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Strategies for Constructing a Labor Education Curriculum System for Emerging Engineering Disciplines in Higher Vocational Colleges

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Abstract

In response to such problems as the disconnection between labor education and professional education in emerging engineering disciplines of higher vocational colleges, the confinement of digital-intelligent applications to the tool level, and the single-dimension curriculum evaluation, this study, taking digital-intelligent empowerment as the starting point, constructs a labor education curriculum system featuring "virtual-real integration and hierarchical progression" together with a whole-process evaluation mechanism characterized by "multi-stakeholder collaboration and digital-intelligent feedback", and carries out practical exploration in the integrated circuit technology specialty cluster of Suzhou Vocational Institute of Industrial Technology. Practice shows that students' digital-intelligent labor literacy and job adaptability have been improved, which can provide a reference for labor education reform in similar institutions.

Keywords

Digital-Intelligent Empowerment; Emerging Engineering Education; Labor Education; Curriculum System; Whole-Process Evaluation

Introduction

In March 2020, the Communist Party of China (CPC) Central Committee and the State Council issued the Opinions on Comprehensively Strengthening Labor Education in Universities, Secondary and Primary Schools in the New Era, which explicitly requires the overall optimization of school curricula and the integration of labor education into the entire process of talent cultivation, in combination with moral, intellectual, physical, and aesthetic education [1]. In terms of connotation, labor education in schools is not equivalent to organizing students to participate in specific productive labor; its focus lies in "educating people through labor", that is, achieving the goal of educating people through the vehicle of labor. Therefore, labor education is not only about guiding students to master labor skills and participate in

labor practice, but more importantly about cultivating their correct understanding of and positive attitude toward labor, helping them respect labor and establish correct labor values, thereby inheriting and carrying forward the spirit of labor.

However, with the advent of a new round of scientific and technological revolution and industrial transformation, digital-intelligent technologies such as big data and artificial intelligence have profoundly changed the social mode of production and exerted a far-reaching influence on the form and essence of labor. To meet the needs of new technologies and the new economy, in December 2017 the General Office of the State Council issued the Several Opinions on Deepening the Integration of Industry and Education [2], which explicitly proposed "adapting to the new round of scientific and technological revolution, industrial transformation, and the development of the new economy, promoting the cross-integration of disciplines and specialties, and accelerating the construction of emerging engineering education". The construction of emerging engineering education thus imposes requirements for the systematic restructuring of talent cultivation objectives, curriculum systems, and evaluation methods. Against this background, how to use digital-intelligent technologies to reconstruct the labor education curriculum system for emerging engineering disciplines in higher vocational colleges, so that the cultivation of labor literacy, the development of professional competence, and the industrial demand for digital-intelligent talent resonate at the same frequency, has become an issue of the times that vocational education reform must address.

1. An Examination of the Current Status of Labor Education Curriculum System Construction in Higher Vocational Colleges from the Perspective of Emerging Engineering Education

At present, professional education in higher vocational colleges increasingly focuses on students' precise mastery of knowledge and the comprehensive improvement of their practical skills. As an important component of the talent cultivation chain featuring the "coordinated development of the five educations", the curricularization of labor education is also advancing continuously. However, measured against the digital-intelligent and systematic development needs of emerging engineering industries such as integrated circuits and the Internet of Things, the labor education curriculum system still lags behind in terms of content structure and implementation mechanism, mainly in the following three aspects.

1.1. Insufficient Integration Between Labor Education and Professional Education, with a Narrow Professional Perspective

The labor processes of emerging engineering industries such as integrated circuits, artificial intelligence, and intelligent manufacturing are highly chain-based and collaborative. Taking the integrated circuit industry as an example, from chip design and wafer fabrication to packaging and testing and complete-machine application,

the labor tasks at each stage involve the cross-coordination of multiple professional skills. However, existing practices of integrating labor education with professional education mostly revolve around a single specialty [3], labor education is either simply embedded in a particular professional practice course, or replaced by general labor courses and public-welfare labor weeks, so that what students learn in labor courses is unrelated to the practical training tasks of their professional courses. This "point-to-point" mode of integration fails to fully consider the labor demand for the intersection of multiple professional skills in the processes of emerging engineering industries; cross-specialty collaboration is obviously absent, making it difficult to cultivate students' systematic cognition of, and collaborative ability across, the complete industrial labor chain.

1.2. The Application of Digital-Intelligent Technologies Remains at the Tool Level, with Superficial Virtual-Real Integration

Digital-intelligent technologies such as virtual simulation, big data, and artificial intelligence provide new support for the reform of labor education curricula, yet existing labor education practices show an obvious "tool-oriented" characteristic. Most higher vocational colleges use digital-intelligent technologies only to reinforce training in individual operational skills [4], without systematically designing labor education curricula at the level of the curriculum system. On the one hand, there is a lack of progressive competency linkage, from the elementary to the advanced, between virtual simulation training and authentic practical tasks; the two are often merely a simple procedural concatenation, and the problem of virtual and real practice being "two separate skins", namely "proficient in the virtual environment, yet still unfamiliar when operating on the job", is widespread. On the other hand, training content and assessment standards have long remained static and rigid, they can neither keep pace with the rapid iteration of emerging engineering technologies nor adapt to individual differences in students' abilities, so the advantage of dynamic adjustment that digital-intelligent technologies should support has not been brought into play.

1.3. Single-Dimension Evaluation of Labor Education Curricula and the Absence of Multi-Stakeholder Collaboration

In response to the digital-intelligent and systematic labor demands of emerging engineering industries, labor education evaluation should cover multiple dimensions (labor values, skill proficiency, professional literacy, and innovation outcomes) with the collaborative participation of enterprises, teachers, and students. However, although current labor education evaluation has shifted from "single outcome-based evaluation" to "pluralistic process-based evaluation" [5], it still falls short of the above requirements. First, the evaluation dimensions are incomplete, the content mostly focuses on skill mastery and labor performance, neglecting the

digital-intelligent collaboration ability and innovation-transformation ability urgently needed by emerging engineering industries. Second, the stakeholder collaboration is weak, enterprises have not yet participated deeply in the construction of the evaluation system, and the evaluation standards and data of the three parties ("enterprise, teacher, and student") are inconsistent and disconnected. Third, the data application is shallow, although some institutions have introduced digital-intelligent evaluation tools, they rely one-sidedly on the explicit data collected by platforms, falling into the misconception that "data supremacy overshadows humanistic judgment", so that digital-intelligent data and stakeholder evaluation remain "two separate skins".

2. The Value Logic of Constructing a Digital-Intelligently Empowered Labor Education Curriculum System for Emerging Engineering Disciplines in Higher Vocational Colleges

The rapid development of digital-intelligent technologies is profoundly reshaping the labor forms and talent demands of emerging engineering industries, while also providing entirely new tools for scenario construction and process evaluation in labor education. Against this background, constructing a digital-intelligently empowered labor education curriculum system for emerging engineering disciplines in higher vocational colleges has become a practical task facing vocational colleges. Its value logic is mainly embodied in three aspects; meeting the urgent need for talent cultivation in emerging engineering education, shouldering the fundamental task of fostering virtue through education, and serving the digital-intelligent transformation of regional industries. The three are interconnected and mutually supportive, together constituting the logical mainline of the construction of the labor education curriculum system.

2.1. The Urgent Need to Cultivate Talent with Digital-Intelligent Composite Labor Literacy

Labor education for emerging engineering disciplines aims to cultivate talent with diversified, comprehensive, and applied qualities, with practicality as one of its core principles. As technologies such as artificial intelligence and the Internet of Things penetrate deeply into industry, a large number of enterprise positions have shifted toward new forms of productive labor ("operating digital equipment, analyzing production data, and collaborating with intelligent systems"), and the demand of emerging engineering industries for talent has shifted from the traditional "operational-skill type" to the "digital-intelligent composite labor-literacy type". As a key vehicle for cultivating students' practical skills and labor literacy, labor education can keep talent cultivation abreast of the evolution of industrial labor forms only by reconstructing its curriculum system with the aid of digital-intelligent technologies, allowing students to undergo complete labor experiences in scenarios

where virtual simulation and real production are interwoven.

2.2. The Intrinsic Requirement for Implementing the Fundamental Task of Fostering Virtue Through Education

Cultivating well-rounded individuals with both virtue and talent is the common pursuit of modern education systems, and fulfilling the fundamental task of fostering virtue through education is the concentrated embodiment of this pursuit in educational practice. Fostering virtue through education takes "virtue" as its foundation and "action" as its endpoint. This fundamental task must be accomplished through practice, the most direct manifestation of which is labor. Only by deeply integrating labor education into the curricula of emerging engineering disciplines in higher vocational colleges, enabling students to understand the value of labor, develop labor norms, and cultivate the spirit of craftsmanship in authentic labor, and to temper their sense of teamwork and professional responsibility in digital-intelligent collaborative labor, can we promote equal emphasis on skill education and value shaping, and unify knowledge impartation with problem solving, so that the fundamental task of fostering virtue through education takes root in labor practice.

2.3. The Realistic Choice for Serving the Digital-Intelligent Transformation of Regional Industries

Serving regional economic development is the basic orientation of higher vocational colleges. At present, Suzhou is accelerating the transformation of its manufacturing industry under the initiative of "intelligent transformation, digital transition, and network connectivity". The digitalization rate of production equipment and the numerical-control rate of key processes in the city have reached 70% and 75% respectively, 80% of enterprises have achieved comprehensive digitalization of key business links, and emerging engineering industries such as intelligent manufacturing and integrated circuits are showing an upgrading trend toward "digital intelligence, cross-boundary integration, and scenario-based application". A large number of positions have shifted toward new forms of labor involving "operating digital equipment and analyzing production data", while the supply of technical talent has failed to keep pace. This requires higher vocational colleges to empower the construction of labor education curriculum systems with digital intelligence, to cultivate, in a targeted manner, composite talent equipped with the ability to apply digital-intelligent tools, cross-specialty collaboration ability, and the spirit of craftsmanship, thereby opening up the connection channel between talent cultivation and industrial demand.

3. Exploration of the Construction Path of a Labor Education Curriculum System for Emerging Engineering Disciplines at

Suzhou Vocational Institute of Industrial Technology in the Context of Digital-Intelligent Empowerment

Facing the trend of digital-intelligent transformation in emerging engineering industries, empowering labor education with digital-intelligent technologies has become a key approach to cultivating high-quality technical and skilled talent. With the strong guidance and support of the Suzhou Vocational Institute of Industrial Technology, the integrated circuit technology specialty cluster of Suzhou Vocational Institute of Industrial Technology, relying on the institute's well-established industry-education integration platform for talent cultivation, has carried out preliminary exploration around the construction of a labor education curriculum system for emerging engineering disciplines.

3.1. Top-Level Design and Platform Building: Constructing a Three-Tier Progressive Labor Education Base

With the strong support of the institute's Party committee and administration, the integrated circuit technology specialty cluster incorporated the construction of the labor education curriculum system into the overall revision of the talent cultivation program, and built, in stages, a three-tier progressive practice platform consisting of "teaching factories, enterprise workshops, and an industry college". On campus, the wafer testing and packaging-and-testing production processes of Huaxin Microelectronics were introduced to build two productive teaching factories, in which typical processes are decomposed into modular training projects; students rotate through posts and master basic skills while developing labor norms under production standards consistent with those of enterprises. Beyond the campus, the cluster jointly established enterprise workshops such as the "Low-Power IoT Intelligent Workshop" with Yitaile and Huaxin Micro, where students, in the capacity of "engineers-in-training", undertake real work orders and experience complete industrial labor processes. At a higher level, the cluster, together with more than 40 organizations including the China Semiconductor Industry Association, the Suzhou Institute of Nano-Tech and Nano-Bionics of the Chinese Academy of Sciences, and MEMSensing Microsystems, co-established an advanced semiconductor industry college oriented toward "specialized, refined, distinctive, and innovative" development, organizing students to carry out innovative practice targeting real technical problems of enterprises. The three tiers of platforms are interlocked, and each tier of courses is supported by authentic labor carriers, ensuring that the "three-tier progression" is not suspended in the air.

3.2. Virtual-Real Integration and Hierarchical Progression: Reconstructing the Labor Education Curriculum Chain

At the level of integrated circuit technology courses, the specialty cluster takes the coordination of virtual simulation and authentic practice as the basic unit and

reconstructs the labor education curriculum chain according to the sequence of "foundation, application, and innovation". The foundation tier emphasizes promoting real practice through virtual training: courses such as Fundamentals of Electronic Technology and Cognition of Integrated Circuit Manufacturing Processes move high-risk procedures, such as equipment disassembly and assembly, die bonding, and wire bonding, forward into the digital twin classroom for repeated rehearsal; only after meeting the standards may students enter the teaching factory for hands-on operation, which reduces training costs and safety risks. The application tier emphasizes competence development through authentic workplace practice, where courses such as Practical Training in Chip Packaging and Testing and IoT Product Assembly, Commissioning, Operation and Maintenance use real work orders from enterprise workshops as their basis, enabling students to integrate discrete skills into well-rounded labor competence through genuine delivery tasks. The innovation tier emphasizes cross-boundary breakthroughs by drawing on skills studios such as the "Wu Zhenying Skills Master Workstation" and the "Chip-Chain Future Skills Master Studio" and by making use of teaching workshops, skills competitions, and innovation and entrepreneurship practice, thereby guiding students to engage in collaborative innovation that addresses the real needs of enterprises. Meanwhile, two articulation rules, namely "hands-on operation is permitted only after passing virtual pre-training" and "upper-tier tasks originate from real problems in the lower tier", ensure that the progression does not run idle, and cross-specialty skill intersection points, such as packaging-and-testing data serving terminal assembly and commissioning and test reports connecting to application scenarios, are embedded into tasks at each tier, so that students of different specialties can labor collaboratively on the same industrial labor chain.

3.3. Multi-Stakeholder Collaboration and Digital-Intelligent Feedback: Constructing a Whole-Process Evaluation Closed Loop

In response to the digital-intelligent and systematic talent demands of emerging engineering industries, the specialty cluster has established four evaluation dimensions (labor cognition, skill mastery, literacy development, and outcome transformation) and refined each into observable and collectable secondary indicators, such as the pass rate of virtual procedures, the first-pass rate of real work orders, contributions to team collaboration, and the adoption of process improvement suggestions, thereby transforming abstract labor literacy into concrete, evaluable performance. To prevent evaluation from degenerating into the subjective judgment of a single stakeholder, enterprise mentors, teachers, and students jointly formulate evaluation standards, jointly review process data, and jointly assess labor outcomes, with the opinions of enterprise mentors directly counted in the overall evaluation. The digital-intelligent scenario combining a digital twin classroom, an intelligent manufacturing production line, and online learning

profiles provides a data foundation for evaluation, with students' operation logs, work order data, and collaboration records being captured throughout the process. However, data collection does not mean that data has the final say, because the specialty cluster stipulates that the weight of digital-intelligent data in the overall evaluation shall not exceed 60 percent, and that the dimensions of labor cognition and literacy development are always evaluated primarily by people and supplemented by data, thereby preventing quantifiable data from obscuring judgments about labor attitudes and the spirit of collaboration. The value of evaluation is ultimately embodied in the feedback stage, in that at the end of each semester the course team and enterprise mentors jointly analyze the differences among the three parties' scores and the process data and make dynamic adjustments accordingly to the ratio of virtual to real class hours and to the difficulty of work orders at each tier. For example, in response to the concentrated errors of a certain cohort of students in setting wire-bonding parameters, the course team promptly increased the proportion of class hours devoted to that procedure in virtual pre-training and raised the rotation frequency at the corresponding stations in the teaching factory, thus setting the "evaluation-feedback-optimization" closed loop truly in motion.

3.4. Strengthening the Teaching Workforce and Safeguards: Consolidating the Implementation Foundation Through School-Enterprise Collaboration

The implementation of the curriculum system and evaluation mechanism cannot do without the dual support of the teaching workforce and resources. The key to integrating labor education into professional courses lies in teachers. Relying on a national-level teaching innovation team for vocational education, the specialty cluster, through a combination of special training and enterprise-based practice, guides professional teachers to organically integrate labor education elements into course teaching and to continuously update their understanding of the industry. Through school-enterprise collaboration, enterprise mentors participate deeply in workshop construction, work order design, and the formulation of evaluation standards, thereby guaranteeing the authentic labor scenarios required for curriculum implementation, linking on-campus labor venues with enterprise internships in a coherent way, and enabling students to develop their competence on a broader practical stage. In terms of digital-intelligent resources, the digital-intelligent labor education teaching resources developed by the specialty cluster now cover four specialties, namely integrated circuit technology, IoT application technology, electronic information engineering technology, and modern communication technology, benefiting more than 3,200 student-person-times and providing foundational support for the continuous operation and iteration of the curriculum chain.

4. Conclusion

The key to constructing a labor education curriculum system for emerging engineering disciplines in higher vocational colleges from the perspective of digital-intelligent empowerment lies in ensuring that every tier of courses corresponds to an authentic labor carrier, that every evaluation indicator corresponds to collectable data and a clearly defined evaluating stakeholder, and that every evaluation feedback corresponds to a concrete adjustment of the curriculum. The preliminary practice of the integrated circuit technology specialty cluster at Suzhou Vocational Institute of Industrial Technology shows that, with the operation of the curriculum system, the breadth of students' participation in real enterprise projects and their job adaptability have improved; the proportion of graduates entering enterprises in the regional electronic information industry cluster has remained at a high level; partner enterprises commonly comment that students "get up to speed quickly"; and in 2025 the specialty cluster was selected as a national high-level specialty cluster. It should be noted that the development of students' comprehensive literacy is the result of the long-term synergistic effect of multiple links such as courses, practical training, and competitions, and the specific contribution of the labor education curriculum system remains to be verified through longer-term and broader follow-up observation. Future work will focus on continuously improving the consistency calibration of the "enterprise-teacher-student" evaluation standards and the industrial coverage of cross-specialty labor tasks, so as to provide a reference for labor education reform in similar higher vocational colleges.

Finding

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