Construction and Implementation Paths of Digital-Intelligent Teaching and Training Condition System in Colleges

Lejiang Guo*, Xu Sun, Fan Wu, Yan Guo
Teaching and Research Support Center, Air Force Early Warning Academy, Wuhan, China
**Corresponding Author*

Abstract: With the in-depth implementation of the national education digitalization strategy, promoting the digital-intelligent transformation of teaching and training conditions in colleges has become a core path for achieving high-quality development of practical education in the new era. At present, the construction of digital-intelligent teaching and training facilities in domestic colleges generally faces practical problems including fragmented lay-out, data silos, decoupling between construction and application, and imperfect operation and maintenance support, which seriously hinders the in-depth integration of digital technology and practical training. Thus, this article systematically analyzes the existing problems and underlying causes of the construction of digital and intelligent teaching and training conditions from three dimensions: surface construction, operational efficiency, and top-level mechanism. It establishes four core construction principles: practice-oriented design, inter-connected data, closed-loop control, and information security. Further-more, this paper constructs an integrated construction system for digital-intelligent teaching and training conditions in Colleges, featuring "digital-intelligent empowerment, three-chain collaboration and four-dimensional integration". Relying on a unified data middle platform, it explores the connection of the three business chains of teaching, training, and support, builds an integrated digital technology infrastructure, and constructs a closed-loop management mechanism covering the entire life cycle of construction, use, management, and operation. This aims to promote the digital upgrade path of teaching and training conditions, achieving collaborative teaching and training, intensive resource allocation, standardized management and operation, and precise education empowerment.

Keywords: Colleges and Universities; Digital-Intelligent Empowerment; Teaching and Training Conditions; Practical Education

1. Introduction

Under the background of the national education digitalization strategy, the deep integration of digital technology and education and teaching has become an inevitable trend. Accelerating the digital and intelligent upgrading of teaching and training conditions in various colleges is an inevitable measure to implement talent cultivation requirements of the new era and consolidate the foundation of practical education [1]. Currently, colleges of all types have varying degrees of problems such as the loose management of traditional offline classrooms and training equipment, complex training scenarios for specialized courses, and scattered and disconnected teaching and training business data [2]. It is imperative to adapt to the standards for cultivating high-quality professionals and promote the digital and intelligent transformation of the teaching and training support system.

2. Existing Problems and Root Causes in the Construction of Digital-Intelligent Teaching and Training Conditions in Colleges

2.1 Surface-Level Issue: Fragmented Construction and Implementation

First, project layout is scattered. Smart class-rooms, virtual training systems and intelligent equipment management platforms are developed by different manufacturers in batches according to the practical training demands and project plans of each department, resulting in inconsistent hardware and software interface standards and poor system compatibility and interoperability.

Second, investment in hardware and software is unbalanced. Construction funds are disproportionately allocated to hardware equipment procurement, while insufficient investment is allocated to digital case libraries, simulation teaching resources, intelligent management platforms and other digital software content, leading to limited application and massive idle equipment with low utilization efficiency.

Third, construction, application and operation & maintenance are disconnected. Colleges lack sound mechanisms to guide regular application of digital equipment and systematic training systems to improve teachers' digital literacy, so most virtual training modules fail to be used on a daily basis. Meanwhile, full-time operation and maintenance staff are insufficient, resulting in low efficiency of fault handling, as well as defective mechanisms for regular equipment inspection, iterative upgrading and scrapping disposal [2].

2.2 Operational Contradiction: Restricted System Operational Efficiency

Multiple structural contradictions hinder the release of digital-intelligent education efficiency in daily operation. To begin with, prominent data silos exist. Data on academic learning, practical training assessment and equipment support belong to independent business systems with inconsistent data standards, failing to support data-driven decision-making for precise digital-intelligent teaching.

In addition, barriers block multi-party collaboration. Sound long-term mechanisms for resource sharing and personnel exchange between research colleges and frontline practical work units are absent, leading to outdated practical teaching content [3].

Moreover, refined management of practical training resources is inadequate. Training venues, simulation equipment and teaching consumables still rely mainly on manual registration and offline application, lacking intelligent resource matching linked to teaching schedules.

2.3 Underlying Root Cause: Imperfect Top-Level Coordination Mechanism

All surface-level problems and operational contradictions stem from inadequate top-level overall planning. One issue is the lack of unified construction standards. Currently, there are no tailored digital construction standards, data norms, or full-cycle intelligent management frameworks that are suitable for practical operation-related specialties. Moreover, the digitalization construction of each department lacks unified constraints [4].

Second, there are gaps in full-process institutional systems. There are no corresponding management regulations for each stage of project assessment, procurement and acceptance, daily use, and equipment operation and maintenance.

Third, there is a severe shortage of compound technical teaching staff. Full-time personnel equipped with integrated capabilities in professional teaching, platform operation & maintenance and simulation development are in great demand, while existing faculty lack adequate digital-intelligent teaching competence.

3. Overall Design Principles for the Architecture of Digital-Intelligent Teaching and Training Conditions in Colleges

3.1 Core Construction Philosophy

Centered on the core concepts of digital-intelligent empowerment and practical education, the construction of digital-intelligent teaching and training conditions in colleges takes artificial intelligence, big data, virtual-real simulation and digital middle platforms as underlying technical support. It aims to break the functional barriers between teaching, practical training and support services, establish a full-life cycle management system covering the construction, application, administration and operation & maintenance of digital-intelligent teaching infrastructure for universities. This will create a pattern of deep integration of artificial intelligence and education.

3.2 Four Core Construction Principles

3.2.1 Practice-oriented principle

All intelligent platforms, digital practical training scenarios and online teaching resources are designed around on-the-job practical operation requirements for majors. Digital-intelligent facility development is guided by post competency standards to avoid formalistic intelligent renovation.

3.2.2 Interconnected data principle

Unify data specifications for college teaching, practical training and support, build secure and controllable data exchange channels to eliminate data silos, and rely on full-domain data to dynamically optimize teaching and practical training.

3.2.3 Closed-loop management and control principle

Connect four links of construction, application, management and operation & maintenance to form a closed-loop process, enabling traceable, controllable and intelligently optimized full-cycle procedures covering project planning, implementation, iteration and scrapping.

3.2.4 Information security principle

Strictly comply with data security management specifications, implement hierarchical control and permission isolation for the collection, storage, transmission and sharing of digital teaching and training data, and balance intelligent application with the bottom line of campus information security [5,6].

4. Exploration on Constructing the Digital-Intelligent Teaching and Training Condition System in Colleges

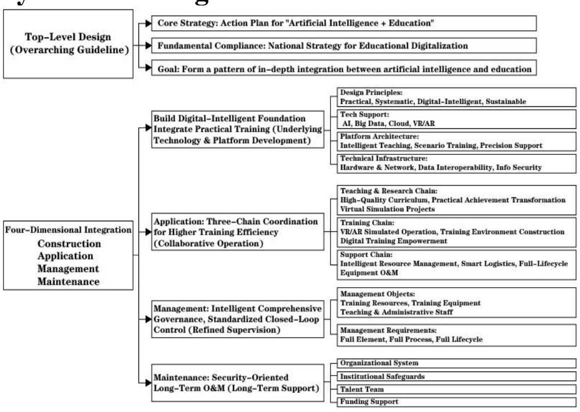

Figure 1. Integrated Architecture Diagram: College Digital-Intelligent Teaching & Training

Under the guidance of the national strategy for educational digitalization and the action plan for "Artificial Intelligence + Education" , based on the practical education needs of colleges and universities, and in response to the pain points such as fragmented construction, application disconnection, and weak operation and maintenance, the construction system of digital-intelligent teaching and training conditions in colleges aims to form an integrated construction pattern of "digital and intelligent empowerment, three-chain collaboration, and four-dimensional integration". That is supported by Integrated Digital Technology Infrastructure, it realizes business coordination across three chains of teaching, training and support, and adopts a four-dimensional full-cycle management guarantee mechanism covering construction, application, management and maintenance, so as to build a constructible, iterable and promotable development system featuring inter-connected businesses and closed-loop workflows [7]. As shown in Figure1.

4.1 Build an Integrated Digital-Intelligent Technology Foundation Support System

The digital intelligence technology foundation is the prerequisite for the construction of digital intelligence teaching and training conditions in educational institutions, and it is the basis for achieving the coordination of the three business chains of teaching, training, and support, as well as the integration of the four dimensions of construction, application, management, and maintenance. Therefore, the digital technology foundation needs to have three core units: a unified data center, an AI intelligent module, and a module for compatibility and adaptation of existing systems. This will provide comprehensive, scalable, highly secure, and highly adaptable digital technology support for the operation of teaching, research, and management in educational institutions. As shown in Figure 2:

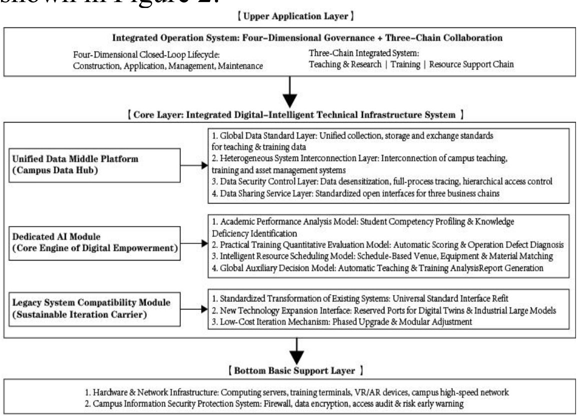

Figure 2. Integrated Digital Infrastructure Support System

4.1.1 Unified data middle platform

The data middle platform is the core hub of the digital intelligence technology foundation, undertaking the task of standardized data governance. It is responsible for the collection, cleaning, storage, circulation, sharing, and application of data in all fields for the construction of digital intelligence teaching and training conditions in Colleges. It serves as the foundation for the effective operation of all teaching, training and support businesses. To address the issue of data silos, the data middle platform needs to establish standardized data governance specifications, unify the collection standards, storage formats, exchange interfaces, and sharing mechanisms for multi-source data such as learning status, training operations, resource and equipment support, to ensure that relevant data can be integrated and utilized with other teaching application platforms in the smart campus, thereby providing standardized data support for intelligent analysis, precise teaching, resource scheduling, and operation management and control in educational institutions[8].

Meanwhile, the data middle platform must strictly implement the requirements for campus network information security management, promptly carry out data desensitization, and classify and manage confidential teaching and research data, student learning situation information, and equipment operation and maintenance data, as well as grant them hierarchical authorization. It should provide access and usage permissions based on job requirements and teaching needs. While ensuring the efficient intercommunication of data, the security of data is guaranteed through the control mechanism of operation traceability and data source tracing.

4.1.2 Dedicated AI intelligent modules

Adapted to the highly specialized and practical requirements of teaching and training, the intelligent application model developed based on AI artificial intelligence technology can optimize educational content, teaching methods and evaluation systems, achieve precise resource allocation, and ensure efficient and scientific teaching. The key points of AI intelligent empowerment in the digital intelligence technology foundation are to build three core application modules: intelligent learning status analysis, quantitative training competency evaluation and intelligent teaching resource scheduling.

The intelligent learning status analysis model is based on students' learning trajectories in multiple scenarios such as classroom learning, practical training, and daily behaviors. It deeply analyzes learning data such as learning duration, participation, preferences, and knowledge weaknesses, thereby constructing a student-specific learning profile and feeding back to personalized teaching [9]. The quantitative practical training competency evaluation model comprehensively assesses students' practical capabilities with quantitative scoring criteria based on assessment results, simulation drills and practical operation standards, enabling objective and precise evaluation. The intelligent teaching resource scheduling model, in combination with data such as learning demands, teaching schedules, and equipment status, intelligently matches the resources, equipment, venues, and personnel required for teaching and training, and provides real-time reminders of the resource operation status, comprehensively enhancing the intelligent empowerment level of teaching and training.

4.1.3 Compatible adaptation module for legacy systems

The compatibility adaptation module can effectively reduce the cost of digitalization construction. It achieves compatibility renovation of the existing facilities such as teaching and training platforms and equipment through methods such as standardized interface transformation, data protocol adaptation, and function module integration, thereby avoiding redundant construction, resource waste, and system fragmentation issues.

At the same time, in line with the long-term vision of educational digitalization, the digital-intelligent technology foundation must reserve extended interfaces and an open technical architecture for emerging technologies such as digital twins and immersive simulation training for various professional large models. This will leave sufficient space for iterative upgrades in subsequent teaching and training reforms and the expansion of new technologies, ensuring the long-term effectiveness and forward-looking nature of digital-intelligent teaching and training infrastructure construction.

4.2 Three-Chain Coordination: Realizing Collaborative Operation of "Teaching-Training-Support" Businesses

Empowered by the integrated digital technology foundation, a collaborative operation model for the three chains of teaching, training, and support is estab Centering on the entire teaching process, a digital-intelligent teaching empowerment system is constructed: relying on the data middle platform, personalized learning plans are formed, preview resources are accurately pushed before class, intelligent interaction is carried out in a timely manner during class, individual learning differences are grasped in real time, and targeted improvement and remedial measures are provided after class. Intelligent analysis of student learning data systematically generates learning portraits to accurately identify knowledge gaps, supporting teachers to optimize teaching plans and select teaching strategies, and advancing targeted and personalized teaching. lished. Through intelligent coordination, the transformation of teaching and training from experience-driven to data-driven mode.

4.2.1 Teaching chain: focus on targeted layered instruction

Centering on the entire teaching process, a digital-intelligent teaching empowerment system is constructed: relying on the data middle platform, personalized learning plans are formed, preview resources are accurately pushed before class, intelligent interaction is carried out in a timely manner during class, individual learning differences are grasped in real time, and targeted improvement and remedial measures are provided after class. Intelligent analysis of student learning data systematically generates learning portraits to accurately identify knowledge gaps, supporting teachers to optimize teaching plans and select teaching strategies, and advancing targeted and personalized teaching.

4.2.2 Training chain: focus on scenario-based practical training

A virtual-real integrated digital training ground is constructed, integrating various digital training modules such as comprehensive scenario simulation, online drills, and simulation operations, for students to conduct practical training. At the same time, full-process data including students' operation steps, operation standardization degree, drill completion degree and assessment scores are automatically collected. Common characteristics and competency weaknesses of students in training sessions are analyzed and identified, and training performance feedback is delivered to the teaching chain to provide references for the selection of teaching priorities, the control of teaching rhythm, and layered remedial instruction for knowledge blind spots.

4.2.3 Support chain: focus on intelligent resource scheduling

Focusing on three core resources of teaching and training: venues, facilities and faculty, an intensive refined resource scheduling and support system covering full life cycles is established. Relying on the integrated digital technology foundation, core data such as the usage status of venues, equipment operation conditions, equipment wear and tear levels, and teacher allocation are dynamically monitored. Matching the teaching plan and the course requirements, these data can optimize the equipment procurement and resource allocation plans, precisely coordinate the scheduling of venues, equipment and personnel, issue equipment maintenance warnings, and effectively enhance the utilization efficiency and guarantee accuracy of teaching and training resources.

With the digital intelligence technology foundation as the hub, through data collection, cleaning, storage and circulation , the three major businesses of the teaching chain, training chain and support chain have formed a dynamic closed loop of "teaching quality improve-ment, training efficiency enhancement, support empowerment", achieving mutual empower-ment, mutual support and dynamic optimization among the three businesses.

4.3 Four-Dimensional Integration: Full-Life-Cycle Management and Control System of Construction, Application, Administration and Operation & Maintenance

Focusing on the complete usage period of digital training facilities, relying on the technical foundation and business system, a closed-loop full-chain management and control system covering four dimensions (construction, application, administration and operation & maintenance) is developed. This ensures the standardized operation, regular efficiency improvement, and continuous iteration of the digital-intelligent teaching and training condition construction system.

4.3.1 Construction dimension: standardized planning and implementation from the source

Standards and standardized management shall be prioritized from the initial stage. The construction of teaching and training conditions should strictly follow the standardized process of demand demonstration, unified standards, centralized procurement, and graded acceptance. Uniform specifications shall be adopted for software and hardware parameters, data interfaces, resource development and technical criteria. Projects that do not meet the standards or cannot be intercommunicated shall not be accepted or put into use. We should avoid fragmentation and incompatibility issues from the very beginning.

4.3.2 Application dimension: standardized application across all scenarios

A standardized application system for digital facilities and digital resources is developed to promote regular in-depth utilization of digital-intelligent teaching and training infrastructure. Standardized operation procedures are formulated for diverse teaching and training scenarios such as smart classrooms and virtual training rooms, clarifying define the usage rights, operation guidelines and application requirements for teachers and students. Mechanisms for digital resource sharing and teaching data retention are established to facilitate circulation of high-quality teaching resources. We also need to standardize the workflows for collection, retention and archiving of teaching and training data, so as to provide a traceable basis for data analysis, quality evaluation, management optimization and teaching reform.

4.3.3 Administration dimension: intelligent supervision of full-domain data

When conducting equipment and facility management based on an integrated digital technology platform, we need to establish a digital management system with full coverage and dynamic monitoring capabilities, which can be used to monitor the equipment utilization rate, resource invocation frequency, venue usage status, and teaching progress in real time. It can identify and rectify the management loopholes in teaching resources through quantitative indicators and visual data, providing data support for refined school management [10]. At the same time, the comprehensive management requires multi-level permission planning to clearly define the data access boundaries for managers, teachers, and students, ensuring the security and stability of resource usage.

4.3.4 Operation & maintenance dimension: closed-loop regular facility management and protection

We need to establish an operation and maintenance mechanism for teaching and training conditions covering regular inspection, fault early warning, loss assessment and equipment upgrading, so as to realize long-term management and maintenance of facilities and equipment. Thus, by leveraging equipment sensing collection, real-time data monitoring technologies, and regular manual inspections, we can achieve automatic fault warning for equipment, and timely handling of performance degradation and consumable shortages, thereby guaranteeing the stable, efficient and regular operation of digital teaching and training facilities.

5. Conclusion

Against the backdrop of steady advancement of education digitalization, digital and intelligent technologies provide new renovation ideas for upgrading college teaching and training conditions, effectively resolving prominent problems such as fragmented construction, isolated data and weak operation & maintenance. Adopting the overall framework of "three-chain collaboration and four-dimensional integration", colleges can rationalize the linkage logic of teaching, practical training and support businesses, standardize full-cycle digital management workflows for facilities, optimize the intelligent allocation mode of practical training resources, and comprehensively improve the quality of interdisciplinary practical talent cultivation.

To fully release the educational value of this system, supporting measures shall be im-proved simultaneously: optimize data middle platform governance in accordance with campus information security specifications, iteratively update intelligent algorithms adapted to professional scenarios, refine full-process digital construction standards, build digital education channels for collaboration among colleges, industrial enterprises and research institutions, and strengthen the construction of interdisciplinary digital-intelligent teaching staff.

In summary, only by deeply integrating digital technologies into the whole process of college teaching and practical training, strictly abiding by campus data security norms, and continuously optimizing the iterative operation mechanism of the system, can colleges develop a digital-intelligent practical training support system matching their school-running characteristics, and provide solid support for the long-term cultivation of high-quality application-oriented talents in the new era.

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