

Course Reform of Water Pollution Control Engineering Based on School-Enterprise Cooperation

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Abstract: Water Pollution Control Engineering is a course with a strong engineering nature, holding a pivotal position within the environmental science and engineering curriculum. However, traditional teaching of Water Pollution Control Engineering primarily relies on school-based instruction supplemented by occasional field internships, which falls short of meeting industry demands for talent. This paper, after analyzing the current status of Water Pollution Control Engineering course teaching and the development of school-enterprise cooperation courses, proposes reform strategies from multiple aspects. These strategies are applied to the teaching of Water Pollution Control Engineering with the aim of cultivating high-quality water treatment technical talents who can better adapt to engineering needs.

Keywords: School-enterprise Cooperation; Water Pollution Control Engineering; Teaching; Reform Strategies.

1. Introduction

As an essential component of environmental science and engineering, the education and research in water pollution control engineering are crucial for cultivating professional talents and promoting technological innovation [1]. However, the traditional teaching model of Water Pollution Control Engineering course often fails to meet the rapidly changing industry demands and the development of the ability to solve complex environmental issues [2]. Reforming and innovating the existing curriculum system has become a common call from both the educational and industrial communities.

The school-enterprise cooperation model is an innovative educational model for collaboration between higher education and enterprises, which has been widely applied in college course teaching in recent years [3]. Through this model, schools can adjust teaching content and methods according to the actual needs of enterprises, enabling students to learn knowledge and skills closely related to practical work. Enterprises can participate in course design, provide internship opportunities, and even directly participate in teaching, thereby cultivating talents that better meet market demands [4-6]. This model not only strengthens the connection between schools and enterprises but also enhances the practicality and pertinence of education, promoting students' employment and career development. Currently, research on introducing the school-enterprise cooperation concept into the teaching of Water Pollution Control Engineering courses is relatively scarce and has significant exploratory value, as this cooperative model can bring new perspectives and improvements to traditional teaching.

This paper aims to explore the application and practice of the school-enterprise cooperation model in the reform of Water Pollution Control Engineering course teaching, and to analyze its positive role in improving the quality of education and cultivating high-quality environmental engineering talents. Through the exploration of reforms in course content, teaching methods, and practical links, this paper will provide theoretical support and practical guidance for the innovation and development of water pollution control engineering

education, in the hope of contributing educational strength to the resolution of water pollution issues.

2. Traditional Course Teaching Issues

Disconnection between theory and practice: Traditional teaching models often focus on theoretical instruction and lack integration with actual engineering practice. Students may struggle to understand the application of theoretical knowledge in real-world water pollution control projects, which can limit their interest in learning and their practical application skills.

Outdated curriculum content: With the rapid development of water treatment technology and the emergence of new treatment methods and equipment, some courses fail to update their content in a timely manner to reflect the latest industry advancements. This can result in students learning knowledge that does not align with the actual needs of the industry.

Lack of practical teaching components: Water Pollution Control Engineering is a highly practical course that requires students to deepen their understanding through hands-on operation. However, many courses lack sufficient practical teaching components such as experiments, internships, or case studies, making it difficult for students to gain the necessary practical experience.

Monotonous teaching methods: Traditional teaching methods may rely too heavily on lectures, lacking interaction and discussion, which limits the cultivation of students' active learning and innovative thinking. Moreover, monotonous teaching methods are not conducive to stimulating students' interest and participation.

Faculty disconnect from the industry: Some university teachers may lack sufficient industry experience, which can make it difficult for them to provide in-depth analysis and guidance from an industry perspective in their teaching. Additionally, a lack of close contact between teachers and enterprises makes it difficult to involve industry experts in teaching, depriving students of more diversified learning resources.

3. Overview of School-Enterprise Cooperation Course Development

The application of school-enterprise collaboration in the construction of professional courses in universities both domestically and internationally is a field that is continuously evolving and deepening. China's Ministry of Education actively promotes school-enterprise co-construction by issuing notices to collect typical cases of industry-education integration and school-enterprise cooperation, to showcase the high-quality development achievements of vocational education, and to coordinate with related work of international conferences.

Liaoning University of Technology organized the construction of a school-enterprise co-construction course resource library, requiring each college to upload no less than five courses that have made significant contributions to the talent training process of the major. Universities and enterprises have established professional practice bases, which not only provide students with practical opportunities but also promote the close integration of teaching content with actual work. Tsinghua University Shenzhen International Graduate School has established joint training bases with multiple enterprises, enhancing students' practical abilities through interdisciplinary characteristic practice courses. The school-enterprise cooperation model encourages innovation in teaching methods and content, such as the application of case teaching methods, introducing actual enterprise problems into course teaching, and enhancing students' practical operation ability and problem-solving skills. Harbin Engineering University has fully promoted the school-enterprise collaborative construction of courses for professional degree graduate students, strengthening the role of course teaching in improving the practical and innovative abilities of graduate students. School-enterprise collaboration also involves the construction of the teaching staff, with universities encouraging teachers from within and experts from enterprises to participate in teaching together, promoting the construction of a dual-teacher teaching team. Hunan University of Humanities, Science and Technology has formulated school-enterprise cooperation course construction and management methods, clarifying the connotation, setting, construction content, and teacher management of school-enterprise cooperation courses.

Overall, the application of the school-enterprise collaborative model in the construction of professional courses in universities at home and abroad is characterized by strong policy support, the continuous emergence of practical cases, the co-construction and sharing of course resources, the construction of professional practice bases, innovation in teaching methods, and the joint cultivation of teaching staff. These measures help to improve the quality of education and students' employability, promoting the deep integration of education and industry.

4. Reform Strategies and Implementation

4.1. Enterprise Participation in Curriculum Outline Development

The curriculum outline is the blueprint for teaching. Involvement of enterprises in the development of the curriculum outline ensures that the course content is closely aligned with the actual needs of the industry. Industry experts

can provide the latest industry development trends, technical standards, and operational procedures, making the course content more relevant to actual engineering needs.

Taking the Water Pollution Control Engineering course at the School of Materials and Environmental Engineering, Chengdu Technological University, as an example, during the compilation of the teaching syllabus for this course, Chengdu Keya Wastewater Treatment Co., Ltd. was fully involved, as shown in **Table 1**. First, through in-depth communication with the school, Chengdu Keya Wastewater Treatment Co., Ltd. assisted in accurately setting the course objectives based on industry needs and technical development trends. Subsequently, a joint working group composed of teaching staff and industry experts was established to jointly take charge of updating and integrating course content, introducing the latest water treatment technologies and practical engineering cases. Throughout the writing process, the enterprise and the school continued to communicate, establishing a feedback mechanism to continuously optimize the course content to adapt to industry development. In addition, both parties also jointly adhered to educational policies and teaching standards to ensure the compliance and authority of the course. Through this close cooperation, the enterprise can not only bring an industry perspective to the university but also help students better understand the combination of theoretical knowledge and practical application, laying a solid foundation for the cultivation of high-quality environmental engineering professionals. It is a process of comprehensively leveraging the advantages of both sides to jointly cultivate talents.

Table 1. Content of the teaching syllabus co-authored by the enterprise

| Number | Chapter | Content of Participation in Compilation |
|--------|-------------------------------------|--|
| 1 | Water quality and self-purification | Overview of wastewater treatment plants |
| 2 | Pre-treatment | Engineering examples of screens and grizzlies |
| 3 | Sedimentation by gravity | Engineering examples of sedimentation tanks |
| 4 | Natural flotation and air flotation | Engineering examples of air flotation tanks |
| 5 | Chemical coagulation | Engineering examples of coagulation methods |
| 6 | Adsorption | Engineering examples of adsorption methods |
| 7 | Ion exchange | Engineering examples of ion exchange methods |
| 8 | Membrane separation | Engineering examples of membrane separation |
| 9 | Activated sludge process | Engineering examples of activated sludge process |
| 10 | Biofilm process | Engineering examples of biofilm process |
| 11 | Anaerobic biological treatment | Engineering examples of anaerobic bio-treatment |
| 12 | Wastewater treatment plant design | Engineering examples of plant design |
| 13 | Activated sludge evaluation | Practical demonstration of performance test |
| 14 | SBR or A2/O experiment | Engineering examples of SBR and A2/O methods |

4.2. Enterprise Participation in Course Design

Enterprises can not only participate in the writing of the curriculum outline but also in the design of the course. Through this in-depth cooperation, enterprises can bring rich industry resources and practical experience to university education, ensuring that the students they train are more in line with market demands and have stronger professional competitiveness.

In the course design phase of Water Pollution Control Engineering at Chengdu Technological University, the school has established a cooperative relationship with Chengdu Keya Wastewater Treatment Co., Ltd., clarifying the objectives and expected outcomes of the course design. Subsequently, industry experts participate in the planning of the course content to ensure that the course covers the key knowledge points and skills required by the industry. Enterprises provide actual engineering cases (as shown in **Table 2**) for analysis and discussion in teaching, enhancing the practicality of the course. At the same time, enterprises recommend or dispatch experienced engineers to participate in classroom teaching, sharing cutting-edge industry technology and engineering experience, and enhancing students' practical operation ability and innovative thinking. Finally, enterprises participate in the evaluation of the course design effect, provide feedback, and help schools continuously optimize the course design and improve the quality of teaching.

Table 2. Engineering examples in course design

| Number | Sewage Type | Engineering Example |
|--------|-----------------------|--|
| 1 | Domestic Sewage | Design of a 60,000 m ³ /d wastewater treatment process for a town |
| 2 | | Design of a 250,000 m ³ /d wastewater treatment process for a city |
| 3 | | Design of a 1,500 m ³ /d wastewater treatment process for a resort area |
| 4 | Industrial Wastewater | Design of a 2,500 m ³ /d wastewater treatment process for a paper mill |
| 5 | | Design of a 400,000 m ³ /a wastewater treatment station for a brewery |

4.3. Providing Internship Opportunities

Practice is the sole criterion for testing truth. Internship opportunities provided by enterprises allow students the chance to engage in real water pollution control projects, to learn engineering knowledge and skills from practice, and to enhance their ability to solve practical problems.

In recent years, the Environmental Science and Engineering major at Chengdu Technological University has worked with Chengdu Keya Wastewater Treatment Co., Ltd. to establish an internship program, clarifying the objectives, content, and expected outcomes of the internship. The enterprise assigns experienced engineers as mentors, responsible for the daily guidance and skill training of students, ensuring that students can participate in actual water treatment projects, such as water quality analysis, process design, and equipment operation. At the same time, the enterprise ensures that the internship environment meets safety standards and provides necessary safety training and personal protective equipment. During the internship, the enterprise maintains communication with the university, dynamically adjusting the internship plan based on the students' performance and learning needs to optimize the program. Additionally, the enterprise holds special lectures or seminars during the internship process, allowing students to

understand the latest industry trends and technical advancements. After the internship, the enterprise actively participates in the evaluation of students, providing feedback to help students summarize experiences and guide their career development. Through a well-designed internship program, the enterprise not only helps students apply theoretical knowledge to practice but also cultivates their professional qualities and innovative abilities, while discovering and nurturing potential talent for the enterprise.

4.4. Introducing Industry Experts for Lectures, Guidance, or Teaching

Regularly inviting industry experts into the classroom for thematic lectures or short-term teaching can bring the most cutting-edge knowledge and technology in the industry to students, broaden their horizons, and improve their innovative thinking abilities.

Chengdu Technological University has established a stable school-enterprise cooperation platform with Chengdu Keya Wastewater Treatment Co., Ltd., by signing a cooperation agreement that clarifies the responsibilities and obligations of both parties, ensuring a stable supply of expert resources. Organizing regular industry expert lectures allows students the opportunity to directly engage with the forefront of the industry, understanding its development trends and professional requirements. Inviting corporate experts to participate in classroom teaching ensures that there is at least four hours of instruction by corporate experts each semester. In addition, a guidance session by experts is set up, allowing students to complete specific learning tasks or projects under expert guidance. Through these approaches, the school-enterprise co-built courses not only improve the quality of teaching and the student learning experience but also strengthen the connection between students and the industry, laying a solid foundation for students' career development.

4.5. Enhancing Practical Teaching Components

Practical teaching is an essential part of professional courses. The main purpose of increasing practical teaching components is to bridge the gap between students' theoretical knowledge and its practical application, enhancing their hands-on operation skills and the ability to solve engineering problems. Through practical teaching, students can apply the knowledge they have learned in real or simulated work environments, strengthening their professional skills and engineering literacy, while also fostering innovative thinking and team spirit.

Firstly, collaborate with enterprises to develop practical teaching projects, such as water quality monitoring and the operation and management of wastewater treatment plants, allowing students to participate in actual water pollution control projects. Secondly, establish on-campus laboratories or off-campus internship bases, equipped with necessary experimental equipment and tools, simulating real engineering environments to provide students with a platform for practical operation. Thirdly, design interactive teaching methods such as case studies, role-playing, and simulated decision-making to increase student engagement and interest in learning. Additionally, invite corporate engineers to participate in teaching, sharing actual engineering experience and guiding students in completing practical projects. Lastly, regularly organize students to participate in academic exchanges and engineering competitions at home and abroad

to broaden their horizons and enhance their practical skills.

Through these approaches, the school-enterprise collaborative Water Pollution Control Engineering course can be more closely aligned with engineering practice, cultivating students' practical skills and innovative abilities, and laying a solid foundation for their future career development.

4.6. Cultivating Dual-Qualified Teachers

Dual-qualified teachers are key to the school-enterprise collaborative courses. University teachers should have certain engineering practical experience, capable of integrating theory with practice, thereby improving the quality of teaching. At the same time, corporate engineers can also participate in teaching as part-time teachers, bringing rich engineering experience.

Chengdu Technological University has established a clear plan for the training of dual-qualified teachers. Firstly, by establishing cooperative relations with enterprises, encouraging teachers to participate in actual projects of enterprises to accumulate experience through engineering practice; secondly, regularly organizing teachers to participate in industry training and technical discussions to update their knowledge structure and grasp the latest industry trends; thirdly, implementing a teacher enterprise post-plan, allowing teachers to hold technical or management positions in enterprises, directly participating in the enterprise's technology research and development and project management; in addition, universities can hire senior engineers or experts from enterprises as part-time teachers to co-teach with in-school teachers, achieving a complementarity of knowledge and experience; finally, establishing a teacher development platform to provide teachers with opportunities for academic exchange and teaching discussion, promoting the professional growth of teachers. Through these approaches, the teachers currently engaged in the teaching of the Water Pollution Control Engineering course at Chengdu Technological University have all grown into dual-qualified teachers who are proficient in both teaching and professional skills, making the teaching of this course more in line with industry demands, improving students' practical and innovative abilities, and providing strong support for the comprehensive and career development of students.

4.7. Joint Scientific Research Projects between Schools and Enterprises

By jointly undertaking scientific research projects with enterprises, students can participate in research under the guidance of teachers and corporate engineers. This not only enhances students' research capabilities but also promotes innovation and renewal of teaching content.

Firstly, universities and enterprises jointly determine the direction and objectives of scientific research projects to ensure that the projects align with course teaching and enterprise needs. Secondly, establish joint laboratories or research centers between schools and enterprises to provide teachers and students with experimental equipment and research platforms. Thirdly, encourage corporate technical personnel to co-mentor students in research projects with university teachers, achieving resource sharing and complementary advantages. Additionally, drive teaching through projects, allowing students to participate in the entire process—from project planning, experimental design, to data analysis and report writing—under the guidance of teachers

and corporate experts. Lastly, regularly organize academic exchanges and result showcases, giving students opportunities to present their research findings, receive peer reviews, and thereby improve their research and academic communication skills.

Table 3 lists some of the enterprise scientific research projects related to the Water Pollution Control Engineering course that teachers and students from the Environmental Science and Engineering major at Chengdu Technological University have participated in over recent years. Through joint scientific research projects between schools and enterprises, not only can teaching content be enriched and teaching quality improved, but students' innovative awareness and practical abilities can also be enhanced, laying a solid foundation for their comprehensive development and career advancement. At the same time, this cooperation also helps university teachers conduct applied research and promotes corporate technological innovation, achieving a win-win situation for both schools and enterprises.

Table 3. School-enterprise collaborative research projects case studies

| Number | Project Name | Collaborating Enterprise |
|--------|---|--|
| 1 | Low-Consumption Sewage Treatment Technology with Artificial Rapid Infiltration | Chengdu Green Vision Co., Ltd. |
| 2 | Salt-Containing Wastewater Concentration Process for Catalyst Production | Southwest Chemical Research and Design Institute Co., Ltd. |
| 3 | Nitrogen Removal from Rural Domestic Sewage by Biochar-Based Filter | Sichuan Haitian Eco-Environmental Technology Co., Ltd. |
| 4 | Key Technology of Nitrogen and Phosphorus Removal from Rural Domestic Sewage | Chengdu Keya Wastewater Treatment Co., Ltd. |
| 5 | Carbon Black Catalytic Ozone Oxidation for the Degradation of Refractory Organic Matter | Chengdu Green Vision Co., Ltd. |
| 6 | Degradation of Dyeing and Printing Wastewater by Rabbit Manure Biochar/PMS | Sichuan Development EST Research Institute Co., Ltd. |

4.8. Establishing a Course Evaluation Mechanism

Establishing a scientific and rational course evaluation mechanism to regularly assess the teaching effectiveness of the course ensures that the course content and teaching methods can be continuously optimized to meet educational goals and industry needs.

In the school-enterprise joint Water Pollution Control Engineering course at Chengdu Technological University, a diversified evaluation system has been established, covering multiple dimensions such as students' knowledge mastery, skill application, innovative thinking, and professional literacy. Industry experts are invited to participate in the formulation of course evaluation standards to ensure that the

standards meet industry standards and enterprise needs. A combination of formative and summative evaluations is adopted, collecting evaluation information through various channels such as classroom performance, laboratory reports, project outcomes, and internship feedback. In addition, regular teaching feedback meetings are organized with students, teachers, and enterprise representatives to listen to opinions and suggestions from all parties and adjust teaching strategies in a timely manner. Information technology means, such as online teaching platforms, are used to collect and analyze teaching data to provide quantitative basis for teaching evaluation. A teaching effect tracking mechanism is established to follow up on the career development of students after graduation to evaluate the long-term effects of course teaching. Through these approaches, the school-enterprise joint course evaluation mechanism can comprehensively and objectively reflect the teaching effects, providing a basis for the continuous improvement of the course, and ensuring that teaching activities always revolve around the core goal of cultivating high-quality talents who meet the needs of the industry.

5. Conclusion

Looking ahead, the continuous deepening of curriculum reform, optimization of the teaching system, enrichment of teaching resources, and improvement of teaching quality are the inevitable trends in the development of education. The practice of school-enterprise joint teaching reform in the Water Pollution Control Engineering course has shown that this model has played a significant role in enhancing the practicality of the course and strengthening students' practical abilities. Through close cooperation with enterprises, the course content is kept up-to-date, reflecting the latest industry needs and technological advancements. Teaching methods have also become more diverse and interactive due to the integration of practice, effectively enhancing students' practical skills and innovative thinking. The exploration of the school-enterprise joint teaching reform in the Water Pollution Control Engineering course provides an innovative

teaching model, offering valuable experience and insights for the field of environmental science and engineering education. In the future, further deepening of school-enterprise cooperation should be pursued, continuously optimizing course content and teaching methods, to cultivate more engineering and technical talents who meet the needs of social development.

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