Exploring Innovation and Development of Yarn Spinning Through Industry-Education Integration: A Practical Teaching Approach

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Abstract: To cultivate outstanding engineering talent capable of both adapting to and spearheading regional economic and social progress, as well as to facilitate the transformation and advancement of local economies and to promote collaboration between universities and regional economies, practical teaching bases should be established. Through the strategic alignment and interactive development of practical teaching bases, it may be possible to deepen the integration between industry and education, as well as the interactions between universities and enterprises. Thus, successful teaching bases leverage the academic strengths of universities and the resources offered by businesses. The approach to industry-education integration revolves around refining the model of collaborative education between universities and enterprises, with a specific focus on refining the talent development process. A case of innovative yarn development design within a spinning study practice teaching base is analyzed in this study to investigate the approach. Within this base, student teams have developed ultra-comfortable yarn, stainless steel fiber/lyocell flame-retardant blended yarn, and stainless steel filament/cotton ply-twisted composite yarn. The case study exemplifies the potential for effective cooperation between universities and enterprises in nurturing talent, leveraging dual-teacher training, providing societal contributions, facilitating employment opportunities, and fostering entrepreneurial initiatives. This collaborative model shows significant potential for comprehensively enhancing the quality of talent cultivation, thereby propelling regional economic and social development.

Keywords: Industry-education integration; Craftsmanship; Yarn development; Innovative design; Practice teaching

1. Introduction

Collaborative talent cultivation through industry-education integration is a critical pathway towards the development of exceptional engineers [1]. In the midst of ongoing scientific and technological revolution coupled with industrial transformation, China's economic and societal progress has been met with significant opportunities as well as challenges [2]. Since the 18th National Congress of the Communist Party of China, General Secretary Xi Jinping has consistently stressed the significance of "key core technologies" for the nation and the persistent need to address "bottleneck" issues within

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engineering and technology fields [3]. To effectively surmount these challenges, the country needs a substantial influx of talented, accomplished engineers with mastery over key core technologies [3]. This imperative not only aligns with President Xi's vision but also hinges upon harnessing the prevailing opportunities of the era, which will require innovation in terms of industry-education integration as well as university-enterprise cooperation [4].

Today, the training of exceptional engineers in China is guided by principles of industry-driven demand and holistic education. This paradigm balances "instrumental rationality" and "value rationality" to underpin the process of talent cultivation. The effects of collaborative talent cultivation through industry-education integration have been evaluated from multiple perspectives [5].

The spirit of craftsmanship has endured across ages. Ancient texts such as the pre-Qin "Mozi," "Zhuangzi," and "Kaogongji in Zhou Rites" encapsulate early notions of the craftsman's spirit. The Ming Dynasty's "Tiangong Kaiwu", written by Song Yingxing, is a concentrated exposition of this same spirit. Craftsmanship, in essence, is the relentless pursuit of excellence in the process of crafting products, emphasizing aspects like design and quality. It entails perpetual enhancement and innovation of skills, coupled with a meticulous and objective approach to creating superior work [6]. This ethos represents an enduring aspiration for quality. Modern applied universities bear the historical mantle of fostering the spirit of craftsmanship and nurturing artisan talents within the framework of industry-education integration and talent cultivation [7].

The present study began with an analysis of the practical teaching of spinning studies in the School of Clothing and Art Engineering, Minjiang University. By harnessing the methodologies of collaborative talent cultivation through industry-education integration, innovative yarn products are developed with the spirit of craftsmanship. Thus, the pedagogical outcomes of industry-education integration are demonstrated through cases of textile innovation.

2. Existing Issues in Collaborative Talent Cultivation via Industry-education Integration

The cotton textile industry is an essential sector in Fujian. With a cotton spinning capacity surpassing 13 million spindles (with over 7 million in the Changle area alone), Fuzhou Province is a major player in the textile industry. The province boasts nearly one hundred cotton spinning enterprises, with more than half of these concentrated in Changle and Fuzhou. Changle's cotton spinning sector is advantageous in terms of its large enterprises, exemplified by Xinhua Yuan Textile Group, Changyuan Textile (Group), and Jinyuan Textile (Group), each overseeing more than 1 million spindles. Enterprises with over 500,000 spindles include Jinyuan, Changyuan, Jinyuan, and Xianglong. The hallmark products of Fujian's cotton spinning industry include cotton, cotton blends, synthetic fibers, synthetic fiber blends; the area also leads the nation in the production of polyester, viscose, and blended yarns. Changle, Fuzhou, and their surrounding areas have become essential bases for synthetic non-cotton yarn and cotton-synthetic blended yarn production in China. Consequently, there is an urgent need to establish a spinning practical teaching base that can be seamlessly linked with enterprises to effectively cultivate applied talents.

In this context, the School of Clothing and Art Engineering, Minjiang University actively promotes university-enterprise cooperation and industry-education integration.

Deepening university-enterprise linkages is a consistent priority for institutions aiming to strengthen practical teaching, highlight the instruction of hands-on skills, and comprehensively enhance the quality of applied talents emerging from universities.

The advancement of industry-education integration and the seamless alignment of universities with enterprises have been a major challenge in terms of cooperative education. On one hand, as industry-education integration develops, university-enterprise convergence has gradually emerged as the main channel for universities to expand their professional practices and internship programs. However, due to the systemic influence of educational institutions, the nexus between universities and enterprises is often superficial, primarily confined to the realm of internships, and thus lacks depth. However, in the context of practical university instruction and teaching base establishment, the latent potential inherent in the convergence of universities with enterprises remains underutilized. Many practical teaching bases primarily serve as experiential learning platforms, with a dearth of momentum or cooperation in terms of university-enterprise integration. Hence, it is imperative to construct practical teaching bases that fully align with university-enterprise collaboration and engender interactive, practice-driven teams. Such strategic initiatives align with the overarching goal of industry-education integration and the seamless fusion of universities and enterprises.

3. Showcasing and Analysis of New Yarn Series Developed with Craftsmanship

3.1. Innovative Development of Ultra-comfortable Yarn

3.1.1. Development Process
(1) Yarn Density and Twist Design

This experiment involved a blend of polyvinyl alcohol (PVA) water-soluble fiber and long-staple cotton fiber, so the desired outcome was a lightweight, soft fabric achieved by high-temperature hydrolysis of the blended materials. Therefore, the yarn density before blending was kept relatively low. Cotton counts normally range from 10S-60S; to align better with the objectives of the experiment, the targeted line density of the blend was set to 45tex.

(2) Spinning Process

After analyzing the properties of PVA fiber and long-staple cotton fiber, and in efforts to reduce costs, appropriate adjustments were made to the production process. Equipment from Tianjin Jiacheng Mechanical and Electrical Equipment Co., Ltd. was applied to optimize resource utilization. Given the equipment's capabilities and the inherent attributes of the raw materials, a carding process was incorporated into the experiment. The formulated process sequence progressed through several steps: Raw material → fiber pretreatment → cotton blending → cotton opening and cleaning → carding → drawing-1 → drawing-2 → roving → spinning → sizing.

(3) Cotton Opening and Cleaning Process

PVA fiber and long-staple cotton fiber have strong hygroscopicity, so temperature and relative humidity are important. Excessively low temperatures or humidity levels cause the cotton fiber surface wax to solidify, weakening the fiber and generating static electricity. Conversely, elevated temperatures or humidity levels soften the cotton wax, escalate fiber friction, and hinder normal stretching; the rollers tend to wind, which causes the sliver to become uneven.

The optimal conditions for effective loosening are achieved within a temperature range of 25-26°C and relative humidity between 55-65%. These conditions balance the cotton wax properties, rendering it suitably pliable for decomposition and conducive to effective fiber opening, dust removal, and stretching. This timeframe is identified as the most opportune for loosening. The main technical parameters of loosening process in this case were a loosening roller diameter of Φ458 mm, loosening roller speed of 280 r/min, and loosening speed ratio of 369 times.

(4) Carding Process

Long-staple cotton fiber has high elasticity and a fluffy quality, so attaining a harmonious balance in the spacing of the material throughout the carding process is important. Notably, both PVA fiber and long-staple cotton fiber have strong hygroscopicity. When the temperature is maintained at 2-26°C and the relative humidity is between 55-65%, the wax on the cotton is suitably pliable, the cotton can readily decompose, and single fibers are conducive to loosening, dust removal, and stretching. These climatic conditions form a opportune juncture for carding. It is important to ensure that equipment is kept dry throughout the process to mitigate issues like winding and congestion. Prudent reduction of the licker-in and cylinder speeds is also necessary to prevent licker-in recycling and cotton knots. Strategically expanding the gap between the cover plate and cylinder also prevents fiber from winding around the cylinder and blocking the cover plate, thereby improving the quality and clarity of the cotton web. Incorporating a leather roller cotton guiding device before the doffing stage enhances the support and stretching of the cotton web, minimizes the tension of the cotton web, minimizes sliver degradation, and improves production efficiency. The main technical parameters of the carding process include a cylinder speed of 500 r/min, cylinder working width of 270 mm, surface line speed ratio (cylinder/licker-in) of 4.1 times, web output speed of 3 m/min, and total draft ratio (doffing/feeding) of 60 times.

(5) Drawing Process

The dryness factor, which is an important concern related to the hygroscopic and fluffy attributes of PVA and long-stable cotton fibers, must be properly considered throughout the drawing process. Within the temperature range of 2-26°C and relative humidity range of 55-65%, the cotton wax is suitably pliable, the cotton readily decomposes, and single fibers are conducive to loosening, dust removal, and stretching, making these the most suitable conditions for drawing. Winding caused by static electricity must also be avoided and irregularities in the sliver must be carefully monitored and prevented. Regular sliver unevenness (mechanical waves) arises due to drafting component malfunctions leading to periodic variations in thickness, while irregular sliver unevenness (drafting waves) stems from erratic movement of suspended fibers within the sliver during drafting, causing alternating thick and thin segments. Stabilizing the components during the drawing process can prevent these problems; if they do occur, the drawing process must be carried out again. To ensure uniformity, the drawing process conducted in this study was a two-pass drawing with a four-strand drawing method in each pass. The main technical parameters of the drawing process included a first pass out speed of 10 m/min, total draft ratio of 6 times, rear area draft ratio of 1.4 times, middle area draft ratio of 1.02 times, and front area draft ratio of 4.21 times.

(6) Roving Process

As mentioned above, the properties of both PVA fiber and long-staple cotton fiber make a temperature range of 25-26°C and relative humidity of 55-65% optimal. Under these conditions, the winding of the roving in the process is moderate and the roving

sliver is uniform. It is important to avoid excessive elongation of the roving during this phase to prevent compromised sliver quality. Careful consideration should also be given to roving twist, striking a balance between low and high. Skillful control of temperature and humidity ensures moderate tension of the roving winding, which should not be overly lax or excessively tights. Regular cleaning of the roving machine is vital to prevent fly waste adherence and consequent fiber aggregation, which can lead to hank yarn entanglement and unevenness in the roving sliver. The main parameters of the roving process in this study include a roving count of 500 tex, twist factor of 90, twist of 40.25 T/m, theoretical bobbin speed of 400 r/min, bobbin winding speed of 300 r/min, back area draft ratio of 1.05 times, front area draft ratio of 1.2 times, and mechanical draft of 5.5 times.

(7) Spinning Process

Again, given the hygroscopicity and fluffiness of PVA and long-stable cotton fibers, the optimal temperature and relative humidity for processing are 25-26°C and 55-65%, respectively. These conditions are conducive to a smooth spinning process. Excessive total draft or back zone draft during the spinning can lead to an uneven sliver and should be carefully controlled. Similarly, inappropriate apron clamping, roller spacing, or roller pressure can lead to an uneven sliver. During the spinning process, the winding of the yarn on the bobbin and the bundling of the yarn tube should be monitored to prevent localized thick yarn. The main parameters of the spinning process included a spindle gauge of 70 mm, spindle number of 24 (on both sides), twist factor of 350, twist of 81 T/m, and twist shrinkage rate of 3%.

(8) Fabric Production

The yarn fabricated through the above processes was used to produce fabric samples on a computerized flat knitting machine (Model LXC-252SC 12G, Jiangsu Jinlong Technology Co., Ltd.). The fabric structure was 1＋1 rib knitting.

(9) Hydrolysis Process

To ensure the complete dissolution of PVA fiber within the fabric and yarn, a temperature 10°C above the fiber's dissolution temperature must be sustained for a defined period. Boiling water temperature was controlled here at 95±5°C, with high-temperature hydrolysis desizing lasting approximately 120 min.

3.1.2. Tests and Analyses

(1) Yarn Mechanical Properties

The breaking strength of pure cotton yarn is 629.7 CN, corresponding to a breaking strength of 13.8 CN/tex and a breaking elongation rate of 7.6%. In contrast, the blended yarn composed of 40% PVA and 60% long-staple cotton blended yarn has a reduced breaking strength of 494.3 CN, breaking strength is 10.8 CN/tex, and breaking elongation rate of 7.6%. The breaking strength this blended yarn after PVA hydrolysis is 389.8 CN, while its breaking strength is 8.5 CN/tex and its breaking elongation rate is 2.6%. The strength of the blended yarn is lower than that of the pure cotton yarn due to the nature of short PVA water-soluble fiber, which, despite individual fiber strength exceeding that of long-staple cotton fiber, does not have robust cohesion with the long-staple cotton fiber. Consequently, during force-induced yarn stretching, fibers with weaker cohesive bonds succumb first. Notably, the mechanical properties of the blended yarn are further compromised after hydrolysis, as the water-soluble fiber dissolves during the high-temperature hydrolysis process. This reduces the density of long-staple cotton thread and increases the gap between long-staple cotton fibers thus reducing the breaking strength of the cotton fabric.

(2) Yarn Softness

The weft-knitted fabric made of pure cotton yarn has a warp elongation of 36.6 mm, a warp bending length of 18.3 mm, a warp bending stiffness of 150.7 mm, a weft elongation of 22.1 mm, a weft bending length of 11.1 mm, and a weft bending stiffness of 33.4 mm. The weft-knitted fabric of 40% PVA and 60% long-staple cotton blended yarn has a warp elongation of 32.8 mm, a warp bending length of 16.4 mm, a warp bending stiffness of 109.6 mm, a weft elongation of 19.4 mm, a weft bending length of 9.7 mm, and a weft bending stiffness of 22.5 mm. After the PVA hydrolysis process, the weft-knitted fabric of 40% PVA and 60% long-staple cotton blended yarn has a warp elongation of 29.2 mm, a warp bending length of 14.6 mm, a warp bending stiffness of 52.2 mm, a weft elongation of 16.9 mm, a weft bending length of 8.5 mm, and a weft bending stiffness of 10.6 mm. The longitudinal bending stiffness of all fabrics, regardless of blending ratio, is greater than the transverse bending stiffness. This is due to the structure of the fabric coil. The longitudinal direction of the coil consists of two ring-shaped columns, while the horizontal direction is an arc. The longitudinal load-bearing capacity is greater than the horizontal, so the bending stiffness of the fabric in the longitudinal direction is larger. The bending stiffness of pure cotton knitted fabric is relatively large due to the shorter length of PVA water-soluble fiber, which softens the cotton fiber blended yarn. However, the bending stiffness of the fabric after desizing significantly decreases as the water-soluble fiber further dissolves during high-temperature hydrolysis, which reduces the density of long-staple cotton yarn, increases the gap between the long-staple cotton fibers, and further softens the cotton fabric.

(3) Breathability

The weft-knitted fabric made of pure cotton yarn has a breathability rate of 91.7 mm·s-1. The weft-knitted fabric of 40% PVA and 60% long-staple cotton blended yarn has a breathability rate of 86.8 mm·s-1. The weft-knitted fabric of 40% PVA and 60% long-staple cotton blended yarn has a breathability rate of 153.2 mm·s-1 after the PVA hydrolysis process. The breathability rate appears to increase as the content of PVA water-soluble fiber increases. This may be due to the dissolution of the water-soluble fiber during the high-temperature hydrolysis process, which increases the gap between the long-staple cotton fibers, thus increasing the breathability of the cotton fabric.

(4) Yarn Cross-sections

Microscopic examination of yarn cross-sections offers insights into the structures of the material. The pure cotton yarn cross-section exhibits a compact arrangement. In contrast, the PVA/cotton blended yarn shows small gleaming spots on its cross-section that are attributable to the inclusion of PVA. The structure remains relatively tight, with fibers near one another. Hydrolyzed PVA/cotton blended yarn shows a looser cross-section with gaps between the fibers. These inter-fiber gaps contribute to enhanced softness and improved breathable comfort in the yarn (as shown in Fig.1-3).
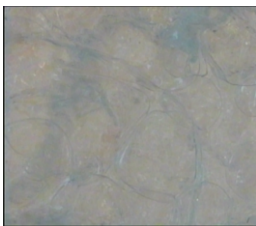

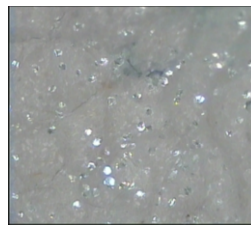**Figure 1.** Cross-section of pure cotton yarn

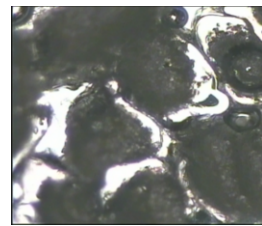**Figure 2.** Cross-section of PVA/cotton blend yarn

Figure 3. Cross-section of PVA/cotton blend yarn after hydrolysis

3.2. Yarn Innovation Practices of Other Groups

3.2.1. Stainless Steel Fiber/Lyocell Blended Flame-retardant Yarn

The welding industry plays an important role in modern industry. Increased demands for protective attire have arisen from both labor safety requisites and scientific standards. In handheld welding processes, where metal splashes and sparks land on steel or iron surfaces, the cooling impact of the air can cause these particles to contact the welder's clothing. These metal splashes can reach temperatures of 500-700°C. Additionally, iron water sparks with diameters over 1 mm are emitted within 30-50 cm from the welder's body, and can puncture clothing, creating holes or even causing burns on the skin. Considering these factors, the melting point of the fabric worn by welders must be a primary consideration when developing anti-welding spatter solutions. However, existing protective clothing options for specialized welding work rely on a limited array of high-temperature resistant fabrics.

Commonly employed high-temperature resistant fabrics in welding work attire include thick cowhide fabric (protection up to 120°C), thickened and treated pure cotton fabric (protection up to 150°C), and aramid or aramid composite fabric (protection up to 260-280°C). These fabrics are commonly used, but do not completely ensure the safety of welders as they perform necessary tasks. Stainless steel fiber fabric is a noteworthy potential candidate material for protective clothing, as it has a melting point of 1350°C and can work continuously in oxidizing environments below 600°C, giving it excellent heat resistance. Preliminary experiments have shown that 900 g/m2 pure stainless steel fiber woven fabric can effectively counter welding spatter. However, due to the inherent limitations to the spinnability of stainless-steel fiber, pure stainless-steel fabric is heavy, expensive, and has poor thermal and humidity comfort.

The roving process was conducted in this study on an FA467E-type fly frame using the parameters listed in Table 1.

Table 1. Roving frame process parameters

Yarn count (g/10 m)	Draw ratio	Twist factor	Initial tension	Twist (turns/meter)	Spindle speed (rpm)	Roller spacing (mm)	Spacer
12.5	5.2	109	800	2.7	500	12×26×40	7.5

The ring-spinning process was carried out using a BS529J-type ring-spinning machine. The specific spinning process parameters are listed in Table 2.

Table 2. Ring-spinning frame process parameters

Yarn count (tex)	Total draw ratio	Twist factor	Twist (turns/meter)	Spindle speed (rpm)	Roller spacing (mm)	Spacer	Type of steel ring
98.4	26	320	360	5000	20×45	4.5	18#

Utilizing Lyocell fiber as a primary material is a promising approach to creating innovative welding service fabrics. Lyocell fiber boasts excellent thermal and humidity comfort while remaining cost-effective. By incorporating stainless steel fiber as a supplementary component, the composite fabric has enhanced flame retardancy and resistance to holes formed by molten metal. In this study, a stainless-steel fiber/Lyocell blended yarn was spun with a 30% proportion of stainless steel and 70% Lyocell. Figure 4 shows a SEM image of this yarn, where the bright colored fiber is stainless steel short fiber, and the dark colored fiber is Lyocell. This blended material, theoretically, has robust flame retardancy and resistance to molten welding spatter.
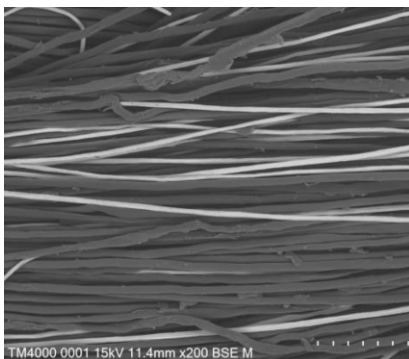
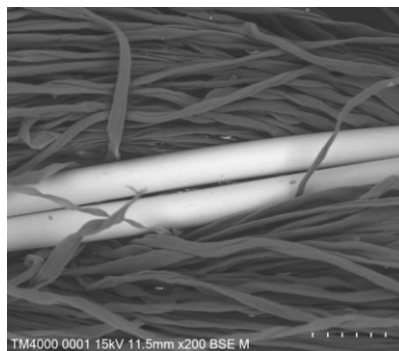**Figure 4.** SEM image of stainless-steel fiber/Lyocell blend yarn

Figure 5. SEM image of stainless-steel filament/cotton composite yarn

3.2.2 Stainless Steel Filament/Pure Cotton Ply-twisted Composite Yarn

To enhance both the flame retardancy and melt-hole resistance of flame-retardant cotton, and to improve the comfort of pure stainless-steel fabric while reducing its cost, stainless steel filaments can be added to the comfortable pure cotton flame-retardant fabric. Stainless steel filaments were ply-twisted with cotton yarn in this study to create stainless steel filament/pure cotton ply-twisted composite yarn. Figure 5 shows a SEM image of this yarn, where stainless steel filaments are bright in color and pure cotton yarn is dark in color.

The manufacturing process involved two strands of stainless-steel filaments and one strand of S-twisted pure cotton yarn being ply-twisted with an S-twist on a digital sample ply-twisting machine at a speed of 300 m/min. The ply-twisted yarn was placed on a digital sample doubling machine for twisting at a twist degree to 15T/10 cm and spindle speed of 4000r/min, thus creating the composite yarn.

4. Spinning Education "Craftsman + Innovation" Practical Teaching Training based on Collaborative Industry-Education Integration Model

4.1. Deeply Integrated Collaborative Education Organization Structure

With a concentrated emphasis on the overarching framework of industry-education integration, the College of Clothing and Art Engineering, Minjiang University has established a comprehensive organizational structure for practice-based teaching. This structure is a collective endeavor shared by educational institutions and corporate entities, fostering an environment of resource synergy. The outcome is a dynamic system of multi-dimensional investments, resource harmonization, and mutually advantageous decision-making protocols. Through a meticulous delineation of roles and responsibilities, the partnership is defined to encompass policy support, funding input, daily teaching activities, and operational management. This framework has created a robust operating structure for practical teaching bases. This approach stands out as an industry-leading model in which enterprises directly participate, characterized by a symbiotic relationship generating benefits for all stakeholders. The dual-subject ethos of industry-education integration generates a virtuous cycle, where the collaborative efforts between academics and industrialists reinforce each other.

4.2. Continuous Regional Economic and Social Development

The fundamental purpose of industry-education integration and school-enterprise cooperation is to bolster industrial development, lead and support industrial transformation and upgrading, and harmonize education with economic and social development. The modern textile and apparel industry college is strategically positioned to align with economic and social progress, catering to market demands and addressing the critical challenge of supplying the industry with new talent. A key facet of this approach involves responding to the talent gap, a situation referred to as the "two skins" predicament. This entails bridging the gap between the skills sought by industries and those possessed by prospective graduates. By adopting a supply-side reform strategy, the college endeavors to elevate the quality of education, optimize the supply of skilled professionals, and nurture a cohort of technically adept and high-caliber engineers.

Central to this endeavor is a keen understanding of the evolving requirements for local economic growth. Through effective collaboration with enterprises, the college strives to equip students with robust practical competencies, foster a strong sense of professional ethics in graduates, and cultivate a well-rounded social service orientation. This holistic approach ensures that graduates are not only technically proficient, but also poised to contribute meaningfully to their communities and to the industry at large.

5. Conclusion

The spinning practice teaching model, based on the principles of industry-education integration and collaborative education, capitalizes on the current state of practical teaching. Drawing upon the strategic advantages of the college's location, this model is centered on the establishment of practical teaching bases to optimize education within universities.

The construction of a spinning teaching practice within the university analyzed in this study adheres to a central approach: Connecting classroom teaching with hands-on experimentation, linking practical training to enterprise production lines, harmonizing classroom and workshop instruction, integrating course-based scientific research with enterprise-driven technological advancements, and forging a link between experimental products and enterprise base products. This approach advances the development of the university's spinning practical teaching base, bolstered by a robust internship system in the textile industry. Students' practical spinning skills are honed through a series of innovative yarn development and design courses in alignment with the industry's needs.

Minjiang University's College of Clothing and Art Engineering, cognizant of industrial demands, is dedicated to deeply fostering industry-education integration and collaborative education. This initiative aims to seamlessly interconnect education, talent cultivation, and industrial chains for not only economic development but also the broader modernization and advancement of the textile industry. Transformation of the practical teaching base creates a hub for nurturing talent, student employment, and technological research. This also creates a center for hands-on instruction, a resource for technical consultation, and a foundation for skilled technical talents and "double-qualified" teacher development, as well as a source of industry-education integration innovation. In sum, these efforts contribute significantly to the significant advancement of the Fujian textile industry.

Acknowledgment

References

[1] Lin J, Geng L. Multi-party Collaborative Education: A New Way to Train High-Quality Engineering Talents in China, *IFEES World Engineering Education Forum-Global Engineering Deans Council (WEEF-GEDC)* **1** (2020), 1-5.

[2] Wu F, Lu C, Zhu M, et al. Towards a new generation of artificial intelligence in China, *Nature Machine Intelligence* **2** (2020), 312-316.

[3] Zhang L. The application of adaptive analytic hierarchy process driven by multisource big data in the training of school-enterprise joint engineering ability, *Scientific Programming* **2022** (2022), 1-14.

[4] Chu H. Research on a New Mode of Integration of Production and Education for Applied Undergraduates, *economic and social development* **4** (2022), 68-72.

[5] Chen M. The Application of Information Technology in Classified Training and Layered Teaching of Marketing Specialty in Higher Vocational Colleges Under the Integration of Industry and Education, *International Conference on Frontier Computing* **2023** (2023): 1106-1115.

[6] Li H, Pang Z. Research on the Cultivation Path of Craftsmanship Spirit of Skilled Talents Based on Professional Post Group, *2nd International Conference on Education, Language and Art* **2023** (2023), 158-166.

[7] Maddock J T. Engineering the Body, Mind, and Soul: Engineering's Endurance in a Technoscientific Society and the Creation of New Entities Through Power/Knowledge Assemblages and Practical Scientific Technologies in Education, *The University of Wisconsin-Madison* **1** (2023), 1-24.