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Research on Innovative Strategies of Educational Management in Vocational Undergraduate Colleges in the Era of Big Data

Haixiang Xiong*

Department of Library, Hainan Vocational University of Science and Technology, Haikou, Hainan, 571126, China
**Corresponding author*

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Abstract: With the in-depth advancement of the digital transformation in education, big data technology has provided a revolutionary opportunity for reconstructing the educational management model of vocational undergraduate colleges. This paper focuses on the research of innovative paths for educational management in vocational undergraduate colleges against the backdrop of the big data era. Firstly, the paper analyzes the systematic challenges currently faced by vocational undergraduate colleges in the practice of educational management, and constructs an application system model to address these issues. Based on this system, the paper further proposes relevant innovative strategies. Only through the three-dimensional linkage of technology, system, and talent to carry out systematic reforms can vocational undergraduate colleges promote the leap of educational management from an experience-based, extensive model to a data-driven, precise and intelligent modern governance model, thereby laying a solid governance foundation for cultivating high-quality technical and skilled talents.

1. Introduction

As the wave of the Fourth Industrial Revolution, represented by big data, artificial intelligence, and cloud computing, sweeps across the globe, human society is accelerating its entry into a new era of "intelligent civilization" where data serves as the core factor of production. Against this grand backdrop, higher education, as a key junction connecting science and technology (the primary productive force), talent (the primary resource), and innovation (the primary driving force), finds the modernization process of its governance system and governance capacity inevitably intertwined with the historical proposition of digital transformation. The Outline for Building a Powerful Education Country (2024-2035), issued in 2024, clearly states that it is necessary to "strengthen data integration, connect the full-chain management information systems for schools, students, and teachers, and build a new big data-enabled education governance system" [1]. This marks that data-driven development has become a core strategic fulcrum for promoting the high-quality development of education at the national level, and also points out the direction for the reform of

educational management in colleges and universities of all types and at all levels.

Vocational undergraduate education, as a key link in China's modern vocational education system, shoulders the important mission of cultivating high-level technical and skilled talents and serving the transformation and upgrading of regional industries. However, in the face of new challenges such as the diversification of student source structure, the prominent demand for personalized development, and the accelerated iteration of industrial technologies, the traditional management model—relying on manual work, featuring rigid processes, and showing delayed responses—has been difficult to adapt, and even become a bottleneck restricting its connotative development. Therefore, how to leverage big data technology to achieve the precise, intelligent, and modern transformation of educational management is not only an internal need for vocational undergraduate colleges to improve their own governance efficiency, but also an inevitable choice for them to fulfill their mission of type-specific education and enhance social attractiveness. Based on the context of the big data era and the actual development of vocational undergraduate education, this study focuses on the core question of "how to systematically construct a new big data-driven educational management model for vocational undergraduate colleges". On the basis of analyzing the current situation and challenges, the paper will construct an application system model covering four dimensions: demand, resource, service, and organization, and accordingly propose a set of innovative strategies integrating multiple elements such as technology, system, and talent. The purpose is to provide a path reference with both theoretical depth and practical value for the digital transformation of educational management in vocational undergraduate colleges, helping them seize opportunities in the new round of scientific and technological revolution and educational reform, and effectively improve the quality of cultivating high-quality technical and skilled talents [2,3].

2. Current Situation of Educational Management in Vocational Undergraduate Colleges in the Era of Big Data

2.1 The Overall Construction of Application Supply System Needs Improvement

According to the 2023 Report on the Informatization Development of Chinese Colleges and Universities, current colleges and universities have significant shortcomings in the informatization construction of scientific research and teaching. Specifically, 29.8% of the "Double First-Class" construction universities and 67.2% of the colleges included in the "Double High-Level Plan" (a national initiative to develop leading vocational colleges and majors in China) do not provide high-performance computing services; 27.3% of the "Double First-Class" construction universities and 75.9% of the "Double High-Level Plan" colleges have not built shared platforms for large-scale instruments and equipment; and 64.7% of the "Double First-Class" construction universities and 44.1% of the "Double High-Level Plan" colleges have not yet established information management systems for scientific research [2]. Such deficiencies in resources and systems have severely restricted the efficiency of scientific research innovation and the effectiveness of resource utilization in colleges and universities. At present, the big data application platforms of many colleges and universities only recommend courses simply based on majors, without integrating students’ learning progress, knowledge mastery, and interests. As a result, they fail to provide truly personalized learning content. This extensive recommendation method means that the potential value of teaching data has not been fully explored, making it difficult to achieve effective transformation from data to practical application, which in turn hinders the improvement of education quality.

2.2 Data "Silos" in the Student Educational Management System

The traditional university management model is mainly based on functional division, resulting in obvious operational barriers between departments. Under this model, the responsibilities of data management are vague, and there is a lack of clear division of labor and coordination mechanisms. At the same time, universities generally lack authoritative big data management centers, which makes it impossible to effectively conduct overall planning and resource scheduling of data resources, thereby affecting the integration and sharing of data. Taking Zhejiang University as an example, departments such as the Scientific Research Office, Academic Affairs Office, and Information Center on campus once operated independently. Although the Information Center had the technical capability to integrate data, it was difficult to get involved due to the lack of a unified inter-departmental coordination mechanism. When teachers attempt to carry out big data-driven teaching innovation, they often face lengthy administrative approvals and difficulties in resource allocation. As a result, even if high-quality data application cases are developed, they struggle to break through the limitations of "silos" and fail to form a scale effect and a collaborative innovation ecosystem—due to the absence of systematic promotion mechanisms and experience-sharing channels.

2.3 Lagging Digital Transformation of Capabilities in Core Decision-Making Links

In the process of building a digital governance system in universities, the digital transformation of decision-making capabilities lags significantly. The 2023 Report on the Informatization Development of Chinese Colleges and Universities shows that in 2022, only 48.1% of universities used big data for school situation analysis; the coverage rate of universities that had built management information systems for development planning was merely 23.7%; and the proportion of universities that used a microservice architecture to build development planning applications was only 7.3%, all remaining at a low level. More seriously, the proportion of universities with digital decision-making has remained stagnant at 39.9% for two consecutive years, indicating a severe lack of depth and breadth in technology application [2]. Currently, most universities still rely mainly on traditional experience and partial data in core decision-making links such as student management and teaching evaluation, failing to make full use of technologies like big data and artificial intelligence to build dynamic analysis models. This makes it difficult for management to obtain comprehensive and real-time information, and unable to accurately identify key issues such as bottlenecks in discipline development and students' actual growth needs. Meanwhile, the coverage of decision-making applications is limited, and the digital support capability is relatively weak. These factors not only hinder the improvement of university governance efficiency but also weaken the accuracy and forward-looking nature of strategic decision-making.

2.4 Regional Differentiation in the Application Effectiveness of Big Data Technology

In terms of management model innovation, the application of big data technology in colleges and universities in central and western China mostly remains at the stage of resource allocation optimization and minor adjustments to management processes [4]. Some institutions only use big data for basic tasks such as student attendance statistics and the distribution of scholarships and grants, failing to fully explore the potential value behind the data [5]. In sharp contrast, colleges and universities in eastern China have demonstrated strong digital transformation capabilities when responding to public emergencies. During the COVID-19 pandemic, for example, some "Double First-Class" universities in eastern China quickly built intelligent platforms covering all scenarios of teaching, management, and services. Through real-time data monitoring and dynamic analysis,

these platforms realized functions such as online teaching quality evaluation and early warning of students' mental states, fully verifying the great potential of big data technology in improving management effectiveness [6]. In addition, there are also significant differences in the digital transformation process among universities of different natures. In particular, ministry-affiliated universities—characterized by large scale and complex organizational hierarchy—face higher reform costs in breaking down inter-departmental data barriers and promoting interdisciplinary collaboration, due to the inertia of traditional management systems.

3. Construction of the Application System of Big Data in Educational Management of Vocational Undergraduate Colleges

Faced with the systematic challenges in the educational management of vocational undergraduate colleges, piecemeal technology applications can hardly solve the problems fundamentally. It is essential to construct an integrated application system that combines top-level design with bottom-level support, and coordinates technology empowerment with business reconstruction.

3.1 Precision-Driven Educational Management

The demand layer serves as the value orientation and logical starting point of the entire system. Its core lies in accurately identifying and defining key data-driven scenarios and core demands from the specific management businesses of vocational undergraduate education. The participants are educational managers at all levels, including university leaders, heads of functional departments and secondary colleges, program leaders, and counselors [7]. The demand layer of vocational undergraduate colleges features distinct "vocational orientation" and "process orientation", and must focus on the entire chain of high-level technical and skilled talent cultivation. Specifically, it is necessary to systematically sort out the following types of key demands. The demand for in-depth linkage between enrollment and employment: This requires going beyond simple statistics on enrollment registration rates and employment rates, and building a closed-loop analysis capability covering "student profile - cultivation process - employment quality" to guide targeted enrollment promotion and optimization of program structure. The demand for academic early warning and precise support under the integrated education mechanism of "post-course-competition-certificate": It is necessary to real-time monitor students' progress in four dimensions—course learning, practical training, competition performance, and certificate acquisition—through data, so as to realize early identification and proactive intervention of learning difficulties. The demand for personalized growth path planning: Based on students' interests and potential, skill baselines, and career tendencies, dynamic recommendations of differentiated technical skill modules and learning resources should be provided to achieve precise cultivation of "one plan per student". The demand for evaluating the effectiveness of industry-education integration: It is required to integrate corporate mentor evaluations, project-based practical training data, and students' practical assessment records, conduct quantitative analysis on the quality and benefits of cooperative projects, and provide decision-making basis for optimizing the school-enterprise cooperation model. The effective operation of the demand layer fundamentally relies on the transformation of managers' data thinking—shifting from passively requesting reports to proactively using data to define problems and seek solutions.

3.2 Integration and Governance of Data Resources

The resource layer serves as the cornerstone for the operation of the entire application system. Its

core task is to transform scattered, heterogeneous, and raw original data into centralized, standardized, clean, and usable high-quality data assets through systematic governance and integration. This process involves the standardization of on-campus data resources and the introduction of off-campus industrial data, with participants including information technology departments, data governance teams, and cooperative enterprises.

The key to on-campus data integration lies in establishing a unified data standard and coding system, as well as building a university-level data middle platform. As the core technical architecture for breaking data silos, the data middle platform converges data from various business systems (such as academic administration, student affairs, practical training, and logistics) into a universal, standardized data asset center through processes like data extraction, cleaning, transformation, and loading. On this basis, efforts should be made to develop databases that reflect the characteristics of vocational undergraduate education—for example, a "Skill Literacy Database" that focuses on collecting information such as students' practical training works, operation records, and achievement levels of skill assessment points.

In terms of introducing off-campus data, under the premise of ensuring security and privacy, it is necessary to establish data exchange mechanisms with leading cooperative enterprises to obtain job skill requirements, industrial technology trends, and detailed evaluations of students' on-the-job internships. Additionally, public data resources from human resources and social security departments and industry associations should be incorporated into the system, thereby constructing a "holographic data resource pool" that covers both on-campus and off-campus scenarios and runs through the entire talent cultivation process. To ensure data security, strict measures for classified and hierarchical data management, access permission control mechanisms, and security audit processes must be established, enabling the value circulation of data under the premise of "usable but invisible".

3.3 Technology Empowerment and Intelligent Services

The service layer is the core output terminal and "intelligent brain" of the system's value. Its core function is to apply big data analysis and artificial intelligence technologies to transform the data assets of the resource layer into operable intelligent tools, service products, and decision support for various management scenarios. Led by technology construction and analysis teams, this layer drives the innovation of management models by encapsulating a series of data services and applications.

The specific service capabilities are reflected in multiple dimensions. Construction of a panoramic view of student growth and intelligent early warning services: By integrating multi-dimensional data (such as academic performance, consumption, social interactions, practical training, and psychology), a dynamic digital profile is built for each student. Machine learning models are used to achieve early identification and precise early warning of risks such as academic failure, psychological crises, and employment difficulties, realizing a shift in the management model from "post-event remedy" to "pre-event intervention". Process-oriented teaching evaluation and optimization services: By analyzing behavioral data from online learning platforms and classroom interaction data, accurate student learning situation insight reports are provided to teachers, supporting them in dynamically adjusting teaching strategies and improving teaching effectiveness. Intelligent matching services for "industry-education demands - talent cultivation": Technologies such as natural language processing are used to analyze massive industrial information and recruitment data, and conduct correlation analysis between this data and the university's curriculum settings and practical training content. Professional optimization diagnosis reports are generated to promote the active alignment of professional chains with industrial chains. In addition, it also includes simulation decision services for resource optimization and allocation

(by building a "digital twin" model of university management to simulate and deduce different strategic decisions) and personalized resource recommendation services for students (intelligently pushing courses, competitions, and internship positions that align with their development). The value of the service layer lies in seamlessly embedding cutting-edge technologies into management processes, making them accessible daily tools for managers and teachers.

3.4 Collaborative Governance and Institutional Guarantee

The organizational layer serves as the "framework" and "foundation" for the implementation and continuous evolution of the entire application system, providing fundamental institutional guarantees for the effective operation of the aforementioned three layers. Its core task is to establish a data governance organizational structure with clear powers and responsibilities, and formulate supporting strategic plans, management systems, and cultural cultivation strategies.

First, it is essential to establish a high-level collaborative organizational structure. This includes setting up a university-level "Data Governance Committee" led by university leaders, which is responsible for approving data strategies and policies; establishing a permanent "Data Management Office" as the executive body, which takes charge of data middle platform operation, quality monitoring, and security assurance; and designating "Data Administrators" in each business department to ensure the implementation of data governance work at the grassroots level. Second, a comprehensive institutional system needs to be formulated. The core is to issue the University Data Management Measures, which clarify the ownership, management rights, and usage rights of data, standardize the whole-life-cycle management process of data, and establish an incentive mechanism that incorporates data sharing and application effectiveness into performance evaluation—so as to stimulate the endogenous motivation for data circulation. At the inter-university collaboration level, efforts should be made to promote the establishment of data exchange standards and security protocols within vocational education groups or university alliances, and explore joint modeling based on privacy-preserving computing technologies such as federated learning, so as to improve the overall digital governance level of vocational education.

Ultimately, the effectiveness of all technologies and systems depends on the transformation of organizational culture. It is necessary to cultivate a management culture of "speaking with data and making decisions based on data" among all educators through continuous training and case demonstrations, thereby creating a sound ecological environment for the successful construction and continuous optimization of the system.

4. Innovative Strategies for Educational Management in Vocational Undergraduate Colleges

The construction of technological informatization in vocational undergraduate colleges is a systematic project that covers internal to external aspects and extends from partial to overall improvement. Big data technology should not only exert its powerful data processing and analysis capabilities in the field of education but also meet the evolving requirements of education and teaching through advanced management concepts and technological innovations that keep pace with the times.

4.1 Optimizing the Support System for Big Data Technology Application

At the critical stage of colleges' digital transformation, building a sound support system for big data technology application has become a core task to enhance the efficiency of educational governance. On one hand, it is essential to establish a standardized data governance system. This involves formulating unified data management standards, regulating the data quality requirements

for colleges to access platforms, and ensuring the integrity, accuracy, and consistency of data. Meanwhile, a data quality monitoring platform should be built, which uses data verification algorithms and quality evaluation indicators to conduct real-time monitoring of the entire data lifecycle—including data collection, cleaning, and transformation—thereby providing a reliable data foundation for big data analysis. On the other hand, efforts should be made to further strengthen data security and privacy protection mechanisms. In the data usage process, the "minimum necessary principle" must be strictly followed: data should be managed by classification and grading, and the access permissions and approval procedures for data of different security levels should be clearly defined. Privacy-preserving computation technologies should be introduced to ensure the security of sensitive college data and personal information of teachers and students while maintaining data usability. Additionally, an emergency response mechanism for data security should be established, emergency plans for data breaches should be formulated, and regular security drills should be conducted to improve the platform's ability to respond to data security risks.

Only in this way can educational administrators leverage real-time dynamic data monitoring platforms to develop precise student management strategies, promote the transformation of college educational management from passive response to proactive governance, comprehensively enhance management efficiency and risk prevention capabilities, and lay a solid digital foundation for the high-quality development of colleges.

4.2 Improving the Top-Level Design and Planning of University Data

In the process of colleges' digital transformation, scientific top-level design is the key to promoting the implementation of big data applications. Only by clarifying the application goals, action priorities, and resource allocation strategies at the current stage can the orderly advancement of transformation work be ensured.

Specifically, systematic research can be conducted to accurately identify the core pain points in student education management. On this basis, a digital capability development strategy should be formulated and released to provide clear direction for big data applications. In view of the rapid changes in the external environment and the dynamic adjustment of the institution's own development needs, the big data application strategy must be highly flexible. On one hand, a regular evaluation mechanism should be established. By tracking the progress of strategy implementation and monitoring application effectiveness, deviations in the execution process can be promptly identified and corrected. On the other hand, successful experiences from institutions such as the National Library Alliance should be learned from, and an adaptive digital strategy should be formulated based on the college's own resource endowments to ensure the feasibility of goal-setting. At present, domestic universities are still in the exploration stage in the field of big data applications, and full coverage has not yet been achieved. Therefore, improving the principles of top-level design is particularly important. This not only requires scientific planning for the long-term development of big data applications but also needs to be based on reality, formulate specific phased goals, and promote the depth and breadth of applications in a gradual manner. Only in this way can a mature big data application ecosystem be built through the continuous optimization of strategic planning, and ultimately realize the comprehensive digital transformation of university management and services.

4.3 Building an Inter-University Collaboration Platform to Promote Resource Symbiosis in the Vocational Education Community

In the era of the digital economy, the data and resources of a single college are limited. Vocational undergraduate colleges should uphold the concept of openness and collaboration, and

actively explore the construction of regional or even national inter-university collaboration platforms to achieve resource complementarity, experience sharing, and ecological co-construction. The foundation for building this platform lies in establishing mechanisms for data interconnection and standard mutual recognition within the alliance. Participating colleges can jointly negotiate and formulate a set of data exchange standards applicable to the field of vocational education, especially realizing mutual recognition of core elements such as course credits, skill certificates, and practical training programs.

On this basis, efforts will be made to promote the sharing of three major resources: One aspect is the sharing of course resources. An online open course alliance for vocational education will be established to support students in taking high-quality online courses across schools and earning credits, thereby making up for the insufficiency of course resources in their own schools. The second point is the complementarity of training resources. A shared reservation platform for practical training equipment and bases will be built, especially for those expensive, precise and low-usage large-scale equipment, to achieve cross-school sharing and improve the efficiency of resource utilization. The third point is the alignment of educational and training resources. Resources of cooperative enterprises from various schools will be pooled to jointly build a "virtual vocational education group", forming a large-scale enterprise demand pool and student supply pool, and striving for better and more targeted internship and employment opportunities for students.

Furthermore, the platform should enable data-based collaborative innovation and quality monitoring. On the premise of data desensitization, colleges can share anonymized data during the talent cultivation process, such as course pass rates, skill qualification rates, and employment relevance. By conducting aggregated analysis of these multi-source data, common laws and potential problems in vocational education can be revealed, providing a more macroscopic and scientific basis for the development of professional standards and teaching reforms. For example, by analyzing the skill shortcomings of students in the same major across multiple colleges, more targeted training modules can be jointly developed. This "smart crowdfunding" based on data collaboration will strongly promote the joint improvement of governance capabilities of the entire vocational undergraduate education group, forming a cluster effect of "1+1>2".

4.4 Enhancing Data Literacy of Management Teams and Cultivating Interdisciplinary Digital Talents

All advanced technologies and systems ultimately rely on humans for implementation and application. Enhancing the data literacy of management teams is the final and most critical step to ensure the implementation of big data strategies.

Firstly, it is necessary to establish a hierarchical and classified data competency development system. For university-level leaders and middle management cadres, the focus of training should be on shaping "data thinking". This enables them to understand data-driven decision-making models, the concepts and value of big data management, and to propose data needs and interpret big data analysis results from a strategic perspective. For frontline managers and counselors, training should focus on the practical application of "data skills", including data querying, report generation, the use of data visualization tools, and understanding basic data analysis models. This equips them to efficiently complete daily work and identify problems using data tools.

For full-time data analysts and business system administrators, in-depth training on "data technologies" is required, covering professional content such as data mining algorithms, data modeling, and data security management.

Secondly, innovate the "learning through practice" training model. Schools can integrate the enhancement of data literacy into actual work scenarios, establish specific projects or practical plans

to promote digital transformation, and encourage management teams to form cross-departmental groups to learn and apply data skills while solving practical problems. For instance, teachers can organize activities such as "Student Academic Warning Model Design Competition" or "Logistics Service Optimization Solution Competition Based on Data", and allow managers to improve their data application capabilities through practical experience.

Finally, improve talent introduction and incentive mechanisms, and optimize the team structure. On one hand, efforts should be made to introduce and cultivate interdisciplinary talents who understand both the laws of vocational education and data technologies. New positions such as "data architect" and "educational data analyst" can be established to inject fresh talent into the management team. On the other hand, an incentive system aligned with data literacy and capabilities should be established, where achievements in data application serve as an important reference for professional title evaluation, selection of outstanding employees, and job promotion. This stimulates the internal motivation of the entire management team to learn about and use data, ultimately building a high-quality, professional team capable of adapting to and leading the digital transformation of educational management.

5. Conclusion

This study systematically explores the innovative paths for educational management in vocational undergraduate colleges in the era of big data. It reveals the systemic challenges currently faced by vocational undergraduate colleges, such as data silos, delayed decision-making, and insufficient literacy. A four-tier application system consisting of the "demand layer, resource layer, service layer, and organization layer" is constructed, and four innovative strategies are proposed: optimizing data governance, strengthening top-level design, building inter-university collaboration, and enhancing team literacy. The research shows that the digital transformation of educational management in vocational undergraduate colleges must achieve the organic integration of technology, systems, and talents. By constructing a data-driven collaborative governance ecosystem, it is necessary to promote the leap of management models from experience-based and extensive management to precise and intelligent modern governance. In the future, with the in-depth integration of artificial intelligence technology, the improvement of data ethics standards, and the deepening of the integration of industry-education data, the educational management of vocational undergraduate colleges will embrace broader development space, providing a solid guarantee for cultivating high-quality technical and skilled talents.

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