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Exploration and Practice of a Future-Oriented Cross-Border Talent Training Model for New Engineering Textiles in the Context of Digital Intelligence

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Abstract: Facing profound challenges and unprecedented opportunities brought about by the latest technological revolution, digital intelligence technologies are fundamentally transforming the global textile industry at a rapid pace. Consequently, traditional textile engineering education increasingly shows significant limitations in addressing complex interdisciplinary needs and rapidly evolving industry demands. To bridge this critical gap, this paper comprehensively analyzes the "Textile New Engineering Experimental Class" educational reform. It details the strategically reconstructed curriculum, which seamlessly integrates "Digital Intelligence Literacy + Engineering Core + Cross-border Innovation" to foster multifaceted skill sets. Furthermore, the study explores the establishment of dynamic interdisciplinary teaching teams and the implementation of a highly structured, five-stage "Learn-Inquire-Think-Discuss-Practice" pedagogical framework. This innovative approach is heavily supported by project-driven learning methodologies and a comprehensive, data-driven evaluation system designed to monitor and enhance student progress continuously. The proposed educational model demonstrates remarkable effectiveness in stimulating students' innovative potential, fostering critical thinking, and building robust cross-border integration capabilities, thereby significantly enhancing their professional competitiveness in a modern technological landscape. Ultimately, this comprehensive study offers a highly valuable, scalable reference and practical blueprint for cultivating advanced, interdisciplinary engineering talents within the broader New Engineering education framework, ensuring graduates are fully equipped to lead future industrial advancements.

Keywords: digital intelligence; engineering education; textile industry; interdisciplinary learning; pedagogical reform

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1. Introduction

Currently, society is undergoing a significant transformation, transitioning from the "Industry 4.0" era, characterized by digital intelligent technologies, to a more advanced stage of development. The textile industry, as a cornerstone of the national economy and an essential livelihood sector, is experiencing profound changes in both its fundamental nature and scope. Innovations such as smart fibers and wearable devices, precise design and flexible production enabled by big data and artificial intelligence, and the growing emphasis on circular economy principles and sustainable development across the product lifecycle are reshaping the industry. These advancements highlight the emerging characteristics of future textile technology, which can be described as increasingly digitalized, intelligentized, environmentally sustainable, and integrated [1]. This evolution introduces both unprecedented challenges and opportunities for cultivating talent in textile engineering. The traditional education model, which primarily focuses on imparting knowledge and skills within a single discipline, has proved inadequate in

addressing the industry's demand for interdisciplinary professionals. These future talents must possess a broad knowledge base across multiple disciplines, demonstrate proficiency in advanced digital intelligence tools, be able to tackle complex systemic engineering problems, and drive innovation within the industry.

In response to this transformative era, China's higher education sector has initiated the "New Engineering" program [2]. This initiative emphasizes the integration of interdisciplinary knowledge and the establishment of robust collaborations between academia and industry to nurture exceptional engineering professionals capable of adapting to and leading future industrial advancements. Building on its expertise in materials, design, engineering, and related fields, our institute has pioneered the creation of the "Textile New Engineering Experimental Class" (referred to as the "Experimental Class"). This initiative represents a comprehensive and systematic reform of the talent cultivation model, rather than a superficial enhancement of existing academic programs. The Experimental Class is designed with digitalization and intellectualization as its core enabling mechanisms, deep disciplinary integration as its defining feature, and a focus on future industrial needs as its guiding principle. This paper seeks to provide an in-depth exploration of the theoretical foundations and practical approaches involved in the development of the Experimental Class [3]. By doing so, it aims to offer valuable insights and experiential guidance for advancing textile engineering education and contributing to the broader framework of New Engineering in China.

2. Innovative Reform Measures

2.1. Reconstructing a "Pyramid-style" Modular Curriculum System: Consolidating Digital Intelligence Literacy and Promoting Knowledge Integration

The Experimental Class has fundamentally transformed the traditional curriculum system by dismantling rigid disciplinary boundaries and introducing a "pyramid-style" modular curriculum framework [4, 5]. This innovative structure is designed with "Digital Intelligence Literacy" as its foundation, "Engineering Core" as its central pillar, and "Cross-border Innovation" as its apex. The approach aims to foster a comprehensive and integrated learning experience that equips students with the skills and knowledge necessary to excel in the rapidly evolving field of textile engineering and related disciplines [6].

Foundation Layer: The foundational layer focuses on strengthening students' proficiency in mathematics, science, and digital intelligence. In the early years of study, the curriculum significantly enhances the depth and breadth of core subjects such as mathematics, physics, and chemistry. To complement these traditional subjects, new compulsory courses like "Engineering Data Analysis and Visualization" and "Fundamentals of Artificial Intelligence" have been introduced. These courses aim to develop students' programming skills while fostering computational thinking. This enables students to translate complex real-world phenomena, such as textile material properties, process parameters, and market trends, into computable and analyzable data models. By doing so, students establish a robust theoretical and methodological foundation that supports advanced applications of digital intelligence in later stages of their education.

Core Layer: The middle grades emphasize the integration and enhancement of interdisciplinary engineering knowledge. Traditional textile engineering courses have been restructured to incorporate cutting-edge advancements. For instance, "Textile Materials Science" now includes elements of "Introduction to Smart Materials," covering innovative materials such as shape-memory polymers, photochromic fibers, and energy-storage fibers. Similarly, courses like "Woven Fabric Design," "Knitwear Design," and "Innovative Fabric Design" have been merged into "Principles of Digital Textile Manufacturing," which introduces students to modern concepts such as smart manufacturing units and digital twins. This interdisciplinary approach ensures that students gain a comprehensive understanding of both traditional and emerging technologies.

Peak Layer: The senior years and graduation projects are entirely centered

on project-based and research-oriented learning [5]. A specialized course, "Comprehensive Project Practice," has been established to immerse students in real-world technical challenges sourced from leading industrial enterprises or major national strategic initiatives. Students are required to form interdisciplinary teams, combining expertise from diverse fields such as materials science and design. Under the guidance of supervisors, these teams navigate the entire innovation process, from idea generation and technical feasibility analysis to prototype design, sample production, and performance evaluation. Additionally, the "Textile Science and Technology Frontiers" lecture series invites prominent scholars and industry leaders to share the latest advancements in the field. This ensures that students remain informed about cutting-edge developments and are prepared to contribute to the future of textile science and engineering.

2.2. Forming Interdisciplinary "Intelligent Connected" Teams and Innovating the "Learn-Inquire-Think-Discuss-Practice" Five-Stage Teaching Paradigm

An interdisciplinary "dual-qualified" and "Intelligent Connected" teaching team was established, encompassing expertise in textile science, materials engineering, computer science, textile design, art studies, and related fields. This team operates under a "modular collaboration" framework, which fosters synergy across diverse disciplines. To address the limitations of traditional classroom settings, a data-driven, five-stage progressive teaching paradigm has been developed. This paradigm, structured around the sequence of "Learn-Inquire-Think-Discuss-Practice," aims to enhance the learning experience by integrating modern pedagogical strategies and technological tools [4, 7].

Learn (Basic Cognition): This stage leverages advanced tools such as Artificial Intelligence-Generated Content (AIGC) and Virtual Reality (VR) to provide students with immersive pre-class preparation. For instance, VR experiences showcasing intangible cultural heritage textile techniques help establish a foundational perceptual understanding [8, 9]. **Inquire (Inspire Inquiry):** During class, instructors stimulate curiosity and guide students to identify real-world challenges through targeted questioning. For example, when exploring smart clothing, students might be prompted to consider how heating elements can balance efficiency and aesthetic appeal. **Think (Deep Internalization):** At this stage, students engage in independent critical thinking, synthesizing art and engineering principles to conceptualize innovative solutions. **Discuss (Collision and Sublimation):** Group discussions and debates are organized to encourage intellectual exchange among students from diverse academic backgrounds, such as engineering and art. These interactions foster collaborative problem-solving and refinement of ideas. **Practice (Practical Creation):** The final stage involves translating conceptual ideas into tangible outcomes. Student teams undertake comprehensive projects, progressing from initial creative sketches and technology selection to prototype development and final product presentation. For example, they might design uniform fabrics for Winter Olympic volunteers that seamlessly integrate functionality with traditional cultural aesthetics.

This innovative teaching paradigm transforms the conventional one-way knowledge transmission model into a dynamic, closed-loop learning process characterized by "data feedback - cognitive iteration." By emphasizing active participation and iterative improvement, the approach effectively stimulates students' intrinsic motivation and creativity. The integration of interdisciplinary collaboration and practical application ensures that students not only acquire theoretical knowledge but also develop the skills necessary to address complex, real-world challenges. This holistic methodology fosters a deeper engagement with the subject matter, preparing students to excel in both academic and professional contexts [10].

2.3. Implementing a "Dual-Supervisor System + Cross-Border Workshop" Collaborative Education Mechanism

To ensure comprehensive interdisciplinary integration, the Experimental Class has adopted a "Dual-Supervisor System" that pairs students with both an academic supervisor and an industry supervisor. Academic supervisors focus on guiding students in academic

planning, strengthening their theoretical foundations, and refining their research methodologies. In addition, industry supervisors, who are professionals from renowned enterprises or research institutions, contribute their expertise by introducing cutting-edge industry trends, addressing real-world technical challenges, and sharing practical engineering experiences. These industry supervisors actively participate in project guidance and facilitate short-term, intensive "Cross-Border Innovation Workshops," which are designed to bridge the gap between academic knowledge and practical application. This dual-supervisor approach ensures that students receive a balanced education that combines theoretical rigor with practical insights, fostering their ability to adapt to diverse professional environments and challenges.

The workshops are structured around specific themes, such as "Smart Sports Monitoring Apparel" or "Zero-Waste Fashion Design," and are conducted over a focused period of two to three days. These workshops immerse students from various academic disciplines in collaborative activities that emphasize brainstorming, rapid prototyping, and solution pitching. By engaging in these intensive exercises, students develop critical skills such as teamwork, effective communication, and the ability to learn and adapt quickly under pressure. Furthermore, these workshops serve as a powerful platform for cultivating cross-disciplinary innovation literacy, enabling students to approach complex problems with creative and integrative solutions. The hands-on nature of these activities not only enhances their technical and creative capabilities but also prepares them to thrive in fast-paced, innovation-driven industries.

2.4. Implementing a "Dual-Supervisor System + Cross-Border Workshop" Collaborative Education Mechanism

Transitioning from the traditional "single exam determines all" approach, a comprehensive evaluation system has been developed to assess students through a full-process, multi-dimensional framework. This system leverages learning behavior data to provide a more holistic understanding of student performance. By moving beyond the limitations of a single examination, this approach ensures a more equitable and thorough evaluation of academic progress and capabilities.

The evaluation system is divided into three key dimensions. First, process-oriented evaluation involves the use of learning management systems to meticulously track student engagement in various academic activities, such as participation in online courses, contributions to group discussions, quality of assignments, and progress in project work. This ensures that every aspect of a student's learning journey is accounted for. Second, capability-based evaluation focuses on a broader spectrum of skills, including critical thinking, innovation, problem-solving, and teamwork. This is achieved through diverse assessment methods such as project reports, design documents, and oral presentations, which provide a comprehensive view of a student's abilities. Lastly, value-added evaluation emphasizes the growth and development of students over time. By comparing baseline assessments conducted at the time of enrollment with capability evaluations at graduation, this dimension offers a scientific measure of the effectiveness of the training process, highlighting individual progress and achievements.

This innovative evaluation system not only ensures fairness and inclusivity but also generates valuable data that can be utilized for teaching diagnostics and continuous improvement. By analyzing this data, educators can identify areas for enhancement and implement targeted strategies to refine the teaching process. This creates a closed-loop quality assurance mechanism, fostering an environment of ongoing development and excellence in education. Such a system represents a significant advancement in academic evaluation, aligning with modern educational standards and addressing the diverse needs of students.

3. Innovative Reform Outcomes

Over the course of several years, the implementation of reform measures has yielded significant and notable outcomes. These efforts have led to substantial improvements in

students' abilities across multiple dimensions [11–13]. Specifically, their capacity for innovation has been cultivated through targeted initiatives that encourage creative thinking and problem-solving. Furthermore, their engineering practice skills have been strengthened through hands-on projects and experiential learning opportunities designed to simulate real-world challenges. These activities not only enhance technical proficiency but also foster adaptability and resilience in dynamic environments. In addition, the comprehensive qualities of students have been systematically developed, encompassing critical thinking, teamwork, and effective communication skills. Such holistic growth ensures that graduates are well-prepared to meet the demands of modern industries and contribute meaningfully to societal progress. The success of these reforms underscores the importance of continuous improvement in educational methodologies to align with evolving academic and professional standards.

3.1. Abundant Student Innovation Achievements, Cross-Border Projects Attract Attention

Students have emerged as a pivotal force in numerous high-level disciplinary competitions and innovation-focused contests hosted by the university. Their participation in events such as international innovation competitions and national technology innovation contests has consistently resulted in significant accolades, showcasing their exceptional capabilities. Projects spearheaded by students from the experimental class have demonstrated remarkable interdisciplinary integration, blending advanced technologies, materials science, and market-oriented solutions. Examples of such projects include "Soft Velvet Garden-Knitted Substrate Flexible Sensors and Eco-Friendly Smart Interactive Home Products," which highlights the fusion of eco-friendly materials with intelligent design principles, and "Rhythmic Weaving: Digital-Intelligence Empowered Innovation and Inheritance of Textile Products Inspired by Guqin Intangible Cultural Heritage," which exemplifies the application of digital intelligence to preserve and innovate upon traditional cultural elements. Another notable project, "Fiber Recycle & Smart Manufacturing-Recycled Textile Composites and Modular Spatial Decoration Products," underscores the importance of sustainable practices and smart manufacturing in addressing environmental challenges. These achievements collectively illustrate the students' growing proficiency in leveraging digital intelligence technologies, pioneering material innovations, and responding effectively to market demands across diverse disciplinary boundaries. Furthermore, the projects reflect a forward-thinking approach to integrating sustainability, cultural heritage, and technological advancement, positioning students as key contributors to the evolving landscape of interdisciplinary innovation. By fostering such capabilities, the university continues to cultivate a new generation of talent equipped to address complex global challenges through creative and impactful solutions.

3.2. Solid Engineering Practice Ability, High Demand from Leading Industry Enterprises

Graduates who have undergone comprehensive, industry-relevant project training during their academic journey exhibit exceptional engineering practice abilities and adaptability in professional environments. Their education equips them not only with a solid foundation in theoretical knowledge but also with hands-on expertise in utilizing modern digital design tools and advanced smart manufacturing processes. This dual proficiency enables them to seamlessly transition into roles within corporate research and development, production, or technical management teams [14–16]. Furthermore, their ability to address complex challenges and innovate within their fields is highly regarded by employers. Follow-up surveys indicate that graduates from the Experimental Classes are particularly sought after by prominent enterprises in various industries. These graduates consistently achieve higher employment rates and command more competitive starting salaries compared to their peers from regular classes. Employers frequently highlight their capacity for creative problem-solving and their readiness to contribute to high-level projects immediately upon entering the workforce. The rigorous training and exposure to real-world scenarios during their studies ensure that these individuals are well-prepared to meet the demands of leading industry enterprises, making them valuable assets in sectors that prioritize innovation and technical expertise. This alignment

between academic preparation and industry expectations underscores the effectiveness of the Experimental Class model in fostering highly capable professionals.

3.3. Great Potential for Academic Advancement, Preliminary Research Literacy Evident

Many exceptional graduates from the Experimental Class have chosen to continue their academic journeys by enrolling in postgraduate programs at prestigious universities, both domestically and internationally [17]. These include leading universities renowned for their expertise in textiles, materials science, and design. Graduates have reported that the comprehensive education they received, emphasizing a robust foundation in mathematics and science, has been instrumental in their ability to adapt to advanced academic environments. The interdisciplinary approach of the program fosters a broader perspective, enabling students to effectively integrate knowledge from various fields effectively. Additionally, the preliminary research training they receive equips them with essential skills to engage with complex and innovative research topics at the postgraduate level. This preparation not only accelerates their ability to contribute meaningfully to cutting-edge research but also positions them as promising candidates for future academic and professional achievements. The program's emphasis on fostering analytical thinking, problem-solving abilities, and creativity ensures that graduates are well-prepared to tackle the challenges of advanced studies. As a result, they demonstrate significant potential for academic advancement and professional growth, reflecting the program's commitment to cultivating well-rounded and capable individuals who can excel in their chosen fields. This holistic preparation underscores the program's role in shaping the next generation of leaders in textiles and related disciplines.

4. Conclusion and Outlook

The reform of the Textile New Engineering Experimental Class exemplifies how digital intelligence technologies can revolutionize talent cultivation, fostering a new generation of interdisciplinary innovators equipped to address the demands of future industries. Central to this transformation is the integration of digitalization and intellectualization, which not only serve as tools for instruction but also act as foundational pillars for reshaping educational ecosystems. By embedding these technologies throughout the training process, students are better prepared to navigate and thrive in an unpredictable and rapidly evolving professional landscape. Furthermore, achieving meaningful interdisciplinary integration requires a comprehensive and systematic approach to curriculum design. This involves more than simply combining courses; it necessitates the reconstruction of curricula, the establishment of collaborative platforms, the innovation of teaching methodologies, and the reform of evaluation systems to create dynamic environments where knowledge, skills, and creativity can interact and flourish. A student-centered, project-based learning approach has proven particularly effective in fostering innovation, as it allows students to engage with real-world industry challenges, integrating theoretical knowledge with practical skills and ethical considerations. Looking ahead, future efforts will focus on strengthening collaborations between academia and industry through initiatives such as joint laboratories, enhancing global perspectives through programs such as dual-degree offerings, and prioritizing ethical and sustainable practices in engineering education. These strategies aim to dismantle traditional barriers, embrace the opportunities presented by digital transformation, and rebuild talent cultivation systems with a focus on openness, adaptability, and innovation. By doing so, the next generation of leaders will be empowered to drive advancements in textile technology and contribute meaningfully to the broader progress of society. This comprehensive approach underscores the necessity of reimagining engineering education to meet the challenges and opportunities of the future.

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