Academic Education Publishing House

Exploration of the Integration of Labor Education and Immersive Project-Based Practical Training Teaching from the Perspective of Curriculum Ideology and Politics

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Abstract: Addressing issues in undergraduate practical teaching, such as the weakening of value guidance, insufficient virtual-real integration, and singular evaluation methods, this paper explores the deep integration of labor education and immersive project-based practical training from the perspective of curriculum-based ideological and political education. The study constructs a "virtual-real linkage" high-level practical training platform and builds a "three-dimensional dynamic" educational mechanism covering knowledge, ability, and literacy. The "three-stage permeation method" is innovatively applied to progressively infuse scientific spirit, craftsmanship, and social responsibility across project cognition, inquiry-based implementation, and innovative reflection. Furthermore, a multi-dimensional evaluation system comprising "skill quantification, attitude observation, and values tracking" is established to effectively resolve the challenge of internalizing ideological elements. Practice demonstrates this model significantly enhances undergraduates' innovative practical abilities and fosters correct labor values, providing a new paradigm for cultivating high-quality applied talents with comprehensive development in morality, intelligence, physical fitness, aesthetics, and labor.

Keywords: Course Ideology and Politics; Labor Education; Virtual Real Linkage; Practical Training Teaching

1. Introduction

With the thorough implementation of the *Comprehensively Strengthening Labor Education in Primary, Secondary, and Higher Education Institutions in the New Era*, labor education has evolved beyond mere skill training. It now emphasizes cultivating virtue through labor and enhancing intelligence through practice, aiming to foster a new generation with a correct outlook on labor [1]. Within the context of curriculum ideological and political education, professional practical training serves as the crucial arena for vocational quality development. It is imperative to break down the traditional divide between technical skills and value cultivation by deeply integrating a respect for labor and the spirit of craftsmanship into skill development. This shift seeks to move from simply “transferring skills” to “forging character and spirit” [2]. Currently, traditional practical training faces significant challenges, including an excessive focus on technical skills at the expense of moral education and a disconnect between theory and practice. These issues lead to a lack of immersive educational experiences that fail to engage students’ core values deeply [3]. Therefore, exploring the profound integration of labor education with immersive, project-based practical training—utilizing scenarios that blend virtual and real elements—can effectively reconstruct the educational ecosystem. This approach addresses the difficulty of genuinely embedding ideological and political elements into practical training, ultimately creating a comprehensive talent development pathway that unites technical competence with spiritual growth.

2. Current Situation and Challenges: Obstacles to the Integration of Labor Education and Practical Training

2.1 Analysis of the Integration Status

At present, labor education within professional practical training in higher education institutions is characterized by a structural contradiction, wherein value orientation falls behind the transmission of technical skills [4]. On one hand, labor education is often narrowly confined to rudimentary physical tasks or janitorial duties, failing to deeply intertwine with the complexity of professional skill development. This disconnect results in a superficial separation between labor and instruction at the implementation level. On the other hand, ideological and political education components are frequently embedded in the practical training process through tokenistic or didactic approaches, lacking systematic instructional design and pathways for internalization [5]. This bifurcation manifests a pronounced instrumental rationality in practical training, emphasizing skill refinement while neglecting the cultivation of spirit. Consequently, it falls short of genuinely reaching students' inner values and thus cannot effectively fulfill the profound educational objective of nurturing virtue through labor.

2.2 Bottlenecks in the Application of Immersive Project-Based Practical Training

Although immersive technologies have gradually been introduced into practical training, their effective application remains hindered by two principal challenges: the disconnect between technology and educational nurturing, and the absence of authentic scenario ecosystems. Firstly, collaborations between universities and enterprises often remain superficial, limited to joint equipment development without deeply integrating the enterprise's genuine production culture, craftsmanship standards, and labor ethos. As a result, virtual training environments appear merely superficial replicas—"resembling in form but lacking in essence"—making it difficult for students to truly experience the pressures and responsibilities intrinsic to professional workplaces [6]. Secondly, existing technological applications tend to prioritize visually high-fidelity simulation of operational procedures while neglecting the cultivation of resilience through adversity and the embodiment of craftsmanship spirit within the training context. This often leads to a technical spectacle that emphasizes proficiency alone, falling into the trap of "technological fetishism" [7]. Lastly, evaluation systems predominantly focus on the final skill outcomes, lacking mechanisms for continuous data collection and quantitative analysis of students' labor attitudes, collaborative spirit, and evolving values throughout immersive interactions. This deficiency obstructs the formation of an effective, closed-loop educational process that truly nurtures character alongside competence.

3. Theoretical Framework: Designing a "Three-Dimensional Dynamic" Integration Mechanism

3.1 The Essence of the "Three-Dimensional Dynamic" Mechanism

The "three-dimensional dynamic" mechanism refers to an educational model that organically couples professional skills, labor attitudes, and value qualities throughout the entire life cycle of project-based practical training, and achieves dynamic coordination as the project progresses.

The first dimension: Professional skills dimension (carrier). This is the explicit main thread of practical training teaching, covering the application of professional knowledge, the resolution of complex engineering problems and the cultivation of technological innovation capabilities. It provides real occupational scenarios for labor education and avoids the "empty generalization" of labor education.

The second dimension: Labor attitude dimension (process). This is the implicit behavioral line of practical training teaching, focusing on students' behavioral performance in immersive interaction, such as the rigor of operation norms, the degree of cooperation in teamwork, and the tenacity when facing technical difficulties. This dimension emphasizes "learning by doing", tempering one's will through hands-on labor practice.

The third dimension: Value literacy dimension (core). This is the soul of nurturing people, aiming to internalize ideological and political elements such as the spirit of craftsmanship, professional ethics, and social responsibility as students' spiritual symbols. It leads the direction of skills learning and endows labor with a higher level of spiritual significance.

The so-called "dynamic" is reflected in the fact that the three dimensions are not static superpositions but rather show a spiral upward interaction as project-based teaching advances (from cognition to implementation and then to innovation): taking skill training as the trigger point, attitude changes are stimulated in the complex labor process, and ultimately elevated to stable value recognition, forming a closed loop of education that integrates "skills, principles, and virtues" [8].

3.2 The "Virtual-Physical Integrated

Development Model" Based on Digital Twin Technology

To facilitate the implementation of the aforementioned "three-dimensional dynamic" mechanism, this study introduced digital twin technology to construct a "virtual-physical integrated" practical training development model [9]. This approach addressed the limitations of traditional labor education in engaging with hazardous, high-cost, and non-observable production processes. Specifically, it established a comprehensive virtual-physical integrated training resource repository spanning the entire chain from "fundamental standards" through "comprehensive skills" to "innovative exploration", thereby providing a technologically immersive platform for labor education.

3.2.1 Constructing a fully mapped "Digital Labor Workshop"

Employing digital twin technology, this research has developed a virtual training platform that mirrors real industrial environments with remarkable fidelity. Innovations such as the "Five-Axis Machining Center Virtual Simulation" and the "Smart Manufacturing Turning Digital Twin Simulation" faithfully replicate authentic production parameters and machine tool motion logic from enterprises into the virtual environment. Students operating these virtual machines are liberated from constraints related to equipment quantity and consumable costs, enabling repeated experimentation and process optimization, thereby internalizing the craftsman's relentless pursuit of excellence.

In the domain of precision inspection and design, tools like the "Holographic Measurement Simulation" and "3D Reverse Engineering Virtual Simulation" render invisible optical measurement principles and complex modeling processes tangible. Within the virtual environment, students engage in reverse reconstruction and holographic inspection of precision components, honing spatial reasoning skills and cultivating meticulous professionalism through iterative calibrations measured in microns.

3.2.2 Establishing a "Safety Trial Ground" where fault tolerance and warnings coexist

By leveraging virtual simulation technology, the chronic problem of "difficulty in internalizing safety education" in traditional labor education can be addressed. Through the "Virtual Simulation of Engineering Training Safety Operation", extreme safety accidents such as mechanical injuries and electric shock caused by non-compliant operations are simulated. This intense sensory impact enables students to deeply understand the safety red line and establish a sense of awe towards life and operating procedures.

Combining "virtual simulation of circuits" and "virtual simulation of electronic product faults", set up complex circuit troubleshooting tasks. Allow students to make "destructive" attempts in virtual circuits, visually demonstrating the consequences of component burnout caused by incorrect operations. Thus, in the cycle of "trial and error - error correction - standardization", they can internalize labor discipline and standardization awareness, achieving a transformation from "passive compliance" to "active safety".

This "virtual-real interaction" model has achieved full coverage from basic circuit troubleshooting to high-end five-axis processing, allowing students to experience the real occupational pressure and labor responsibility in the virtual world, providing a solid material support for the "three-dimensional dynamic" education mechanism.

4. Practical Pathway: Instructional Implementation Based on the "Three-Stage Immersion Method"

4.1 Teaching Strategy: The "Three-Stage Immersion Method"

The "Three-Stage Immersion Method" aligns with students' cognitive development and the trajectory of skill acquisition, decomposing the objectives of labor education into three progressive phases: "Cognitive Awakening — Experiential Engagement — Value Transcendence", which permeate the entire lifecycle of project-based teaching [10].

First Stage: Cognitive Awakening — Infusion of "Baseline Awareness" through Virtual Trial and Error

During the project inception and planning phase, emphasis is placed on cultivating awareness of labor safety and regulatory compliance. Leveraging the reversibility inherent in virtual simulation technologies, "trap-style" instructional modules are designed around high-risk, forbidden operations. Students are permitted to "err" within the virtual environment, viscerally witnessing the catastrophic consequences of unsafe practices—such as equipment damage or accidents. This potent visual and experiential jolt instills a deep-seated reverence for labor discipline, firmly establishing the foundational labor principle that “safety constitutes the greatest economy”.

Second Stage: Experiential Engagement — Inculcating the “Spirit of Craftsmanship” through Virtual-Physical Synergy

Throughout the project execution and problem-solving phase, focus shifts to the relentless pursuit of excellence and cultivating resilience. Utilizing the digital twin platform for virtual machining or circuit simulation debugging, students must achieve “zero tolerance” or “zero fault” standards in the virtual realm before proceeding to hands-on operations. This iterative process, often repeated dozens of times, not only serves as rigorous professional skills training but also tests the limits of students’ patience and concentration. The objective is to internalize the spirit of craftsmanship as a habitual manifestation through intensive “virtual labor” coupled with meticulous “physical execution”.

Third Stage: Value Transcendence — Embedding “Sense of Responsibility” through Reflective Improvement

In the project acceptance and evaluation phase, emphasis is placed on fostering social responsibility and innovative consciousness. Students are guided to transcend the mere technical aspects and assess their labor outcomes through the lenses of user experience, social benefit, and professional ethics. By retrospection and analysis of errors or defects encountered during training, students gain profound insight into the societal ramifications of their work, thereby achieving a transformative shift from being mere “artisans of skill” to embodying the identity of committed “custodians of responsibility”.

4.2 Implementation Vehicle: Design of Immersive Project-Based Practical Training Tasks

To ensure the thorough realization of educational objectives, this research leverages the hardware infrastructure and virtual simulation platforms of the Engineering Training Innovation Institute, selecting the two core modules of “Electronic Technology” and “Metalworking Internship” to construct representative immersive training projects. Through task designs that embody a “virtual-physical mirroring” approach, students naturally undergo the transformative experience of the “Three-Stage Immersion” throughout the completion of concrete engineering assignments [11].

For the electronic internship section, taking the "Design and Production of Intelligent Temperature Measuring Instruments" project as the carrier, a full-cycle electronic product development scenario is constructed. During the project's cognitive period, students first enter the "Virtual Simulation of Electronic Product Faults" system to troubleshoot preset faults such as reverse power connection and static breakdown. Through the visual impact of component "bursting", they awaken their absolute respect for electrical safety regulations. During the implementation period, a "virtual-real dual-drive" mode is adopted. Students need to first conduct circuit design and component configuration in the circuit simulation software, and then carry out physical soldering replication. Through repeated corrections and meticulous operations, they hone their meticulous and patient craftsmanship qualities. During the acceptance period, precision traceability and error analysis are conducted to guide students to review product quality from the perspective of technical ethics, and to inspire a sense of responsibility and mission to serve the country through science and technology, as shown in Figure 1.

In response to the imperative transition from traditional metalworking internships to intelligent manufacturing, this initiative harnesses “Digital Twin Technology for Intelligent Turning” and “Five-Axis Machining Center Virtual Simulation” to reconstruct conventional machining training. Addressing the inherent hazards and barriers associated with traditional metalworking practice, the project unfolds across the three-stage immersion methodology. During the cognitive phase (Stage One), the “Engineering Training Safety Operation Virtual Simulation” vividly reenacts mechanical injury incidents. Through immersive first-person experiences, students confront and dismantle any sense of complacency or luck, thereby establishing a foundational mindset grounded in risk awareness and bottom-line thinking. In the execution phase (Stage Two), leveraging the digital twin of intelligent turning systems and the five-axis machining center platform, students engage in meticulous, micron-level iterative trial and error within the virtual environment to optimize cutting parameters. Only upon achieving fully compliant virtual workpieces are they granted permission to operate actual equipment. This rigorous regimen cultivates a scientific rigor and indomitable perseverance requisite for tackling complex engineering challenges. Finally, in the reflection phase (Stage Three), "3D Reverse Modeling Virtual Simulation" enables digital reconstruction and process retrospection of the final products. Students collaborate in teams to propose improvement schemes, thereby reinforcing a spirit of innovation and nurturing the profound patriotism and craftsmanship emblematic of "Master Artisans of a Great Nation", as they transcend from mere manufacturing to intelligent manufacturing, as shown in Figure 2.

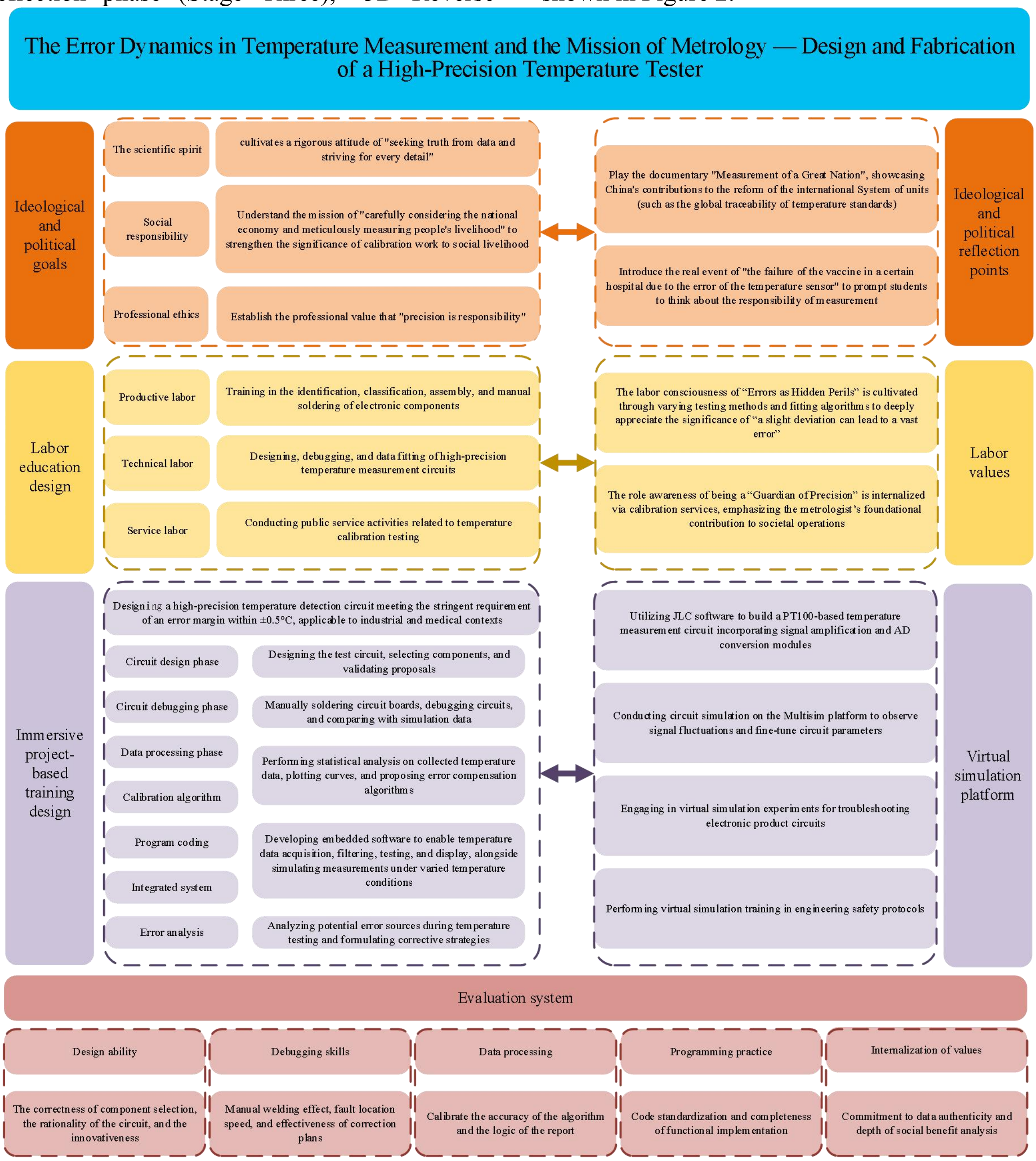

Figure 1. Case Study 1 of Engineering Training Project Reform

5. Evaluation and Reform: A Comprehensive Quality Monitoring System for the Entire Talent Cultivation Chain

5.1 Establishing Multi-Dimensional Assessment Indicators

This study breaks away from the single skills assessment model and constructs a three-dimensional evaluation matrix covering both "hard skills" and "soft qualities". The weight distribution tends to guide students to pay attention to the labor process and professional ethics.

The first is the "skill quantification" evaluation (accounting for 40%): focusing on accuracy and standardization. Relying on the automatic recording function of the digital twin system, students' professional skills are objectively scored. The system not only records various technical indicators of the final product, but also focuses on capturing key data during the operation process, such as "the rationality of process parameter Settings", "the standardization of tool usage", and "the logic of operation steps". Ensure the objectivity and scientific nature of skills assessment and reflect the technical rigidity of labor education.

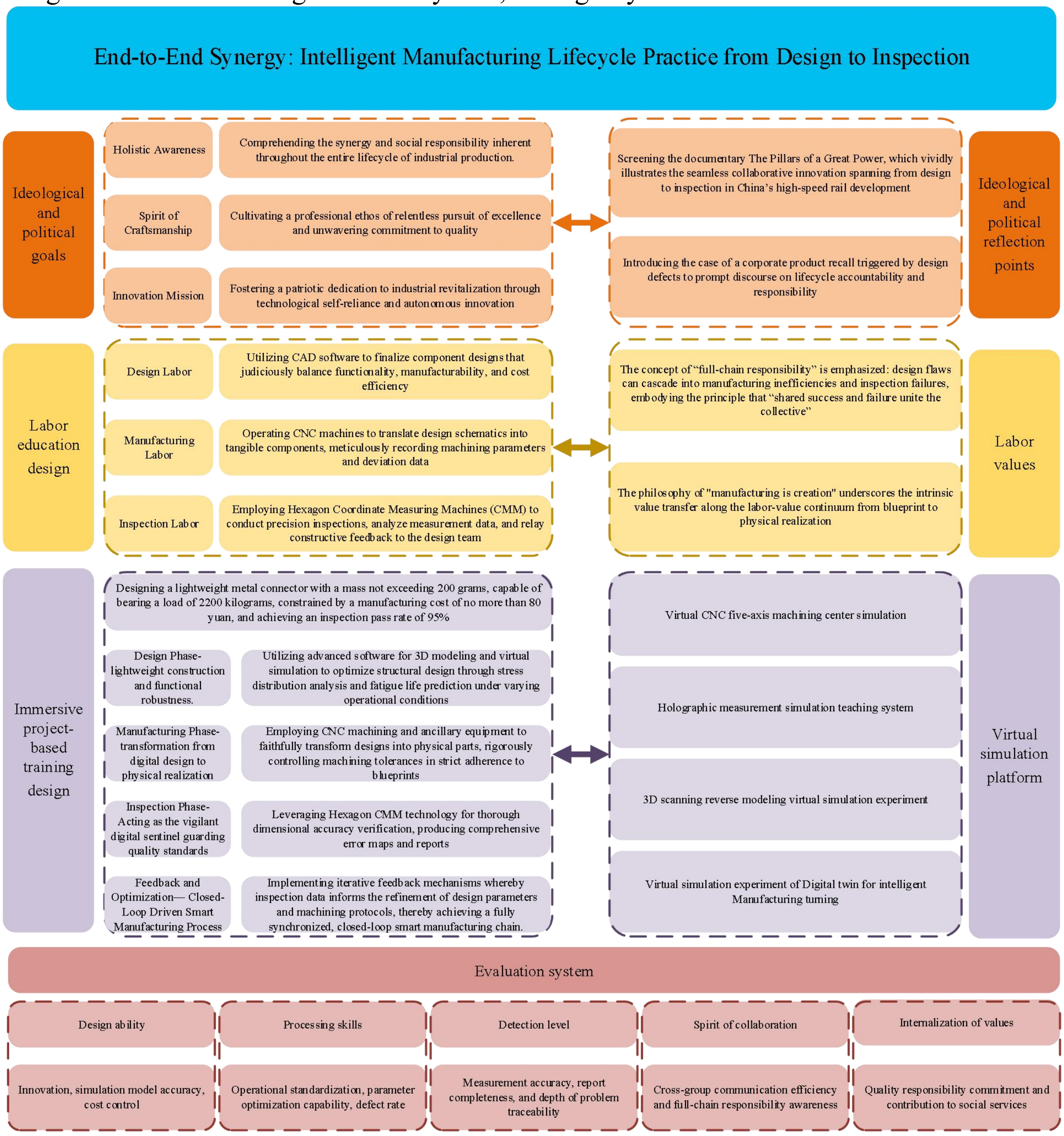

Figure 2. Case Study 2 of Engineering Training Project Reform

The second is the "attitude observation" evaluation (accounting for 30%): focusing on participation and resilience. By using the background logs and behavior analysis algorithms of the training platform, a "digital portrait" of students' implicit labor attitudes in immersive interactions is created. Record the effective interaction duration and operation frequency of students in the virtual simulation environment to eliminate the phenomenon of "idling". Focus on tracking students' behavioral feedback when they encounter "virtual failures" or "processing failures". For instance, count the "retry count" and "parameter correction iteration rate" of students after circuit debugging failures. If students can repeatedly try and constantly optimize until they succeed when encountering difficulties, the system will give them high scores to quantitatively evaluate their meticulous and indomitable craftsmanship spirit.

The third is the "value tracking" evaluation (accounting for 30%): focusing on sense of responsibility and collaboration. Adopt a method that combines subjective evaluation with objective recording. Bottom-line thinking assessment: Count the number of violations and the accuracy rate of emergency response by students in the "Virtual Simulation of Safe Operation", implement the "one-vote veto system for safety", and strengthen the respect for life and rules. During the reverse modeling and process review stage, the communication efficiency and contribution of students are evaluated through mutual assessment within the group and collaboration logs. Through the project summary report and ethical reflection defense, the depth of students' understanding of technical ethics and social responsibility is examined.

5.2 Feedback-Driven Evaluation and Continuous Improvement

Establish a two-way feedback mechanism based on data to continuously optimize "teaching" and "learning".

"Accompanying" diagnosis and improvement for students. The practical training system will generate an individual's "labor literacy map" in real time. During the practical training process, if students continuously engage in high-risk and non-compliant operations or experience a sudden drop in operational efficiency, "warning prompts" should be immediately issued, and relevant standard demonstration videos should be pushed for correction, achieving a transformation from "post-event accounting" to "in-process intervention". After the practical training, students can not only see their skill scores, but also their "craftsman index" and "safety Credit score", identify their shortcomings in professional qualities, and determine the direction for improvement.

Embracing a “data-driven” iterative approach to pedagogy, educators acquire a macro-level understanding of the class’s overall practical training status through online data analytics. For instance, if the data reveals a consistently elevated wastage rate during the “welding training” module, this signals potential deficiencies in instructional guidance or an imbalance in task difficulty. In response, instructors can dynamically recalibrate their teaching strategies by refining the training project’s task milestones and integrating ideological and political education more thoughtfully. This process cultivates a virtuous cycle of “instructional implementation—data feedback—strategy optimization—quality enhancement”, thereby ensuring that the integration of labor education with professional practical training is not only tangible but also profoundly effective.

6. Conclusion

Grounded in the forefront of undergraduate practical teaching reform, this study pioneers the construction of a “three-dimensional dynamic” integration mechanism and leverages digital twin technology to create an advanced training ecosystem characterized by seamless virtual-physical interaction. This innovation has triumphantly dismantled the traditional barriers between labor education and professional skill training. Empirical results demonstrate that the implementation of the “Three-Stage Immersion Method” effectively intertwines the intangible spirit of labor and craftsmanship with concrete, project-based tasks, thereby facilitating a transformative pedagogical shift from passive didacticism to immersive experiential learning. Concurrently, the establishment of a multidimensional evaluation system—encompassing skill quantification, attitudinal observation, and value tracking—provides rigorous, data-driven validation of the otherwise implicit ideological and political education outcomes. This approach decisively addresses the prevalent challenges of overemphasizing technical proficiency at the expense of moral cultivation and the disjunction between virtual simulation and practical application.

Acknowledgement

This work was financially supported by 2025 Open Competition Teaching Reform Project at China Jiliang University (Grant No. HEX2025016) and Zhejiang Province 14th Five-Year Plan Undergraduate Teaching Reform Project (Grant No JGBA2024227) and Zhejiang Provincial Key Project of Educational Science Planning (Grant No. 2025SB154) and 2025 Zhejiang Provincial Graduate Teaching Reform Project (Grant No JGCG2025636).

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