Occupation and Professional Education Vol. 1 No. 12, 2024

Academic Education Publishing House

Educational Reform of Environmental Science and Engineering Programs in the Context of New Quality Productivity

Lin Wang[1,*], Jintao Yan[1], Hao Luo[2], Xiaogang Luo[3], Jing Sun[1], Juzhen Wu[1]

[1] School of Materials and Environmental Engineering, Chengdu Technological University, Chengdu, China

[2] Kimou (Southwest China Qingshen) Surface Treatment Recycling Eco-industrial Park, Meishan, China

[3] Qingshen County Machinery Industry Research and Service Center, Meishan, China

**Corresponding Author.*

Abstract: Under the emerging paradigm of new quality productivity, environmental science and engineering education is confronted with significant reform opportunities. The disciplinary restructuring should systematically align with industrial advancement and technological progress through multifaceted approaches: Optimizing curricular architecture by restructuring fundamental courses and enhancing comprehensive experimental modules alongside engineering practice components; Innovating pedagogical methodologies through case-based instruction and project-oriented learning to cultivate holistic competencies; Strengthening faculty development via professional capacity building and interdisciplinary integration, while establishing university-enterprise collaborative platforms; Enhancing practical pedagogy through tripartite university-government-industry cooperation models, implemented through three strategic dimensions - laboratory project-driven learning, jointly constructed practice platforms, and deepened industry-academia-research-application integration through regional collaborations. These initiatives aim to achieve interdisciplinary knowledge integration and foster industry-aligned professionals with innovative capabilities and practical expertise, thereby addressing the talent demands of new productive forces development, promoting environmental industry innovation, and providing intellectual support for achieving carbon peak and neutrality targets.

Keywords: Environmental Science and Engineering; Education Reform, New Quality Productivity; University-Government-Industry Collaboration; Innovative Practices

1. Introduction

The series of seminal discourses on New Quality Productivity provide theoretical frameworks and developmental trajectories for environment-related industries. The advancement of New Quality Productivity prioritizes innovation-driven growth anchored in strategic emerging industries, aiming to achieve dynamic equilibrium at an elevated level between novel supply-demand dynamics and to cultivate productive forces characterized by high technology, efficiency, and quality [1]. Within this context, China's environmental protection sector is actively exploring pathways to transition from high-energy-consumption, high-emission models toward green and low-carbon paradigms. Initiatives such as establishing eco-friendly industrial chains and developing green, low-carbon circular economy systems not only significantly advance carbon peak and neutrality targets but also enhance the holistic efficacy of New Quality Productivity. This is achieved by optimizing supply-demand synergies, strengthening interactions among ecosystem components, and stimulating market vitality [2, 3]. Consequently, under the New Quality Productivity paradigm, environmental professionals demonstrating high standards, practice-oriented competencies, and innovation-driven capabilities will become increasingly indispensable to enterprises. However, despite universities serving as primary incubators for talent development and supply, there remains a notable disconnect between academic outputs and the employment market's tepid responsiveness to such specialized human capital.

However, under the New Quality Productivity paradigm, existing environmental technology professionals struggle to meet the demands of economic development and employer expectations. This discrepancy stems from three systemic challenges: 1) Curriculum-Tech Mismatch in Rapidly Evolving Fields. The swift pace of environmental technology innovation necessitates dual updates to curricula and talent development objectives to align with shifting labor market requirements [4]. For instance, within the green transition framework, emerging sectors like green hydrogen production—encompassing hydrogen generation, storage technologies, and associated novel materials, processes, and equipment—have surged in national strategic importance. However, current educational resources predominantly rely on textbooks developed during the 12th and 13th Five-Year Plan periods. While these materials cover foundational principles, they fail to integrate recent technological advancements and application breakthroughs. Consequently, environmental professionals risk operating with outdated knowledge structures, lagging behind industry innovation trajectories [5]. 2) Overreliance on Theoretical Pedagogy. Academic training remains heavily skewed toward theoretical knowledge dissemination, predominantly delivered through instructor-led lectures complemented by class assignments and summative examinations. Although such approaches effectively scaffold students' disciplinary knowledge systems, they inadequately address practical skill cultivation and innovative thinking development. This pedagogical gap creates a disconnect between graduate competencies and employer needs, particularly in contexts demanding hands-on problem-solving and adaptive innovation [5]. 3) Interdisciplinary Competency Deficits. Environmental challenges inherently require interdisciplinary integration of knowledge from materials science, information technology, biology, and related domains, necessitating an "Environment + N" interdisciplinary framework. However, current professionals exhibit limitations in both domain-specific expertise and interdisciplinary adaptability. Persistent shortcomings in lifelong learning capacities, cross-disciplinary collaboration skills, and intellectual agility further constrain their ability to navigate complex, technology-driven environmental solutions [6].

Therefore, confronting the developmental imperatives of New Quality Productivity and the talent demands of the environmental protection industry, educational restructuring in Environmental Science and Engineering has become critically imperative. Such reforms must be synchronized with the advancement of New Quality Productivity, requiring comprehensive reforms encompassing curriculum modernization, pedagogical innovation, faculty capacity building, and the establishment of tripartite university-government-industry collaborative platforms and operational frameworks. These coordinated efforts aim to cultivate professionals equipped with innovative acumen and practical competencies in Environmental Science and Engineering, thereby aligning human capital outputs with the evolving needs of sustainable industrial transformation.

2. Educational Reform Strategies for Environmental Science and Engineering Program Development

2.1 Curriculum System Optimization

The curriculum system constitutes the cornerstone of disciplinary education. At Chengdu Technological University, the Environmental Science and Engineering curriculum is structured around four pillars: general education, disciplinary foundations, professional education, and practical training. During the first two years, disciplinary foundations predominantly focus on chemistry and biology, emphasizing fundamental concepts, principles, and core techniques. However, despite allocating substantial contact hours to these disciplines—with theoretical and experimental modules covering four major branches of chemistry and diverse microbiology courses—the pedagogical outcomes remain suboptimal compared to peer institutions [7]. Critical deficiencies manifest in two dimensions: 1) Fragmented Knowledge Integration: Insufficient interdisciplinary articulation between courses impedes students' ability to synthesize cross-disciplinary knowledge into a coherent framework. This undermines the cultivation of competencies in applying chemical and biological principles to address complex environmental engineering challenges. 2) Limited Experimental Innovation: Laboratory courses predominantly employ verification-oriented experiments designed around isolated disciplinary concepts. Such a structure fails to equip students with the practical agility required in professional settings, particularly in experimental design, data analytics, and problem-solving tailored to real-world environmental scenarios. Consequently, systemic optimization of the curriculum architecture is urgently required to bridge these pedagogical gaps.

Following multi-year exploratory research, iterative pilot testing, and localized adaptation, our institution has developed a curriculum architecture and instructional methodology aligned with its strategic positioning as an "application-oriented engineering university." Key reforms include: 1) Disciplinary Streamlining: Curtailing credit hours allocated to chemistry and biology disciplines while retaining core theories with practical relevance. This restructuring strengthens interdisciplinary linkages with foundational professional courses. 2) Experiential Learning Enhancement: Introducing comprehensive laboratory modules and engineering practicum components.

Figure 1 delineates the restructured curriculum framework, which can be divided into 4 parts. 1) General Education: Cultivates ethical and professional values alongside scientific and humanistic literacy, establishing intellectual and ideological foundations. 2) Disciplinary Foundations: Simplified chemistry curricula (e.g., University Chemistry I/II) and environmental microbiology courses replace traditional fragmented chemical subdisciplines. Experimental training is consolidated into dedicated experimental weeks, employing group-based pedagogical cycles encompassing literature review, experimental design, technical presentations, peer discussions, implementation, and iterative feedback. This approach holistically assesses students' knowledge integration and applied problem-solving capabilities. 3) Interdisciplinary Expansion: Recalibrated credit hours enable integration of emerging domains such as intelligent environmental monitoring systems and functional environmental materials, fostering interdisciplinary competence while maintaining core water-air-solid waste engineering curricula. 4) Practice-Oriented Capstone: An experiential learning continuum - spanning industrial internships, engineering project simulations, and technological innovation practicums—bridges theoretical knowledge with professional demands. This progression from conceptual awareness to applied execution systematically develops innovative thinking and comprehensive professional competencies.

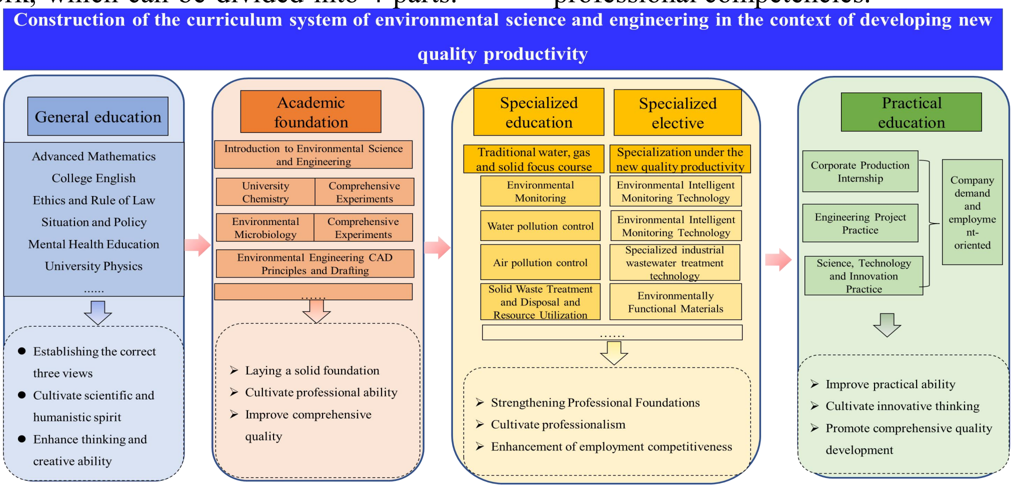

Figure 1. Construction of the Curriculum System of Environmental Science and Engineering in the Context of Developing New Quality Productivity

2.2 Innovative Pedagogical Approaches

Pedagogical innovation is pivotal to enhancing teaching efficacy. New Quality Productivity underscores the integration of knowledge, technology, and innovation, prioritizing the cultivation of creative competencies and practical skills. For Environmental Science and Engineering—a discipline characterized by broad knowledge domains, rapid technological evolution, and close ties to real-world applications—traditional teacher-centric lecturing methods prove inadequate. These approaches predominantly expose students to textbook-based case studies and theoretical content, failing to provide authentic contexts for applied knowledge transfer. Passive learning modes further inhibit peer-to-peer and instructor-student interactions, stifling collaborative problem-solving and innovative thinking. Additionally, a significant proportion of environmental science students at our institution are transferred from other disciplines, exhibiting heterogeneous interests, academic foundations, and learning capabilities. Conventional pedagogy struggles to accommodate such individualized and differentiated learning needs, necessitating methodological innovation to boost engagement and interactive dynamics.

To address these challenges, faculty in our Environmental Science program have adopted a hybridized pedagogical framework integrating case-based instruction, project-based learning (PBL), flipped classroom models, and technology-enhanced teaching strategies (Figure 2). This multifaceted approach aims to holistically develop students' analytical, technical, and innovative capacities.

Case-Based Instruction in Practice: In Water Pollution Control Engineering, instructors exemplify pedagogical innovation through industry-aligned case studies. For instance, when teaching refractory industrial wastewater treatment, faculty integrate firsthand engineering experiences from electroplating enterprises. Detailed discussions cover physicochemical processes (e.g., heavy metal removal), advanced biological nitrogen/carbon removal, tertiary treatments (e.g., membrane filtration for fluoride elimination), and integrated water-solid-gas pollution control systems. Instructors further contextualize theoretical principles by demonstrating how experimental optimization techniques—such as orthogonal design and response surface methodology—reduced operational costs in real-world scenarios. These authentic cases stimulate student engagement and independent critical thinking.

Project-Based Learning (PBL) Implementation: In Environmental Ecology, faculty have developed over 15 PBL modules, including the Panzhihua Dry-Hot Valley Ecosystem Restoration Project. Students collaboratively execute projects through iterative phases: literature review, proposal development, implementation, and outcome evaluation. To deepen knowledge application, the Zhihuishu (Smart Tree) intelligent platform is leveraged to pre-release categorized learning tasks addressing project-specific challenges. For example, in the biodiversity module, pre-class tasks include: "Define biodiversity. Identify factors influencing biodiversity in the Panzhihua Dry-Hot Valley project." This preparatory focus primes students for project-centric inquiry. During classes, multimedia presentations of interim findings are required, with instructors guiding discussions to distill key biodiversity determinants and conservation strategies. Post-class assignments on Zhihuishu reinforce knowledge retention and conceptual expansion.

Technology-Enhanced Learning Synergies: The flipped classroom model is operationalized through curated digital resources (e.g., pre-recorded lectures, simulation software) uploaded to Zhihuishu. Class time is reallocated to collaborative problem-solving workshops and real-time data analysis exercises, maximizing interactive learning.

Collectively, these pedagogical strategies facilitate knowledge internalization, skill advancement, and innovation cultivation, aligning graduate competencies with the interdisciplinary demands of New Quality Productivity.

2.3 Strengthening Faculty Capacity

An excellent faculty is the key to improving the quality of education. The construction of the faculty can be strengthened in the following aspects. A high-caliber faculty cohort is pivotal to advancing educational quality. Our institution has strengthened faculty capacity through three strategic initiatives.

1) Enhancing Professional Competencies. The first one is structured Professional Development. Discipline-specific workshops are regularly organized at the teaching and research section (TRS) and college levels, utilizing roundtable discussions to strategize disciplinary development prospects, trajectories, and implementation measures. Outcomes are codified into actionable

guidelines. The second one is Performance-Driven incentivization. A merit-based incentive system encourages faculty participation in high-impact domestic and international academic conferences, particularly flagship events within their disciplines. Colleges are further supported to host such conferences, amplifying institutional and faculty visibility. The third one is pedagogical capacity building. Faculty training programs prioritize mastery of diversified teaching methodologies, supported by self-assessment and peer-review mechanisms to ensure alignment with cutting-edge knowledge and technological advancements. These efforts broaden professional horizons and elevate instructional efficacy [8]. The forth one is targeted skill enhancement. Early-career faculty are actively engaged in pedagogical innovation competitions and teaching skill contests. Through multi-tiered refinement processes (TRS → college → university) and personalized mentorship from external experts, teaching competencies are systematically upgraded.

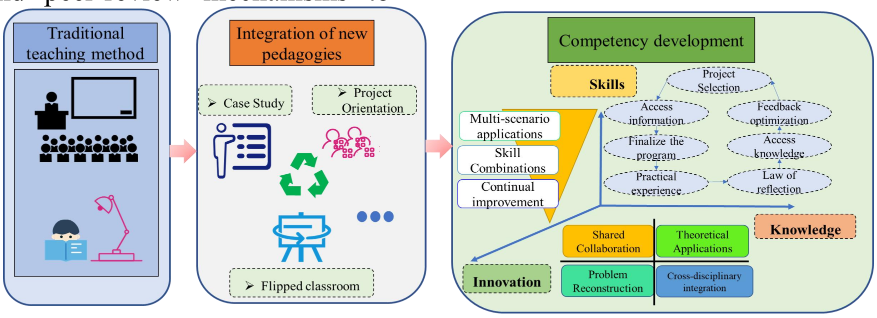

Figure 2. Improvement and Effectiveness of Teaching Methods in the Context of Developing New Quality Productivity

2) Fostering Interdisciplinary Integration

The first one is cross-disciplinary curriculum development. Collaborative initiatives between Environmental Science and Engineering faculty and peers in Artificial Intelligence, Materials Science, and related disciplines have yielded interdisciplinary courses (e.g., Intelligent Environmental Monitoring, Environmental Materials Science), synthesizing multidisciplinary knowledge. The second one is convergent research collaboration. Faculty across disciplines and sub-specializations are incentivized to co-develop cross-disciplinary research proposals, breaking academic silos through synergistic partnerships.

3) Building University-Enterprise Collaborative Platforms

The first one is industry-aligned Curriculum Co-Design: Core courses (e.g., Water Pollution Control Engineering, Air Pollution Control Engineering) are jointly developed with high-tech enterprises, integrating practitioner insights on real-world engineering challenges to ensure curriculum-industry alignment. The second one is faculty immersion in industry practice: Structured industry placements enable faculty to refine course content through experiential learning (“learning by doing”), transforming theoretical abstraction into applied, problem-focused pedagogy. The third one is regional industry-academia hubs. Established in Meishan, Luzhou, and other regions of Sichuan Province, these hubs strengthen faculty capacity through on-site engagement in enterprise operational diagnostics, collaborative R&D projects, and technology transfer, simultaneously boosting corporate competitiveness. The fourth one is motivational frameworks. Performance-linked rewards (e.g., teaching excellence awards) and accelerated promotion pathways incentivize sustained pedagogical innovation [9].

These initiatives have yielded demonstrable outcomes: elevated faculty expertise, deepened interdisciplinary synergies, and robust university-industry linkages. This revitalized faculty ecosystem provides a sustainable foundation for advancing educational quality, fostering a dynamic and competitive academic workforce capable of cultivating future-ready professionals. These advancements propel institutional educational capabilities to new heights, ensuring alignment with the evolving demands of New Quality Productivity.

2.4 Enhancing Practical Pedagogy through University-Government-Industry Tripartite Collaboration

Practical pedagogy constitutes an integral component of Environmental Science and Engineering education. To cultivate interdisciplinary talents equipped with integrated knowledge, technical proficiency, and innovative capabilities, a tripartite university-government-industry collaborative model has been institutionalized, operationalized through three strategic dimensions (Figure 3).

1) Laboratory-Driven Skill Development

The university leverages existing laboratory resources through institutionalized initiatives such as Laboratory Open Access Funds, Undergraduate Innovation and Entrepreneurship Training Programs, and the Seedling Talent Development Scheme. Regularly reservable laboratory facilities are strategically deployed to enhance students' practical competencies. A mentorship accountability system has been institutionalized, assigning dedicated advisors to guide undergraduates academically and professionally throughout their four-year trajectory. Under this framework, students actively engage in national competitions including the National Energy Conservation and Emission Reduction Competition for College Students, China "Internet+" Innovation and Entrepreneurship Competition, and "Challenge Cup" National Academic Science and Technology Works Competition, achieving notable accolades. This model fosters a self-reinforcing cycle of motivation, increasingly attracting student participation in project-based learning. 2) University-Enterprise Collaborative Innovation. Industry partnerships are anchored in joint R&D centers and practice-oriented training bases. Through strategic alliances with enterprises across multiple provinces, the university addresses corporate challenges via industry-sponsored projects, co-producing peer-reviewed publications, patents, and co-applying for government-funded research initiatives and scientific and technological advancement awards. This symbiosis simultaneously resolves industrial bottlenecks and amplifies faculty research outputs. Furthermore, tripartite talent development mechanisms—faculty industry secondments, student internships, and enterprise co-training programs—enable hands-on exposure to advanced technologies under expert mentorship. Students cultivate industry networks while enterprises identify and nurture prospective talent. 3) University-Government-Industry Synergistic Platforms. Government partnerships facilitate the establishment of regional R&D hubs and policy-informed information platforms. Capitalizing on governmental policy frameworks, regulatory guidance, and financial subsidies, students participate in applied engineering projects while the university advances local talent development and corporate modernization. This tripartite collaboration deepens industry-academia-research-application integration, achieving mutually reinforcing benefits for sustained pedagogical advancement [9, 10].

The tripartite university-government-enterprise collaboration model synergistically enhances the practical skills and innovative capacities of Environmental Science and Engineering students through three strategic pillars: laboratory project-driven initiatives, university-enterprise co-constructed practice platforms, and university-region partnerships deepening industry-academia-research-application integration. This framework holistically integrates cross-sectoral resources, fosters mutually reinforcing interactions, and provides robust support for cultivating interdisciplinary talents proficient in knowledge integration, technical mastery, and innovative problem-solving. By leveraging collaborative governance, it drives sustained optimization of practical pedagogy, ensuring alignment with the evolving demands of New Quality Productivity and advancing the professional education ecosystem toward excellence.

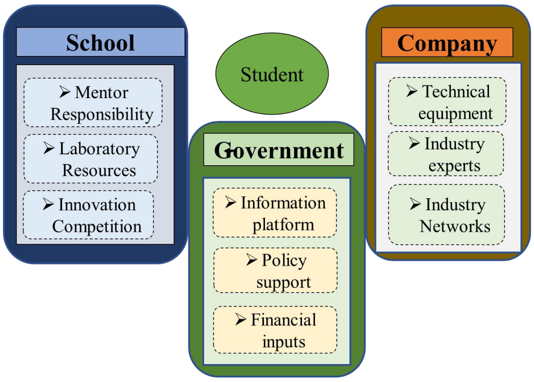

Figure 3. Enhancing Student Practical Competencies through University-Government-Industry Tripartite Collaboration under the New Quality Productivity Development Paradigm

3. Conclusion

In response to the developmental imperatives of New Quality Productivity, educational reforms in Environmental Science and Engineering emerge as pivotal drivers for advancing innovation within the environmental protection industry. By modernizing curricula to integrate interdisciplinary teaching and practice-oriented projects, academic institutions cultivate professionals equipped to address complex environmental challenges. Concurrently, active engagement from enterprises and governments fosters a collaborative educational ecosystem that incentivizes innovation and practical application. This tripartite synergy facilitates the deep integration of knowledge, technology, and creativity, delivering robust human capital and intellectual infrastructure to accelerate the realization of New Quality Productivity objectives.

Acknowledgments

This work was supported by the Talent Research Program of Chengdu Technological University, reduction mechanisms of antibiotic resistance gene under co-exposure to antibiotics and heavy metals in shortcut nitrification and denitrification (2024RC042), and the Research Project of the Center for Reform and Development of Emerging Universities, reform and practice of demand-driven training models for environmental protection professionals in poverty-alleviation counties of Sichuan Province (XJYX2020B18).

References

[1] Yu H, Zhang L. Research On The Cultivation Of Top Innovative Talents In Universities Under The Conditions Of New Quality Productivity. Educational Theory And Practice, 2024, 27(3):3-8.
[2] Lang H. On The Macro-Ecological Perspective Of New Quality Productivity. Journal Of China University Of Geosciences (Social Sciences Edition), 2024, (1):1-10.
[3] Zhao L, Shao X. Green Technology Empowering New Quality Productivity: Logic, Pathways, And Safeguard Measures. Journal Of Chongqing University Of Technology (Social Science), 2024, (1):1-27.
[4] Xu Y, Zhou P, Wu Y, et al. Exploration On The Training Model Of Vocational Environmental Protection Talents Under The Background Of Carbon Peak And Carbon Neutrality. Environmental Education, 2024, 12(31):31-35.
[5] Wang P, Xu Z, Pan S, et al. Practical Teaching Reform Measures For Environmental Engineering Under The Background Of Emerging Engineering Education. Western Quality Education, 2022, 8(10):142-144.
[6] Liu J, Li Y, Chen W, et al. Environmental Talent Cultivation From The Perspective Of Ecological Civilization: Needs, Challenges, And Strategies. Journal Of Higher Education, 2024, 10(35):171-174.
[7] Yue J, Bi C. Reform Of Undergraduate Environmental Program Training Schemes In Local Universities: A Case Study Of The 2019 Curriculum At Tianjin University Of Technology. Education Modernization, 2021, 4(27):69-72.
[8] Li M. The Internal Logic And Integration Path Of "Dual-Qualification" Faculty Development In Vocational Education Under New Quality Productivity. Education Horizon, 2024, 16(60):60-64.
[9] Chen L, Zhang T, Yin Z, et al. Reform And Practice Of Practical Teaching Systems For Environmental Engineering. China Metallurgical Education, 2018, 6(74):74-76.
[10] Cui F. Functional Positioning Of Industry-Education Integration Communities Under The Background Of New Quality Productivity. Hunan Education (Version C), 2024, 6(35):35-37.