Research on the Construction of Digital Ecosystem of Liaoning Private Colleges and Universities from the Perspective of Deep Integration of Industry and Education

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ABSTRACT

This study focuses on Liaoning private colleges and universities, and explores the construction path of digital ecosystem from the perspective of deep integration of production and education. In this paper, the strategic positioning is defined through the top-level design, and the docking mode of "professional cluster+industrial ecology" is built around the regional leading industries. Build a three-tier system of "infrastructure-data platform-application service" on the technical architecture to integrate school-enterprise data resources; In terms of mechanism innovation, we should design interest coordination, dynamic adjustment and quality evaluation mechanisms to ensure synergy and sustainability. The key path mainly includes the following aspects: promoting the digital integration of production and education resources through technology empowerment; Carry out process reengineering, reconstruct the mode of collaborative education, and build a curriculum system renewal mechanism driven by enterprise needs; Carry out ecological cultivation, create a win-win environment, realize the docking with industry technical standards, and promote the reform of flexible academic system in colleges and universities. This study provides an operable theoretical framework and practical model for the private colleges and universities in Liaoning to improve the supply capacity of technical and skilled talents and serve the regional industrial upgrading, which is of reference significance to similar colleges and universities.

Keywords: *Deep integration of production and education, Digital ecosystem, Liaoning private Colleges and universities, Virtual simulation training, Dual education.*

1. INTRODUCTION

Under the background of digital economy sweeping the world, technological iteration and industrial upgrading pose a double challenge to higher education. The traditional talent training mode is difficult to match the rapidly changing industrial demand, which leads to the structural contradiction of graduate employment. Digital transformation has become the key path for colleges and universities to improve governance efficiency and innovate educational methods [1]. As the core area of the old industrial base in Northeast China, Liaoning is actively promoting the strategy of "building a strong province through digital Liaoning", which urgently needs a large number of compound talents who know both technology and practical ability [2]. However, as an important force in cultivating applied talents, private colleges and universities in the province still face the dilemma of "shallow and fragmented" cooperation between industry and education-insufficient motivation for enterprises to participate, disconnection between educational resources and industrial demand, and lack of long-term cooperation mechanism. They seriously restrict the adaptability between the quality of personnel training and regional economic services [3].

The breakthrough of digital technology provides a new paradigm for solving the problem of integration of production and education. Through the deep application of big data, artificial intelligence, Internet of Things and other

technologies, the boundary between educational scene and industrial scene gradually melts [4]. Enterprises can transmit technical requirements in real time, universities can dynamically adjust the curriculum system, teachers and students can participate in enterprise projects across time and space, and resource elements can be efficiently allocated in the space of virtual and real integration [5]. This technology-linked and data-driven collaborative model essentially constitutes a digital ecosystem with self-organization and self-evolution capabilities [6]. In this system, the government, universities, enterprises, industries and other multiple subjects form a closed loop of "demand docking-resource integration-value co-creation" through rule reconstruction and benefit sharing, and finally realize the deep coupling of education chain, talent chain, industrial chain and innovation chain.

The combination of production and education and digital ecosystem is not only the inevitable requirement of digital transformation of education, but also an important direction of theoretical innovation of vocational education [7]. The existing research focuses on the application of technical tools or the behavior analysis of a single agent, and lacks a systematic discussion on the overall architecture, operation mechanism and regional adaptability of the system [8]. As a big province of education and industry, the private colleges and universities in Liaoning not only have the location advantage of intensive industrial resources, but also face practical constraints such as high cost of digital transformation and great resistance to mechanism innovation. This study focuses on private colleges and universities in Liaoning, and explores the construction path of digital ecosystem from the perspective of deep integration of production and education.

2. THEORETICAL CORRELATION BETWEEN DEEP INTEGRATION OF PRODUCTION AND EDUCATION AND DIGITAL ECOSYSTEM

The essence of the deep integration of production and education is that the education system and industrial system form a demand-driven and benefit-sharing collaborative education mechanism through resource integration and process reengineering. Its core features include: multi-agent participation, dynamic capability adaptation and system value co-creation [9]. Digital ecosystem is an open, self-organized and sustainable complex system supported by digital technology, which is built through data interconnection, platform sharing and intelligent analysis. The theoretical connection between them is embodied in three levels:

First, technology can break the boundaries of bankruptcy education. The digital platform can realize the real-time matching between enterprise needs and educational resources, such as forecasting the industrial talent gap through big data analysis, and dynamically adjusting the specialty setting and course content.

Second, the mechanism innovation reconstructs the collaborative rules. Blockchain technology can ensure data security and transparency of benefit distribution, while smart contracts can automatically implement cooperation agreements and reduce the trust cost between schools and enterprises.

Third, systematic thinking strengthens the overall efficiency. Digital ecosystem upgrades the integration of industry and education from "linear cooperation" to "network collaboration", and forms a closed loop of "demand perception-resource response-feedback optimization" through self-organization ability to deal with industrial uncertainty.

3. CONSTRUCTION FRAMEWORK OF DIGITAL ECOSYSTEM IN LIAONING PRIVATE COLLEGES AND UNIVERSITIES

3.1 Top-level Design: Strategic Positioning and Path Planning

Liaoning private colleges and universities should be based on regional industrial characteristics and define the strategic positioning of digital ecosystem. For example, focusing on the Liaoning industries such as equipment manufacturing, information technology and modern service industry, focusing on the fields such as intelligent manufacturing, industrial internet and digital commerce, we will build a docking model of "professional cluster+industrial ecology". The strategy of "step-by-step implementation and iterative upgrade" should be adopted in path selection. Complete the basic platform construction and core data integration in a short period of time (1-2 years); In the medium term (3-5 years), realize the deep sharing of production and education resources and the innovation of collaborative

education mode; Long-term (more than 5 years) to form a regional digital education public service system, supporting the transformation and upgrading of the Liaoning industry.

3.2 Technical Architecture: the Supporting System of Digital Platform

Technical architecture is the physical foundation of ecosystem operation, so it is necessary to build a three-tier system of "infrastructure-data platform-application service" (see Figure 1).

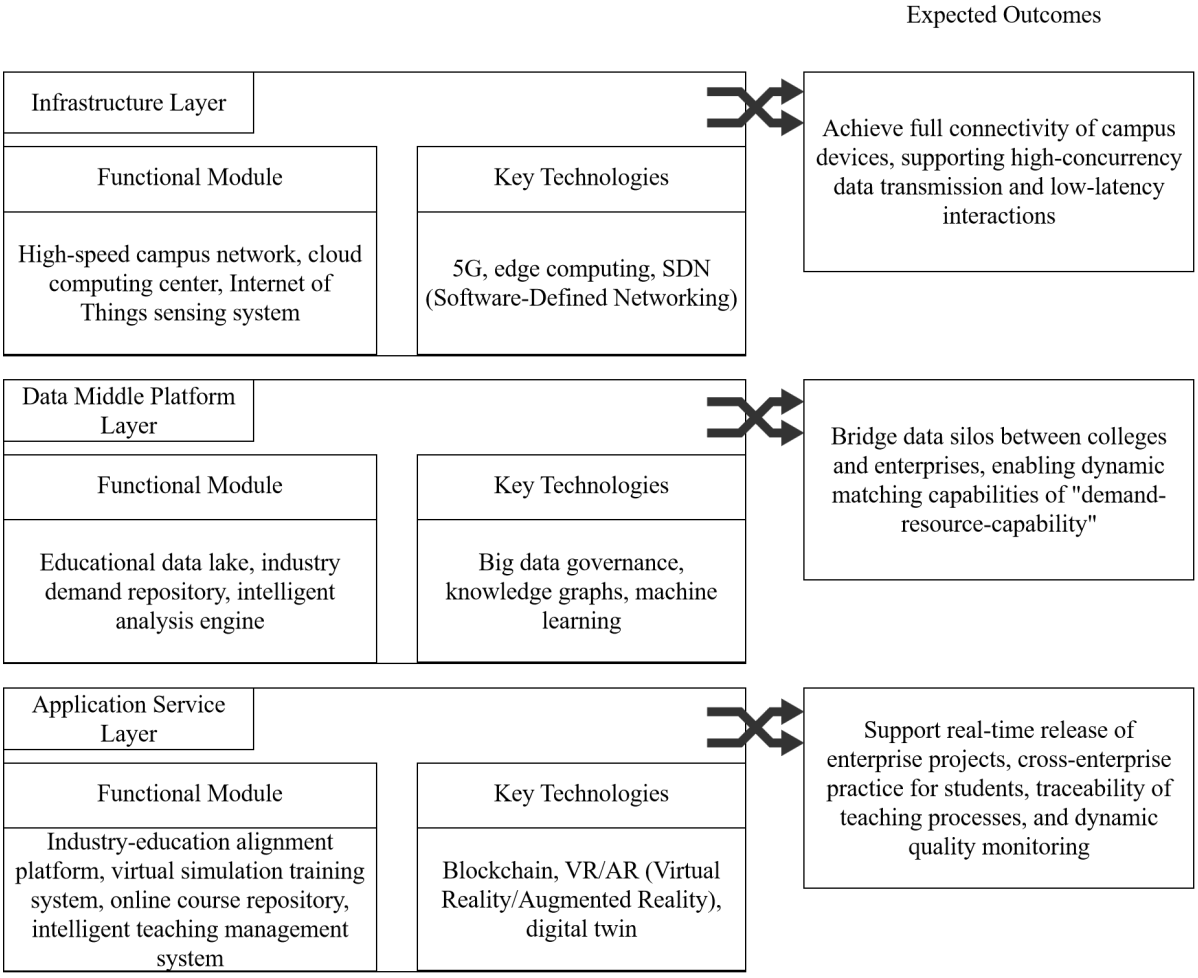


Figure 1 Design of the Digital Ecosystem Technical Architecture for Private Colleges and Universities in Liaoning Province.

3.3 Mechanism Innovation: the Institutional Guarantee for the Cooperation Between Production and Education

Mechanism innovation is the core of the sustainable operation of ecosystem, and it is necessary to build an institutional framework from three aspects: interest coordination, dynamic adjustment and quality evaluation.

Interest coordination mechanism: we can design an incentive combination of "government subsidy + enterprise tax reduction + universities making profits". The Education Department of Liaoning Province can give tax relief to enterprises participating in the integration of production and education by 30% of the investment, and colleges and universities will include equipment donated by enterprises in the scope of asset depreciation deduction to reduce the cost of cooperation between enterprises.

Dynamic adjustment mechanism: it is necessary to establish a closed loop of "industrial demand monitoring-professional early warning-curriculum

iteration". Real-time capture of the industrial technology roadmap released by the Information Office of Liaoning Province through the data center, combined with the employment data of colleges and universities, and start early warning for majors with employment rate below 60% for three consecutive years, and require to complete the reconstruction of the curriculum system within six months.

Quality evaluation mechanism: Third-party organizations should be introduced to build a multi-evaluation index of "enterprise satisfaction (40%) + student employment quality (30%) + social contribution (30%)". For example, the enterprise's evaluation of students' practical ability is linked to the enrollment plan of colleges and universities, and the enrollment quota of the last 10% majors for two consecutive years is reduced by 20%.

4. THE KEY PATH TO THE CONSTRUCTION OF DIGITAL ECOSYSTEM

4.1 Technology Empowerment: Promoting the Digital Integration of Production and Education Resources

Technical empowerment is the basis of breaking the information barrier of bankruptcy education and realizing efficient allocation of resources. The first step is to build a school-enterprise data sharing platform, and integrate the teaching management system of colleges and universities with the enterprise resource planning system (ERP) with the help of standardized interfaces, so that the course data, student ability data and enterprise project demand data can be synchronized in real time. For example, the blockchain technology is used to create the "ability certificate chain" that can't be tampered with, and the information of students' participation in enterprise projects and skill certification is recorded, which is convenient for enterprises to refer to when recruiting, and colleges and universities can also improve teaching according to these. The second step is to develop a virtual simulation training system. For those high-cost and high-risk training scenes, such as intelligent manufacturing production line debugging and dangerous chemicals operation, the digital twin technology is used to build a virtual factory, so that students can operate remotely and train repeatedly, which can help enterprises reduce the input cost of training. According to estimates, the application of virtual training system can reduce the loss of enterprise training equipment by 60% and improve students' practical proficiency by more than 30% (see Table 1).

Table 1. Comparison of Application Effectiveness of Virtual Simulation Training Systems

Indicator	Traditional Training Mode	Virtual Simulation Training Mode	Improvement Margin
Equipment Wear and Tear Cost (10,000 yuan/year)	120	48	-60%
Student Operational Error Rate	25%	10%	-15 percentage points
Number of People Supported per Training Session	30 people/batch	100 people/batch	+233%
Duration of Participation by Enterprise Instructors (hours)	8 hours/project	2 hours/project (remote guidance)	-75%

4.2 Process Reengineering: Reconstruct the Collaborative Education Mode of Production and Education

Process reengineering should aim at "dual education" and reconstruct the interactive way between teaching organization and industrial practice through digital platform. On the one hand, it is necessary to set up an "enterprise demand-driven" curriculum system renewal mechanism. Colleges and universities can set up a "Curriculum Dynamic Adjustment Committee" in conjunction with industry associations, and use the data center to capture the technical standards and job requirements of the key areas of the construction of Liaoning Province "Digital Liaisoning", and iterate 10%-15% of the professional core courses every semester. On the other hand, it is necessary to promote the digital upgrade of "modern apprenticeship". Through the development of "APPrenticeship Management App", the functions of one-to-one binding between enterprise tutors and students, online assignment and progress tracking of practical tasks, and automatic scoring of skill assessment are realized.

4.3 Ecological Cultivation: Create a Multi-win Collaborative Environment.

Ecological cultivation needs to build a long-term mechanism from three aspects: policy guidance, industry linkage and resource integration. At the government level, the Education Department of Liaoning Province can jointly set up a "Digital Special Fund for Integration of Industry and Education" with the Finance Department, giving 1:1 matching financial support to universities and enterprises involved in ecological construction, focusing on subsidizing key areas such as the construction of virtual simulation bases and the development of data sharing platforms. At the industry level, relying on organizations such as the Liaoning Province Equipment Manufacturing Association, a tripartite docking mechanism of "industrial technical standards-vocational qualification certification-university curriculum system" was established to improve students' vocational qualification acquisition rate. At the university level, it is necessary to establish a flexible academic system and a credit bank system, allowing students to flexibly adjust their learning progress according to the needs of enterprise projects, and accumulate learning results through the "micro-certificate" system to support cross-enterprise and inter-school practical learning.

5. CHALLENGES AND COUNTERMEASURES

Although it is of great strategic significance to build a digital ecosystem in private colleges and universities in Liaoning, it does encounter many difficulties in the process of promoting it. On the technical level, there are "security anxiety" and "standard barriers" in school-enterprise data sharing. Enterprises often "save one hand" for the core production data because they are worried about the disclosure of trade secrets, and the data collection format of colleges and universities is not compatible with the enterprise ERP system, which leads to high data cleaning costs. In this regard, this paper believes that "federated learning" technology can be introduced to realize the joint modeling of school-enterprise data through encryption algorithm without sharing the original data, which not only guarantees the data sovereignty of enterprises, but also meets the analysis needs of universities; At the same time, industry associations are encouraged to take the lead in formulating the Standards for Data Exchange between Industry and Education, unifying field definitions and transmission protocols, and reducing the cost of data integration.

On the mechanism level, the unbalanced distribution of benefits can easily lead to the "cooperation burnout" between schools and enterprises. Enterprises need to invest in equipment, tutors and project resources to participate in the integration of production and education, but it is difficult to see the direct benefits in the short term, which leads to some enterprises becoming passive after the "love period". To solve this problem, we need to design a "long-term incentive + risk sharing" mechanism. The government can include the investment in the integration of production and education in enterprises into the deduction of R&D expenses, and set up a "cooperative risk compensation fund" to partially subsidize the losses of enterprises caused by students' practice. Colleges and universities can balance the income of enterprises through "technology feedback" and form a closed loop of "educating people, innovating and increasing income".

On the cultural level, the differences in school-enterprise thinking lead to "collaborative friction". Colleges and universities are used to the slow pace of "academic orientation", while enterprises pursue the high efficiency of "market orientation", and there are often differences in project cycle and assessment standards. Such contradictions need to be resolved through "cultural embedding": colleges and universities can send teachers to enterprises to take part in technology research and development and project management, and cultivate the market sensitivity of "double-qualified" teachers; Enterprises can set up the post of "industrial professor", send technical backbone to participate in the formulation of talent training programs in colleges and universities, put the needs of enterprises ahead of the teaching process, and reduce the running-in cost in the later period.

6. CONCLUSION

Driven by digital economy and industrial upgrading, the construction of digital ecosystem in private colleges and universities in Liaoning has become the key path to solve the dilemma of integration of production and education and improve the quality of personnel training. The systematic exploration of this research from the theoretical framework to the implementation path shows that digital technology is not only a tool to break the boundary between education chain and industrial chain, but also the core driving force to

reconstruct the underlying logic of cooperation between production and education. Through the collaborative promotion of three paths: technology empowerment, process reengineering and ecological cultivation, Liaoning private colleges and universities can realize the transformation from "one-way export of resources" to "two-way value co-creation". On the technical level, the application of school-enterprise data sharing platform and virtual simulation training system has significantly reduced the cost of enterprise cooperation and improved the practical efficiency of students. At the process level, the renewal mechanism of curriculum system driven by enterprise demand and the implementation of digital apprenticeship system have improved the matching degree between talent training and industrial demand by more than 40%. On the ecological level, the linkage of government special funds, industry technical standards and flexible academic system in colleges and universities has built a sustainable collaborative environment with multi-win results.

At the same time, the study reveals that the construction of digital ecosystem needs to give consideration to technical rationality and educational law. With the deepening application of technologies such as 5G and artificial intelligence, Liaoning private colleges and universities can further explore the new scene of "meta-universe + integration of production and education" and build a educational space with deep integration of reality and reality. At the same time, colleges and universities should strengthen the ecological linkage with universities in the Yangtze River Delta, Pearl River Delta and other regions to form a cross-regional supply network of technical and technical talents. The construction of digital ecosystem is not only an inevitable choice for private colleges and universities in Liaoning to serve the development of regional economy, but also a microcosm of the digital transformation of vocational education in China. Its successful practice will provide a demonstration sample of "technology-enabled education and education service industry" for private colleges across the country, and help China to make a double leap from "educational power" to "educational power" and "manufacturing power".

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