science and Engineering, Zigong 643000, China

*Corresponding author: tangtang100@126.com

## Abstract

**Traditional talent cultivation model for water supply and drainage majors, there are common practical pain points such as the disconnection between scientific research resources and classroom teaching. These issues make it difficult to adapt to the industry talent cultivation requirements in the context of the new engineering education. This study concentrate on the collaborative the scientific research empowerment, competition practice and talent cultivation as the core research thread, systematically analyzes the common issues existing in the current water supply and drainage major in the aspects of scientific research-based education and competition-based education, and constructs a collaborative talent cultivation system featuring layered progression, integration of competition and teaching, and linkage between research and innovation. The study proposes specific paths for transforming scientific research project resources into teaching cases, experimental training content, and competition topics, building a discipline competition matrix covering the entire cultivation cycle of basic cognition-comprehensive practice-innovation breakthrough, and improving the construction of dual-teacher guidance teams and process evaluation mechanisms. The results show that the deep collaboration between scientific research and competition can effectively break down the barriers between theoretical teaching and engineering practice, significantly enhance student ability to solve complex water engineering problems, and provide a reliable research path for the cultivation of applied and innovative talents in the water supply and drainage science and engineering major in the context of new engineering education.**

## Keywords

**Water supply and drainage; scientific research; discipline competition; Integration of competition and education; Talent cultivation.**

## 1. Introduction

Water is a fundamental and leading element for economic and social development, and also a core carrier for safeguarding people livelihood, health, and ecological security. As the only engineering discipline in our country with benign social cycle of water as its core research focus. Water Supply and Drainage Science and Engineering undertakes the core mission of cultivating professionals in the fields of water system planning and design, construction and operation and maintenance, water purification, and water environment restoration. From the emergency response to the major water pollution incident in the Songhua River, to the full coverage construction of urban sewage treatment plants nationwide, and to the current nationwide promotion of comprehensive treatment of five types of water, sponge city construction, and sewage resource utilization initiatives, generations of water supply and drainage professionals

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have always been the core force supporting the implementation of the national water security strategy.

With the urbanization process enters a stage of high-quality development, the pace of technological iteration in the water supply and drainage industry has noticeably accelerated. New directions such as smart water management, digital twin water systems, low-carbon water treatment technologies, and novel disinfection techniques are continuously emerging. The industry demand for talent has shifted from a singular focus on engineering execution capabilities to a demand for composite skills encompassing theoretical innovation, technological research and development, and interdisciplinary collaboration. The traditional training model for water supply and drainage professionals has long centered around classroom theoretical instruction and confirmatory experiments, providing students with limited opportunities to engage in real-world research projects and complex engineering scenarios. Consequently, a significant number of students, even after completing four years of professional study, still struggle to independently undertake comprehensive tasks such as water treatment process optimization, pipe network system simulation, and water environment scheme design. The mismatch between the supply side of talent training and the demand side of the industry has become increasingly prominent.

In order to destroy this backdrop, many domestic universities with water supply and drainage majors have begun to explore reform paths that integrate scientific research resources and academic competitions into their talent cultivation systems [1]. Some universities have built practical innovation platforms for students by introducing professional competitions such as the national college water supply and drainage technology innovation competition deep-water cup, the challenge cup national college extracurricular academic technology works competition, and the national college energy conservation and emission reduction social practice and technology competition. At the same time, relying on teacher scientific research projects and horizontal engineering projects, students are guided to enter research laboratories in advance to participate in research work [1-2]. However, from the overall practical situation, the scientific research education and competition education work in most universities is still in a state of fragmented promotion. Scientific research projects are disconnected from daily course teaching, and only a small number of top students can participate in scientific research training. Discipline competitions are in a state of independent operation of competitions, without deep linkage with professional training programs and curriculum systems [3]. The participation of a large number of ordinary students is low, making it difficult to achieve innovation ability improvement for all students.

Based on this realistic background, this study takes the collaborative mechanism between scientific research empowerment and competition practice as the core research object. It systematically sorts out the pain points existing in the current talent cultivation system, constructs a feasible collaborative cultivation path, and provides theoretical reference and practical support for improving the quality of talent cultivation in water supply and drainage science and engineering under the background of new engineering.

## 2. Research Progress on The Talent Cultivation Path of Water Supply and Drainage

### 2.1. Progress of relevant domestic research

Research on the domestic academia on the cultivation of talents in the water supply and drainage discipline has long focused on directions such as engineering education professional certification and practical teaching system reform. Early studies generally pointed out that as a typical engineering discipline, water supply and drainage must strengthen practical teaching links and enhance students engineering practical operation abilities. Some universities have

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also made preliminary explorations by increasing internship and training hours and building campus practice bases. With the comprehensive promotion of the new engineering construction, more and more scholars have begun to pay attention to the value of scientific research and competitions in talent cultivation [4].

In the dimension of empowering talent cultivation through scientific research, existing research generally believes that opening up teacher scientific research resources to undergraduate teaching can effectively break the traditional teaching mode of teachers teaching theories and students memorizing knowledge points. Allowing students to actively construct knowledge driven by real scientific research problems and students to directly engage with the most cutting-edge technological directions in the industry can establish a sense of professional identity that professional learning serves national needs. Transforming teacher scientific research achievements into course cases, experimental projects, and graduation design topics can significantly enhance students' understanding depth of professional knowledge.

In terms of empowering talent cultivation through academic competitions, existing research has reached a basic consensus of promoting learning, teaching, and innovation through discipline competitions. Holding professional education theme class meetings for academic competitions, systematically sorting out competition systems covering different academic years, and dismantling the preparation logic by combining award-winning project cases have effectively stimulated the enthusiasm of water supply and drainage engineering students to participate in competitions, forming a good academic atmosphere for scientific innovation. At the same time, virtual simulation and digital twin technology have been introduced into practical teaching reforms, reversely integrating innovative ideas from competitions into experimentation, internship, and graduation design links, achieving the transformation of competition results into teaching resources. Establishing a competition guidance team led by key teachers and building a full-chain competition education mechanism, a tiered inheritance model of extensive contact in lower grades and deep participation in higher grades can be formed, achieving the ability coverage of academic competitions for all students.

## 2.2. Progress of relevant research abroad

In developed countries in Europe and America, the cultivation of talents in water supply and drainage-related majors generally adopts a problem-oriented learning and project-oriented learning model. The core logic is to use real water environment scientific research projects and engineering practice projects as the core carriers for talent cultivation. Universities in countries such as the United States and Germany generally do not establish an independent discipline competition system, but instead embed the requirements of various industry innovation competitions directly into the curriculum design and graduation design links of professional training programs. The process of students completing their coursework is also the process of preparing for competitions, achieving a complete integration of scientific research projects, practical teaching, and innovation competitions.

For example, the environmental engineering major at the University of Michigan in the United States directly incorporates the actual pipe network optimization and sewage treatment plant upgrading and renovation projects of the local municipal water department as core course design topics for junior year students. Students complete the scheme design and defense in groups, and excellent schemes can directly represent the school to participate in the national environmental engineering innovation competition. Some excellent design achievements are even directly adopted and implemented by the water department. This training model fully connects the entire chain of classroom learning, scientific research practice, competition innovation, industry implementation. Students have accumulated a wealth of real-world engineering project experience before graduation, enabling them to quickly adapt to industry job demands [5].

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# 3. Analysis of Existing Issues in The Cultivation of Water Supply and Drainage Professionals

## 3.1. The disconnection between scientific research resources and teaching links

In the water supply and drainage major in most domestic universities, the scientific research work of teachers is relatively isolated from undergraduate teaching. On the one hand, a large number of teachers are engaged in vertical scientific research projects and horizontal engineering projects, but these highly quality scientific research resources are rarely open to undergraduate students. The topics selection, experimental platforms, and research results of scientific research projects are mostly only for graduate students, making it difficult for undergraduate students to get in touch with real scientific research problems. On the other hand, the content update speed of undergraduate classroom teaching lags behind the industry technology iteration speed. A large number of course cases still follow the traditional process content of ten years ago, and cutting-edge content in industries such as smart water management, low-carbon water treatment, and sewage resource utilization is difficult to enter the core curriculum system, resulting in a significant gap between the knowledge students learn in school and the actual needs of the industry.

This bidirectional disconnection directly leads to students' professional learning being in a state of passive reception. Many students, even in their junior year, are still unclear about the research directions of the water supply and drainage major, and they do not know which real engineering problems their theoretical knowledge can solve. As a result, their professional identity and learning initiative are difficult to fully stimulate.

## 3.2. The discipline competitions and professional training system are fragmented from each other

Currently, the discipline competition work for water supply and drainage in many universities is in a state of students participating spontaneously and teachers providing sporadic guidance. The competition system has not been deeply integrated with the professional training program. Firstly, the threshold for participating in competitions is set unreasonably. Most competitions are only open to senior students, leaving junior students with little opportunity to participate. This results in only a small number of science and technology active individuals participating in competitions, while most ordinary students have never participated in any professional competitions throughout the process, and their innovation ability is not exercised. Secondly, the competition content is disconnected from the course knowledge points. Many competition topics do not align with the teaching content of core courses such as hydraulics, water quality engineering, and water supply and drainage pipe network systems. Students need to spend a lot of extra time learning completely unfamiliar content, which not only increases their academic burden but also makes it difficult to achieve the goal of promoting learning through competition. Thirdly, the competition results are not aligned with the credit recognition system. The considerable time and effort students invest in participating in competitions cannot be converted into corresponding practical credits, which greatly dampens the enthusiasm of ordinary students to participate.

## 3.3. Mismatch between team composition and collaborative education requirements

Collaborative education in scientific research and competitions poses higher demands on the competency structure of instructors. Teachers must not only possess solid research capabilities but also be familiar with industry competition rules and able to precisely align with student abilities to provide tiered guidance. However, most current guidance teams in the water supply

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and drainage discipline exhibit two distinct shortcomings: Firstly, most full-time teachers within the university possess solid theoretical and research foundations, but generally lack practical front-line engineering experience and insufficient understanding of the latest practical needs of the industry. When guiding competition projects, they are prone to the issue of emphasizing theoretical innovation and neglecting engineering implementation, resulting in a large number of competition entries remaining at the laboratory prototype stage and struggling to adapt to actual industrial scenarios. Secondly, external industry mentors, mostly from front-line units such as water companies and municipal design institutes, possess rich practical engineering experience, but rarely deeply participate in daily teaching and competition guidance processes. They can only provide sporadic advice during the competition defense phase, failing to establish a stable collaborative guidance mechanism between dual mentors.

## 4. Specific Pathways for Synergistically Enhancing Talent Cultivation Through Scientific Research Empowerment and Competition Practice

### 4.1. Establishing a hierarchical and progressive competition system to achieve full coverage of all students

In order to break the limitations of past academic competitions, which were only open to a small number of senior students, we have constructed a tiered and progressive competition system that covers the entire training cycle from freshman to senior year, allowing students with different ability levels to find their own entry points to participate.

Freshman basic cognitive level: For newly enrolled students, we organize the water supply and drainage major science and innovation introduction competition. The competition focuses on low threshold themes such as hydraulic demonstration experiments, fun water device making, and hometown water environment research. It does not require students to possess complex professional knowledge, but rather focuses on guiding students to establish perceptual cognition of the major and stimulate their interest in learning it.

Sophomore comprehensive practice level: Targeted at sophomores who have completed their professional basic courses, this level guides students to integrate knowledge points from courses such as analytical chemistry and microbiology in water treatment, enabling them to complete small innovative experiments and design simple devices, thereby enhancing their basic experimental operation skills.

Junior innovation tackling level: Targeting juniors who have completed core professional courses, we prioritize promoting high-level professional competitions such as the national college water supply and drainage technology innovation competition deep-water cup, the challenge cup national college extracurricular academic technology works competition, and the national college energy conservation and emission reduction social practice and technology competition. We have guided students to integrate knowledge from core courses like water quality engineering and water supply and drainage pipe network systems to develop comprehensive innovative works, thereby honing their ability to solve complex engineering problems.

Senior year achievement implementation tier: Targeting senior students, this tier deeply integrates academic competitions with graduation projects and major innovation projects. It supports students in directly extending their competition entries into topics for their graduation projects, promoting further optimization and implementation of their competition entries. Meanwhile, it connects students with industry innovation and entrepreneurship competitions, providing incubation support for those with entrepreneurial aspirations.

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## 4.2. Establishing a normalized mechanism for the transformation of scientific research resources into teaching and competitions

Introduce clear incentive policies to encourage teachers to proactively open their research resources to undergraduate teaching and student competitions, and establish three types of normalized transformation pathways.

First, the transformation path of research project topics. Professional teachers are required to disassemble at least two or three sub-topics suitable for undergraduates from their ongoing research projects every year, serving as an alternative topic pool for student competitions, major innovation projects, and course design. For example, the research on soil heavy metal pollution control conducted by teachers can be disassembled into topics such as soil heavy metal content and morphological analysis, and the changing characteristics of heavy metals during soil heavy metal electrokinetic remediation, which can be directly provided to students as competition topics, allowing student innovative practice to be always based on real research problems.

Secondly, the path to opening up resources for scientific research platforms. Establishing a comprehensive open system for professional laboratories targeting undergraduates. Scientific research platforms such as water treatment laboratories, pipe network simulation laboratories, and virtual simulation laboratories in the water supply and drainage major are all open to students participating in scientific research training and competitions free of charge during their spare time. At the same time, a specialized instrument operation training system for undergraduates is formulated to enable students to independently operate large instruments such as gas chromatography, liquid chromatography, and online water quality monitoring, providing hardware support for student innovative practice.

Thirdly, the path for the transformation of scientific research achievements into teaching. Teachers are encouraged to integrate representative scientific research achievements of leading figures in the water supply and drainage field into classroom teaching cases. For example, the top-notch scientific research achievements in the industry, such as the emergency purification technology for drinking water, the theory of urban water circulation system and green disinfection technology by academician. It can be transformed into teaching cases for core courses such as water quality engineering, allowing students to directly engage with the most cutting-edge technological advancements in the industry, thereby enhancing the frontier and attractiveness of classroom teaching.

## 4.3. Build a dual-qualified guidance team that collaborates both inside and outside the school

Addressing the shortcomings of the traditional guidance team capability structure, we have established a dual-teacher collaborative guidance mechanism consisting of full-time teachers within the school and industry mentors from outside the school.

On the one hand, optimize the competency structure of on-campus instructors. Establishing a competition guidance team led by key teachers and coordinated by young teachers, set up special guidance groups for different competition directions, regularly organize instructors to conduct engineering practice training in water enterprises and municipal design institutes, enhance the engineering practice ability of full-time teachers, and address the issue of emphasizing theory and neglecting engineering among on campus teachers. At the same time, establish a workload recognition and incentive mechanism for instructors, equate the work of instructors guiding students in scientific research training and academic competitions with the workload of core course teaching, give preferential treatment in professional title evaluation, excellence evaluation, and selection, and fully mobilize the enthusiasm of instructors for guidance.

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On the other hand, we have established a stable mechanism for the participation of off campus industry mentors. We have invited industry mentors with rich front line engineering experience from partnered water utilities, municipal design institutes, and environmental technology enterprises. We have clarified the responsibilities and requirements of industry mentors, requiring each mentor to participate in at least two competition guidance activities every year, providing practical engineering guidance for students works and compensating for the lack of practical industry experience among on campus teachers. Through the collaborative efforts of the dual mentor team, student competition entries not only possess sufficient technological innovation but also meet the actual industry engineering standards, significantly enhancing the overall quality of their works.

## 5. Achievements Have Been Made In Innovating the Cultivation of Talents in The Water Supply and Drainage Discipline

In recent years, water supply and drainage major has always adhered to the orientation of talent cultivation quality in our university. Through continuous exploration and practice, the innovation and practical abilities of students majoring in water supply and drainage have been continuously improved. They have achieved remarkable results in academic competitions. Students have participated in and achieved excellent results in competitions such as the China international college innovation competition, the deep-water cup national college water supply and drainage technology innovation competition, and the challenge cup national college series of science and technology academic competitions. In the past three years, the graduate entrance examination rate of graduates majoring in water supply and drainage has reached over 30% for four consecutive years. Students have presided over and completed more than twenty national, provincial, and university level college student innovation and entrepreneurship training programs, and published five articles. They have won two national bronze awards in the China international collegiate innovation competition, one provincial gold award, two provincial silver awards, three provincial bronze awards, and one second prize in the Sichuan provincial college extracurricular academic science and technology works competition. They have also won one second prize and one best style award in the deep-water cup national collegiate water supply and drainage technology innovation competition. The innovative talent cultivation model has been publicized by multiple media outlets.

## 6. Conclusions

This study addresses the practical pain points of talent cultivation in the water supply and drainage science and engineering discipline under the new engineering paradigm. It systematically elucidates the core logic of the bidirectional synergy between scientific research empowerment and competition practice. Furthermore, it constructs a hierarchical competition matrix covering the entire training cycle, a mechanism for the transformation of scientific research resources into teaching, a dual-teacher collaborative guidance team, and a diversified evaluation system. This forms a replicable and scalable collaborative talent cultivation pathway. Practical experience demonstrates that this pathway effectively overcomes the pain points of the traditional talent cultivation model, such as the disconnect between theory and practice, and the separation of scientific research and teaching. It comprehensively enhances the engineering innovation capabilities of water supply and drainage students, achieving a virtuous cycle of promoting learning, teaching, and innovation through competitions.

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