

## Article

# "Green + Intelligent" Dual-Core Drive: Restructuring and Practice of the Training Model for Outstanding Engineers in the Field of Textile Chemistry and Dyeing and Finishing Engineering

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**Abstract:** Facing profound global industrial adjustments and urgent national strategic demands, China's textile printing and dyeing industry increasingly requires high-level, specialized engineering talents to effectively support its comprehensive green and intelligent transformation. By critically analyzing the existing constraints and bottlenecks prevalent in professional postgraduate education—such as the persistent disconnection between theoretical instruction and practical application, as well as the often superficial nature of industry-academia collaboration—this study proposes an innovative "Green + Intelligent" dual-core training model. This comprehensive framework systematically restructures the traditional curriculum to seamlessly integrate cutting-edge interdisciplinary knowledge, thereby ensuring that students are equipped with the latest technological advancements. Furthermore, the model significantly deepens industry collaboration through the implementation of a substantive dual-supervisor system, bridging the gap between academic research and industrial practice. It actively enhances students' engineering innovation capacity through immersive participation in specialized workshops, high-level academic competitions, and integrated industry platforms. Concurrently, pedagogical teaching methods and academic evaluation systems are fundamentally reformed to strongly emphasize project-based learning, critical thinking, and tangible practical value. Extensive practical application demonstrates that this optimized dual-core model substantially improves postgraduates' complex problem-solving skills, technological innovation ability, and overall professional competence. Ultimately, this approach supplies vital, high-quality talent essential for the sustainable upgrading of the textile industry, while simultaneously offering valuable theoretical insights and practical paradigms for the broader reform of modern engineering education.

**Keywords:** green manufacturing; intelligent manufacturing; engineering education; textile chemistry; innovation capacity

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## 1. Introduction

The textile industry has long been a cornerstone of human civilization, serving as a reflection of a nation's industrial progress and capacity for innovation. In the modern era, characterized by a global emphasis on climate action and rapid technological advancements, China's textile dyeing and finishing sector is undergoing a significant transformation. This shift marks a departure from traditional scale-based expansion toward a model driven by quality enhancement and innovation. National strategies such as "Made in China 2025" emphasize the importance of green and intelligent manufacturing, setting a clear trajectory for sustainable and high-end industrial growth. These strategies prioritize breakthroughs in critical technologies and the development of

competitive industrial clusters. However, the realization of these ambitious goals is fundamentally dependent on the availability of skilled talent, particularly engineers who possess expertise in advanced technologies and the ability to address complex industrial challenges effectively [1].

The field of Textile Chemistry and Dyeing and Finishing Engineering plays a pivotal role in enhancing the aesthetic, functional, and economic value of textiles. It is also at the forefront of efforts to achieve green and intelligent transformation within the industry. Despite its importance, the current postgraduate education system in this field faces significant challenges in meeting the evolving demands of the industry. Existing training frameworks are outdated and fail to align with practical industry requirements. Academic courses often lack relevance to real-world applications, and collaborations between academia and industry remain superficial and underdeveloped. Furthermore, the implementation of the "Dual-Supervisor System," which is intended to bridge academic and industrial expertise, is frequently nominal and ineffective. Additionally, there is a notable deficiency in fostering systemic thinking and innovation among students. This disconnect between the supply of skilled professionals and the industry's growing demand for advanced expertise poses a significant obstacle to China's aspirations of transitioning from being a major textile producer to a global leader in the textile sector.

In response to these challenges, this project is designed to align with national strategies and address the specific needs of the textile industry. It focuses on the professional development of postgraduate students specializing in this field, proposing a novel training model centered on the dual principles of green and intelligent development. By implementing comprehensive reforms, the project aims to revamp the existing training system to cultivate well-rounded professionals [2, 3]. These individuals will be equipped with advanced technical knowledge, a strong foundation in ecological ethics, and proficiency in intelligent systems. The ultimate objective is to support the high-quality development of the textile industry and contribute to the broader goal of establishing China as a global leader in the textile sector. Through this initiative, the project seeks to bridge the gap between academic training and industry requirements, ensuring that future engineers are capable of driving innovation and sustainability in this critical field.

## **2. Reform Objectives and Core Concepts**

The primary aim of this teaching reform is to address the significant gap between the current educational training model and the evolving demands of industrial transformation and technological advancement. By focusing on the cultivation of exceptional engineers, the initiative seeks to prepare professionals who are not only capable of adapting to the dynamic requirements of the "Green + Intelligent" era but also equipped to lead its progression [4]. The reform is built upon three foundational concepts: "Dual-Core Drive," which emphasizes the integration of theoretical knowledge with practical application; "Three-Dimensional Restructuring," which involves a comprehensive overhaul of curriculum design, teaching methodologies, and evaluation systems; and "Whole-Process Empowerment," which ensures continuous support and development for students throughout their academic journey. These principles collectively aim to foster innovation, enhance interdisciplinary collaboration, and promote sustainable development within the engineering field, ultimately aligning educational outcomes with the broader goals of industrial modernization and ecological responsibility [5].

### *2.1. Dual-Core Drive: Defining the Strategic Orientation of Talent Cultivation*

"Green" and "Intelligent" represent two transformative paradigms that are reshaping the future trajectory of the textile printing and dyeing industry. The Green paradigm emphasizes sustainability as the cornerstone of industrial progress, necessitating that future engineers acquire expertise in areas such as green chemical molecular design, bio-based material applications, water-saving and waterless dyeing techniques, clean production methodologies, and waste recycling systems. Beyond technical proficiency, it

is essential for these engineers to develop a deep understanding of engineering ethics and social responsibilities, particularly in relation to energy conservation, emission reduction, and environmental stewardship [6]. These principles are integral to fostering a culture of sustainable innovation within the industry. On the other hand, the Intelligent paradigm focuses on revolutionizing the industry's operational quality and efficiency. This requires engineers to adeptly utilize advanced technologies, including big data analytics, artificial intelligence, and the Internet of Things, to enable intelligent monitoring, optimization, and control of processes. For instance, technologies such as intelligent color matching and digital printing are pivotal in enhancing production flexibility, precision, and overall efficiency. By embedding these paradigms into the talent cultivation framework, the reform ensures that students are equipped not only with technical knowledge but also with the ability to adapt to evolving industry demands [7, 8]. This holistic approach shapes their knowledge base, skill sets, and ethical values, preparing them to lead the industry toward a future defined by sustainability and technological advancement. The integration of Green and Intelligent principles into education serves as a strategic foundation for nurturing professionals capable of driving innovation and addressing global challenges in textile manufacturing.

### *2.2. Three-Dimensional Restructuring: Systematically Optimizing the Structure of the Talent Cultivation System*

To achieve the outlined objectives, this project is dedicated to a comprehensive restructuring of the existing training system across three critical dimensions. The first dimension involves restructuring the knowledge system. This approach aims to address the fragmented nature of traditional curricula, which often segregate chemistry, process, and engineering management into isolated components. By integrating these disciplines into interdisciplinary, modular, and cutting-edge course clusters, the initiative ensures that students acquire a cohesive and advanced knowledge framework that aligns with contemporary academic and industrial demands. The second dimension focuses on restructuring the training process. This entails moving away from the conventional linear model of "theory first, practice later" and adopting a dynamic, spiral approach. This new model integrates theoretical instruction, engineering practice, and innovative research into a continuous and iterative learning process. By immersing students in authentic engineering environments, they are encouraged to apply theoretical knowledge to solve real-world problems, fostering both practical skills and innovative thinking. The third dimension emphasizes restructuring the evaluation mechanism. Traditional evaluation methods often prioritize academic publications over practical achievements. This project seeks to shift the focus towards a multi-dimensional, process-oriented evaluation framework. This new system incorporates input from multiple stakeholders and evaluates students based on their contributions to engineering applications, technological innovations, and overall skill development. By aligning evaluation criteria with practical and innovative outcomes, the initiative aims to cultivate well-rounded professionals equipped to address complex challenges in their fields [4, 9].

### *2.3. Whole-Process Empowerment: Focusing on the Core Competencies of Outstanding Engineers*

The ultimate goal of the reform is to empower students by equipping them with the essential core competencies required to excel as outstanding engineers. These competencies encompass several critical areas. Firstly, students must develop the ability to address complex engineering problems. This involves leveraging multidisciplinary knowledge to systematically analyze and resolve practical challenges, such as optimizing processes, designing innovative products, and implementing environmentally sustainable technical transformations. Secondly, fostering engineering technological innovation capability is vital. Students should cultivate the ability to explore cutting-edge advancements, engage in exploratory research, and execute process scale-up and engineering verification tasks effectively. Thirdly, engineering systems thinking and design ability are indispensable. This requires students to evaluate the economic,

environmental, and societal impacts of products and processes from a comprehensive life-cycle perspective, ensuring sustainable and efficient outcomes. Lastly, professional and teamwork abilities are crucial for success in modern engineering contexts. These include strong communication skills, effective management practices, adherence to ethical standards, and the capacity to collaborate across cultures and disciplines. By emphasizing these competencies, the reform aims to produce engineers who are not only technically proficient but also capable of addressing global challenges and contributing to the advancement of society through innovative and responsible engineering practices.

### **3. Main Reform Measures and Practical Pathways**

#### *3.1. Restructuring an Interdisciplinary Curriculum System Oriented towards Achieving Outstanding Engineer Competencies*

Course teaching serves as the primary avenue for imparting essential knowledge and skills. This initiative has undertaken a comprehensive restructuring of the curriculum to prioritize a "solid foundation, strong interdisciplinary focus, and emphasis on frontiers." The engineering rigor of core courses, such as "Modern Dyeing and Finishing Process Engineering," has been significantly enhanced through the integration of project-based learning modules. For example, students engage in practical, real-world projects like "Process Optimization for Energy Saving in Low-Temperature Dyeing," where they collaborate in teams to diagnose problems, design solutions, and present their findings. This approach not only strengthens their technical expertise but also fosters teamwork and problem-solving abilities. Additionally, the curriculum introduces modular elective course groups in four key areas: "Green Chemical Technology," "Intelligent Dyeing and Finishing," "Functional Textiles," and "Sustainability Engineering." These elective modules allow students to tailor their learning paths according to their interests and career aspirations. To ensure the courses remain aligned with industrial advancements, at least 30% of the lectures in all classes are dedicated to seminars led by industry experts or discussions of real engineering cases. This integration of industry perspectives ensures that students are exposed to cutting-edge developments and practical applications in their field. By combining foundational knowledge with interdisciplinary and industry-focused learning, the restructured curriculum aims to cultivate engineers who are not only technically proficient but also adaptable to the evolving demands of modern engineering challenges.

#### *3.2. Deepening Industry-Education Integration, Building a New Synergistic Education Mechanism Based on a "Community of Interests"*

Industry-education integration plays a pivotal role in the cultivation of exceptional engineering talent. This initiative seeks to transition from traditional, loosely structured school-enterprise collaborations to a more cohesive and mutually beneficial framework, described as a "community of interests." To achieve this, high-standard training bases are established by partnering with leading enterprises specializing in green technology or intelligent manufacturing. These partnerships are formalized through binding agreements that clearly delineate responsibilities, including the management of intellectual property rights, ensuring transparency and accountability. A key feature of this approach is the implementation of the "Dual-Supervisor System," which mandates that enterprise supervisors possess senior-level expertise with a minimum of ten years of professional experience. This ensures that students receive guidance from highly qualified industry professionals. To further enhance the effectiveness of this system, enterprise supervisors are provided with competitive remuneration packages and opportunities to earn academic titles, creating strong incentives for their active participation. Additionally, regular pedagogical training sessions are conducted to equip these supervisors with the necessary skills to set practical learning objectives and accurately assess the engineering competencies of students. This comprehensive strategy not only bridges the gap between academic learning and industry requirements but also fosters a sustainable ecosystem for

producing highly skilled engineers who are well-prepared to meet the demands of modern industries.

### *3.3. Strengthening the Cultivation of Engineering Innovation Capability, Building a "Three-Level Ascension" Platform*

This initiative fosters innovation through a structured progression of three interconnected platforms, each designed to enhance engineering capabilities and bridge the gap between theoretical knowledge and practical application. The Basic Experiment Platform serves as a foundational resource, offering students unrestricted access to state-of-the-art equipment and facilities that enable exploratory research and experimentation. This platform encourages creativity and the development of technical skills by providing an environment conducive to hands-on learning and discovery. The Sci-Innovation Competition Platform builds upon this foundation by engaging students in industry-relevant challenges through participation in national-level contests [10, 11]. These competitions not only stimulate critical thinking and problem-solving but also provide opportunities for students to collaborate with peers and industry professionals, thereby fostering a deeper understanding of real-world engineering demands. Finally, the Horizontal Project Platform integrates postgraduate students into enterprise-driven projects as formal team members. This immersive experience exposes them to practical constraints, such as budget limitations, time management, and client requirements, while guiding them through the process of transforming technical concepts into tangible engineering solutions with measurable value. Together, these platforms create a comprehensive ecosystem for cultivating advanced engineering innovation capabilities.

### *3.4. Reforming Teaching and Evaluation Methods, Emphasizing an Engineering Capability Orientation*

Teaching methods are undergoing significant transformation, shifting towards student-centered approaches that prioritize active engagement and practical application. Models such as project-based learning and flipped classrooms are increasingly adopted to foster deeper understanding and critical thinking. These methods encourage students to take ownership of their learning process, promoting collaboration and hands-on problem-solving. The evaluation system has also evolved to incorporate diversified assessment strategies, moving beyond traditional final exams. Students are now assessed through project reports, teamwork contributions, and other practical outputs that reflect their ability to apply theoretical knowledge in real-world scenarios [12, 13]. For dissertation evaluations, committees comprising academic and industrial supervisors focus on the engineering application value of the work. Key evaluation criteria include technical innovation, systematic problem-solving capabilities, and measurable benefits such as energy savings or efficiency improvements. Additionally, emphasis is placed on students' ability to independently demonstrate engineering skills and produce solutions that address complex challenges. This holistic approach ensures that graduates are well-prepared to meet the demands of modern engineering industries.

### *3.5. Strengthening the Construction of a "Dual-Qualified" Faculty Team, Consolidating the Foundation of Education*

This initiative focuses on enhancing faculty development through a dual transformation strategy aimed at bridging theoretical knowledge and practical expertise. Academic staff are encouraged to gain hands-on experience by participating in enterprise placements, which are incentivized to foster their professional growth and practical skill acquisition. Their contributions, such as the development of innovative solutions and tangible achievements like patents, are integrated into performance evaluations to ensure their efforts are recognized and rewarded. On the other hand, enterprise supervisors are systematically trained and evaluated to adopt teaching methodologies, ensuring they can effectively mentor students. A dynamically updated database is utilized to maintain a pool of high-performing mentors, replacing those who do not meet the required standards [14, 15]. This reciprocal approach not only strengthens the collaboration between

academia and industry but also ensures the creation of a stable and high-quality faculty team. By combining theoretical instruction with practical application, this model aims to cultivate a robust educational foundation that supports the development of well-rounded professionals equipped to meet the demands of modern industries.

#### **4. Preliminary Results of the Reform and Reflection**

##### *4.1. Main Outcomes*

The pilot program has led to a significant enhancement in the engineering practice and innovation capabilities of postgraduates. Participants demonstrated a marked improvement in their ability to address practical challenges effectively. The dissertation topics chosen by these students were directly derived from real-world enterprise projects, ensuring that their research outcomes were closely aligned with industry needs. These results were not only theoretical but also practical, as several technical solutions developed during the program were adopted by enterprises, contributing directly to production processes and generating substantial economic benefits. This practical application underscores the program's success in bridging the gap between academic research and industrial application. Furthermore, the initiative has deepened and broadened the scope of collaboration between universities and enterprises. The relationship has evolved from a basic talent supply model to a more integrated strategic partnership. This includes the joint establishment of research and development centers and collaborative applications for major national research initiatives. Enterprises have shown increased initiative and investment in the talent cultivation process, reflecting a shared commitment to innovation and development [16, 17]. Additionally, the program has significantly enhanced the employment competitiveness and social recognition of its graduates. Employers have expressed a strong preference for these graduates due to their robust theoretical knowledge, exceptional practical skills, and innovative mindset. This has translated into higher starting salaries and more promising career trajectories compared to previous cohorts. The success of these graduates has also contributed to a positive branding effect for the program, further solidifying its reputation as a model for effective postgraduate education reform.

##### *4.2. Existing Problems and Reflections*

Challenges in the comprehensive promotion of reform efforts are multifaceted and require significant attention to detail. The deep integration of industry and education imposes substantial demands on the management mechanisms of universities, the dedication and energy of teaching staff, and the active cooperation of enterprises. As the scope of pilot programs expands, ensuring that all cooperative bases and "dual supervisors" consistently meet established standards remains a persistent challenge. This necessitates ongoing efforts to refine and enhance operational frameworks. Furthermore, institutional barriers continue to hinder progress. Current postgraduate training management systems, characterized by rigid program durations, inflexible credit recognition processes, and standardized dissertation review criteria, often conflict with the flexible and personalized nature of this innovative training model. Addressing these conflicts requires higher-level policy support and institutional innovation to create a more adaptable and supportive framework. Another critical issue lies in the need for improved long-term incentive mechanisms. Establishing a sustainable benefit-sharing system is essential to fully mobilize the enthusiasm and commitment of enterprises and their supervisors. Such mechanisms are pivotal in ensuring the stability and longevity of reform initiatives [18]. Without a well-structured approach to incentivization, the momentum of these reforms may falter over time. Therefore, addressing these interconnected challenges through strategic planning, policy adjustments, and collaborative efforts is vital to achieving meaningful and lasting progress in the reform process.

#### **5. Conclusion and Outlook**

Addressing the practical challenges in cultivating exceptional engineers in Textile Chemistry and Dyeing and Finishing Engineering, this study introduces a comprehensive reform framework centered on the dual principles of "Green + Intelligent." By restructuring the curriculum to emphasize sustainability and advanced technologies, fostering deeper collaboration between academia and industry, enhancing opportunities for innovation-driven practices, reforming teaching evaluation methods, and investing in faculty development, the proposed model effectively narrows the gap in talent development. This approach not only strengthens the engineering capabilities of postgraduate students but also aligns their expertise with the evolving demands of the textile industry. The integration of green practices ensures that graduates are equipped to contribute to environmentally sustainable solutions, while intelligent systems prepare them to leverage cutting-edge technologies in their professional endeavors. Together, these reforms create a robust foundation for producing highly skilled engineers capable of addressing complex challenges in the textile sector.

Future efforts will prioritize the establishment of a School-Enterprise Collaborative Education Alliance to facilitate long-term partnerships and sustainable cooperation between academic institutions and industry stakeholders. Additionally, integrating information technology into education through virtual teaching platforms will enable more dynamic and accessible learning experiences. Developing scientific evaluation metrics for engineering competencies will ensure that training outcomes are rigorously assessed and aligned with industry standards. Furthermore, disseminating these reform practices on a national scale will contribute to the broader advancement of engineering education. The commitment to cultivating engineers who can lead future innovations remains a continuous endeavor, requiring persistent refinement of training models and strengthened collaboration between academia and industry. These efforts are essential for supporting the development of a globally competitive textile industry and ensuring that graduates are equipped to drive progress in sustainability, technological innovation, and industrial excellence.

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