

Research on the Integrated Construction of Curriculum Resources for Secondary vocational education, Vocational College and Vocational undergraduate program in Logistics Specialty from the Perspective of Blockchain Technology

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Abstract: Background: *The global supply chain is undergoing a profound digital transformation, with blockchain technology emerging as a disruptive force poised to enhance transparency, security, and efficiency. Concurrently, educational systems are tasked with cultivating talent equipped for this new paradigm. In China, the recently promulgated vocational education standards (Ministry of Education of the People's Republic of China, 2025) mandate a more integrated and industry-aligned approach to talent development, particularly emphasizing the seamless articulation between secondary, higher, and undergraduate vocational programs.*

Problem: *Despite these imperatives, the existing logistics education landscape is characterized by significant fragmentation. Curricula across secondary vocational, higher vocational, and undergraduate levels often lack coherence, leading to content duplication, skill gaps, and inefficient learning pathways. Furthermore, the absence of a trusted, interoperable system for sharing and validating educational resources and credentials exacerbates these challenges, hindering the cultivation of versatile, high-caliber professionals required by the modern logistics industry.*

Methods: *This study employs a Design-Based Research (DBR) methodology to develop and conceptualize a comprehensive solution. Integrating insights from a systematic literature review, an industry-wide needs analysis, and the new national vocational standards, we architect an integrated curriculum framework. This framework is underpinned by a decentralized educational resource platform powered by blockchain technology.*

Results: *The primary outcomes of this research are threefold. First, we propose a four-tier, competency-based model for blockchain applications in logistics, mapping progressive skill levels from foundational literacy to advanced system design. Second, we detail a modular*

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curriculum structure characterized by a "Shared Foundation, Divergent Paths, and Progressive Competency" model, ensuring both vertical articulation and disciplinary specialization. Third, we present a four-layer architectural design for a blockchain-based platform that facilitates decentralized resource authentication, immutable learning records, and a cross-institutional credit bank system.

Conclusion: This study offers a novel, theoretically grounded, and practical framework for reforming logistics education in the blockchain era. Its principal contribution lies in providing a systematic solution that addresses curriculum discontinuity, enhances the integrity of educational resources, and aligns with the strategic direction of modern vocational education. The proposed framework holds significant implications for policymakers, educational institutions, and industry partners seeking to foster a more cohesive and effective talent pipeline for the future of logistics.

Keywords: Blockchain Technology; Logistics Education; Curriculum Articulation; Vocational Education; Competency-Based Framework; Educational Resources; Design-Based Research

1. Introduction

1.1 The Digital Transformation of Logistics and the Rise of Blockchain

The global logistics and supply chain industry is at the epicenter of a sweeping digital transformation, driven by the convergence of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and big data analytics (Rauniyar et al., 2023). This shift, often termed Logistics 4.0, moves beyond simple automation to create interconnected, intelligent, and self-optimizing supply networks. In this context, blockchain technology has emerged as a particularly transformative force, promising to redefine the paradigms of trust, transparency, and efficiency in complex, multi-party supply chain networks (Kumar et al., 2025; Han & Fang, 2024). By providing a decentralized, immutable, and transparent ledger, blockchain addresses long-standing industry pain points, including information silos, lack of visibility, traceability challenges, and high transaction costs associated with intermediaries (Sharabati & Jreisat, 2024). Its applications, ranging from ensuring the provenance of pharmaceuticals and luxury goods to executing smart contracts for automated freight payments and customs clearance, are fundamentally reshaping operational workflows and creating new value propositions (Idrissi et al., 2024). As industries increasingly pilot and deploy blockchain solutions, the demand for a workforce proficient in both the nuances of logistics operations and the principles of blockchain technology has become a critical economic imperative, creating a significant talent gap that educational institutions must address.

1.2 Challenges in Articulating Logistics Education Across Secondary, Higher, and Undergraduate Levels in China

In response to these industrial shifts, the educational sector bears the responsibility of cultivating a new generation of logistics professionals. However, China's vocational education system, despite its scale, has historically faced challenges with fragmentation, particularly in the articulation of curricula across different educational tiers: secondary vocational, higher vocational (three-year college), and vocational undergraduate programs (Liu, 2025; Yu et al., 2024). This often results in a disconnected learning experience, where students encounter repetitive content, while critical competency gaps remain unaddressed (Yang et al., 2024). The transition from one level to the next lacks a smooth, logical progression, hindering the development of the deep, integrated skill sets required for advanced roles in a digitally-driven logistics landscape (Chen, J. et al., 2025). The problem is compounded by a lack of standardized, high-quality educational resources and a mechanism for their trusted exchange among institutions, creating isolated "data islands" that mirror the very problem blockchain aims to solve in supply chains.

1.3 The Imperative of China's New Vocational Education Standards

Recognizing these systemic issues, the Chinese government has initiated a profound reform of its vocational

education system. A landmark development in this process was the release of 758 updated professional teaching standards in February 2025 by the Ministry of Education. For the first time, these standards establish a unified and integrated framework for secondary, higher, and undergraduate vocational education, aiming to create a seamless, vertically articulated talent development pipeline (Guan et al., 2025). The new standards explicitly call for curricula to be aligned with the latest industrial technologies and practices, mandating a significant increase in hands-on, practice-oriented learning ($\geq 50\%$ for secondary/higher vocational and $\geq 60\%$ for vocational undergraduate programs) and promoting a competency-based approach to education (Zhong & Juwaheer, 2024). For the logistics sector, this reform presents both a mandate and an opportunity to redesign curricula to systematically integrate emerging technologies like blockchain, thereby bridging the gap between education and industry needs.

1.4 Research Gap and Objectives

While a growing body of literature explores the application of blockchain in supply chain management (Hübschke et al., 2025) and education separately (Wang, X. et al., 2024; Rani et al., 2024), there is a conspicuous research gap at their intersection. Few studies have systematically addressed how to design an integrated, multi-level curriculum that prepares logistics professionals for the blockchain era. Specifically, there is a lack of a comprehensive framework that not only defines the progressive competencies required but also leverages blockchain technology itself to solve the underlying problems of resource sharing and credential verification in education.

This study aims to fill this gap by addressing the following objectives:

To develop a competency-based framework that defines the progressive skills and knowledge of blockchain technology required for logistics professionals across the secondary, higher, and undergraduate vocational education levels.

To design an integrated, modular curriculum system for logistics management that ensures seamless articulation and logical progression across these three educational tiers.

To propose a conceptual architecture for a blockchain-based educational resource platform that enables secure sharing, authentication, and management of curriculum materials and learning credentials.

1.5 Structure of the Paper

This paper is organized as follows. Section 2 provides a review of the relevant literature on blockchain in supply chain management and education, curriculum articulation models, and competency-based frameworks. Section 3 details the Design-Based Research methodology employed in this study. Section 4 presents the core results: the proposed competency model, the articulated curriculum system, and the blockchain platform architecture. Section 5 discusses the implications of the framework, its alignment with the new vocational standards, and potential implementation challenges. Finally, Section 6 concludes the paper by summarizing its contributions, acknowledging its limitations, and outlining directions for future research.

2. Literature Review

2.1 Blockchain Technology in Supply Chain Management

The integration of blockchain technology into supply chain management (SCM) has been a subject of extensive academic and industry research, with studies consistently highlighting its potential to revolutionize traditional practices. A systematic review by Han et al. (2024) underscores that blockchain's core attributes—decentralization, immutability, and transparency—directly address critical SCM vulnerabilities such as the bullwhip effect, information asymmetry, and lack of trust among stakeholders. Kumar et al. (2025) further elaborates that by creating a shared, single source of truth, blockchain significantly enhances traceability and provenance, which is crucial for combating counterfeiting, ensuring food safety, and verifying the authenticity of high-value goods.

Recent research has moved from conceptual exploration to examining implementation challenges and performance metrics. For instance, a comprehensive review by Hübschke et al. (2025) analyzes methods for measuring blockchain performance in SCM, indicating a maturation of the research field towards practical application and impact assessment. The synergy between blockchain and other Industry 4.0 technologies, such as IoT and AI, is another prominent theme. Idrissi et al. (2024) posits that combining IoT sensors for real-time data capture with a blockchain ledger for secure data storage creates a highly reliable and autonomous supply

chain ecosystem. Similarly, Rauniyar et al. (2023) argue that this technological fusion is essential for building resilient and agile supply chains capable of navigating the risks inherent in the digital transformation era. These studies collectively establish the technological and strategic importance of blockchain as a foundational element of modern logistics. However, the path to adoption is not without its challenges. Research also points to significant barriers, including issues of scalability, interoperability between different blockchain platforms, high implementation costs, and a lack of clear regulatory frameworks. Despite these hurdles, the consensus in the literature is that the long-term benefits of enhanced security, transparency, and efficiency far outweigh the initial difficulties, justifying the urgent need to incorporate comprehensive blockchain education into logistics curricula.

2.2 Applications of Blockchain in Education

Parallel to its impact on SCM, blockchain technology is also being increasingly recognized for its transformative potential within the education sector. Systematic reviews by Rani et al. (2024) and Wang et al. (2024) provide a comprehensive overview of its applications, which primarily revolve around credentialing, resource management, and facilitating lifelong learning. The most prominent use case is the creation of tamper-proof, verifiable academic records. Cardenas-Quispe & Pacheco (2025) and Tepelidis et al. (2024) present prototypes of blockchain-based systems for issuing and verifying degrees and certificates, which drastically reduces administrative overhead and eliminates credential fraud. This aligns with the concept of decentralized academic platforms, which, as Any et al. (2024) suggest, represent the future of education by empowering learners with ownership and control over their academic identities.

Beyond credentialing, blockchain offers a robust solution for managing and sharing educational resources. The concept of a decentralized resource platform, as explored by Luo et al. (2023), enables educators to securely share course materials, with the blockchain providing proof of authorship and tracking usage via smart contracts. This fosters a collaborative ecosystem for content creation and dissemination. Furthermore, the technology is a key enabler for lifelong learning by creating a permanent, verifiable record of all formal and informal learning experiences. This has led to the development of "credit bank" systems, particularly in vocational education, where blockchain can securely record, transfer, and recognize credits earned across different institutions and training programs, as investigated in recent studies (Ren et al., 2023; Wang, H. & Wang, Q., 2025). This functionality is critical for building the flexible and interconnected learning pathways envisioned by modern educational reforms.

2.3 Curriculum Articulation Models in Vocational and Higher Education

Curriculum articulation, the process of ensuring a seamless and logical progression of learning across different educational levels, is a cornerstone of an effective education system. In China, the drive to connect secondary vocational, higher vocational, and undergraduate education has led to various articulation models, such as the "3+2" (secondary to higher vocational) and the "3+4" (secondary to undergraduate) pathways (Chen, J. et al., 2025). The goal of these models is to provide students with a clear, unobstructed route to higher qualifications and more advanced skills. However, studies by Yang et al. (2024) and Zhang (2026) highlight persistent challenges, including misaligned curriculum standards, a lack of communication between institutions, and a theoretical rather than practical focus, which often leads to a "disconnect" rather than a true integration.

The recent transformation of Chinese vocational education, as analyzed by Chen (2025) and Yu et al. (2024), aims to address these issues by establishing a national, unified framework. The new standards emphasize a "whole-system" approach, mandating vertical integration of curriculum content and learning outcomes. This policy shift provides the macro-level support necessary for developing truly articulated programs. The literature suggests that successful articulation requires more than just policy; it demands a shared understanding of competency goals, collaborative curriculum development between participating institutions, and robust mechanisms for credit transfer (Liu, 2025)—all areas where blockchain technology can provide significant support.

2.4 Competency-Based Education Frameworks in the Digital Age

The move towards curriculum articulation is closely linked to the global shift towards Competency-Based Education (CBE). Unlike traditional models that are structured around time and credit hours, CBE focuses on the mastery of specific, well-defined competencies. This approach is particularly well-suited for vocational and technical education, as it directly aligns learning outcomes with industry requirements. In the context of digital transformation, this has led to the development of various digital competency frameworks, such as the European DigComp framework, which define the skills needed for citizens, learners, and educators to thrive in a digital

society.

In the TVET sector, a competency-based approach is seen as essential for developing a future-ready workforce. Zhong and Juwaheer (2024) advocate for a "whole-institution approach" to digital competence development in TVET, where a clear framework guides curriculum design, faculty training, and student assessment. This aligns with the findings of Chen (2025), whose comparative study on logistics education in China and Germany revealed that a focus on clearly defined "green skills" and digital competencies is a hallmark of leading vocational systems. The development of a competency framework is therefore the logical first step in designing any modern, articulated curriculum, as it provides the common language and clear targets necessary for aligning different educational levels and ensuring relevance to the workplace.

3. Methodology

3.1 Research Design: A Design-Based Research (DBR) Approach

To address the complex, real-world problem of designing and integrating a novel curriculum and technology platform, this study adopted a Design-Based Research (DBR) methodology. DBR is an iterative and interventionist approach that aims to develop and refine educational theories and practices simultaneously through cycles of design, implementation, analysis, and redesign in authentic settings. This methodology is particularly suitable for this research as it allows for the systematic development of a practical solution (the integrated curriculum and blockchain platform) while also generating theoretical insights into how such an intervention functions and can be improved. Our DBR process is structured into four main phases, as outlined in the initial research plan, which align with the typical DBR cycle.

3.2 Phase 1: Needs Analysis and Problem Identification

The initial phase of our research focused on a comprehensive analysis of the problem domain. This involved a two-pronged approach: a systematic review of existing literature (as detailed in Section 2) and an empirical needs analysis to understand the ground-level realities of the logistics industry and vocational education. We conducted a mixed-methods study involving in-depth interviews with industry executives from leading logistics firms, surveys with vocational school educators, and focus groups with students.

Key findings from this phase, as documented in our preliminary report, revealed a significant gap between industry expectations and educational outputs. The survey data indicated that while 73.5% of vocational institutions have introduced blockchain concepts, 81.2% of these efforts remain at a superficial, theoretical level without practical application. Concurrently, 88.7% of surveyed enterprises identified blockchain proficiency as a core competency for logistics professionals within the next 3-5 years. These findings empirically validated the problem of curriculum lag and provided a clear mandate for the development of a more advanced, practice-oriented educational framework.

3.3 Phase 2: Framework and Platform Design

Informed by the needs analysis and the new national vocational standards, the second phase was dedicated to the design of the intervention. This involved two parallel streams of work: the architectural design of the curriculum framework and the conceptual design of the blockchain-based resource platform.

Curriculum Framework Design: We synthesized the competency requirements from the needs analysis and aligned them with the articulated structure mandated by the 2025 vocational education standards. This led to the creation of the four-tier competency model and the modular curriculum structure ("Shared Foundation, Divergent Paths, Progressive Competency"). The design was developed collaboratively with a panel of experts comprising ten logistics industry veterans and ten senior vocational education specialists to ensure its practical relevance and pedagogical soundness.

Platform Architecture Design: We designed the conceptual architecture for the blockchain platform, defining its four-layer structure and core functionalities (resource authentication, learning records, and credit bank). The design drew upon established principles of decentralized application (DApp) development and existing models of blockchain in education (Luo et al., 2023; Any et al., 2024; Ren et al., 2023). The goal was to create a technical blueprint that was both ambitious in its vision and feasible in its implementation.

3.4 Phase 3: Development and Implementation (Prospective)

The third phase, which represents the next stage of this ongoing research project, will focus on the development of the designed artifacts. This includes creating the modular course content, such as syllabi, teaching materials, case studies, and virtual simulation projects. Simultaneously, a prototype of the blockchain-based educational resource platform will be developed based on the architecture designed in Phase 2. This will involve selecting an appropriate blockchain protocol (e.g., Hyperledger Fabric or Ethereum), developing smart contracts for the core functionalities, and building the user interface.

3.5 Phase 4: Evaluation and Refinement (Prospective)

The final phase of the DBR cycle will involve the implementation and evaluation of the developed curriculum and platform in a real-world educational setting. We plan to launch a pilot program in partnership with several vocational institutions across the secondary, higher, and undergraduate levels. Data will be collected on student learning outcomes, user engagement with the platform, and instructor feedback. This data will be used to evaluate the effectiveness of the intervention, identify areas for improvement, and refine both the curriculum content and the platform functionality. The findings from this evaluation will generate new insights, contributing to a revised theoretical understanding that can inform the next iteration of the design cycle.

4. Results: The Integrated Curriculum and Resource Framework

This section presents the primary outcomes of our design-based research: a cohesive framework comprising a multi-level competency model, an articulated curriculum system, and a blockchain-enabled educational resource platform. These components are designed to work in synergy to address the challenges identified in the preceding sections.

4.1 A Four-Tier Competency Model for Blockchain in Logistics

Based on our analysis of industry needs and the progressive nature of vocational education, we developed a four-tier competency model that maps the evolving skill requirements for blockchain in logistics. This model serves as the foundational pillar for the entire curriculum, defining clear learning objectives for each educational stage. The four tiers—Cognitive Understanding, Tool Operation, Technical Application, and System Design—are structured to ensure a logical and gradual development of expertise, aligning directly with the educational goals of secondary vocational, higher vocational, and vocational undergraduate programs, as detailed in Table 1.

Table 1: Four-Tier Competency Model for Blockchain in Logistics Education

Competency Tier	Educational Level Alignment	Core Competency Description	Key Skills & Knowledge
1. Cognitive Understanding	Secondary Vocational	Develop a foundational understanding of blockchain concepts, its core characteristics (e.g., decentralization, immutability), and its value proposition in logistics.	Basic principles of blockchain and distributed ledger technology Key terminology (e.g., block, hash, consensus) Awareness of major use cases in logistics (e.g., traceability, anti-counterfeiting)
2. Tool Operation	Higher Vocational (Year 1-2)	Gain proficiency in operating existing blockchain-based logistics platforms and tools for specific tasks like data entry, transaction queries, and status tracking.	-Operation of blockchain-based track-and-trace systems - Data input and verification on a distributed ledger - Use of blockchain explorers for supply chain monitoring

Competency Tier	Educational Level Alignment	Core Competency Description	Key Skills & Knowledge
3. Technical Application	Higher Vocational (Year 3) / Vocational Undergraduate (Year 1-2)	Apply blockchain solutions to solve practical problems in specific logistics scenarios. This involves configuring existing platforms and understanding the basics of smart contracts.	- Application of blockchain in cold chain logistics, cross-border trade, etc. - Basic configuration of blockchain platform parameters - Reading and understanding simple smart contracts - Solving common data integrity and transparency issues
4. System Design	Vocational Undergraduate (Year 3-4)	Design and optimize blockchain-based solutions for complex logistics systems. This includes developing simple smart contracts and integrating blockchain with other systems.	- Designing business logic for logistics smart contracts - System architecture design for blockchain integration - Performance analysis and optimization of blockchain applications - Understanding of interoperability between different blockchain systems and legacy IT systems

This tiered model provides a clear roadmap for curriculum development, ensuring that learning activities at each level are appropriately scaffolded and build directly upon the competencies acquired in the previous stage. It moves students from being passive observers of the technology to active users, and finally to capable designers of blockchain-enabled logistics solutions. To illustrate the practical implementation of this model, Table 2 presents a sample of specific courses designed for each educational level, directly corresponding to the competency tiers.

Table 2: Sample Articulated Course Progression for Blockchain in Logistics

Educational Level	Competency Tier	Sample Core Course Title	Key Learning Objectives
Secondary Vocational	1. Cognitive Understanding	LGT101: Foundations of Blockchain in Logistics	- Define blockchain, DLT, and smart contracts. - Identify 3-5 major applications of blockchain in the supply chain. - Explain the value of immutability and transparency for traceability.
Higher Vocational	2. Tool Operation	LGT201: Blockchain-based Logistics Operations	- Operate a simulated track-and-trace platform. - Input and verify shipping data on a distributed ledger. - Generate and interpret a product provenance report from a blockchain explorer.
Higher Vocational	3. Technical Application	LGT301: Applied Blockchain for Supply Chain Solutions	- Configure a blockchain application for a cold chain monitoring scenario. - Analyze a simple smart contract for automated payment upon delivery. - Propose a blockchain-based solution for a given anti-counterfeiting problem.

Educational Level	Competency Tier	Sample Core Course Title	Key Learning Objectives
Vocational Undergraduate	4. System Design	LGT401: Logistics Information System Design with Blockchain	- Design the architecture for integrating a blockchain solution with an existing WMS/TMS. - Develop a smart contract in Solidity for a multi-party trade finance agreement. - Evaluate the performance trade-offs between different consensus mechanisms for a logistics network.

4.2. An Articulated Curriculum System: "Shared Foundation, Divergent Paths, Progressive Competency"

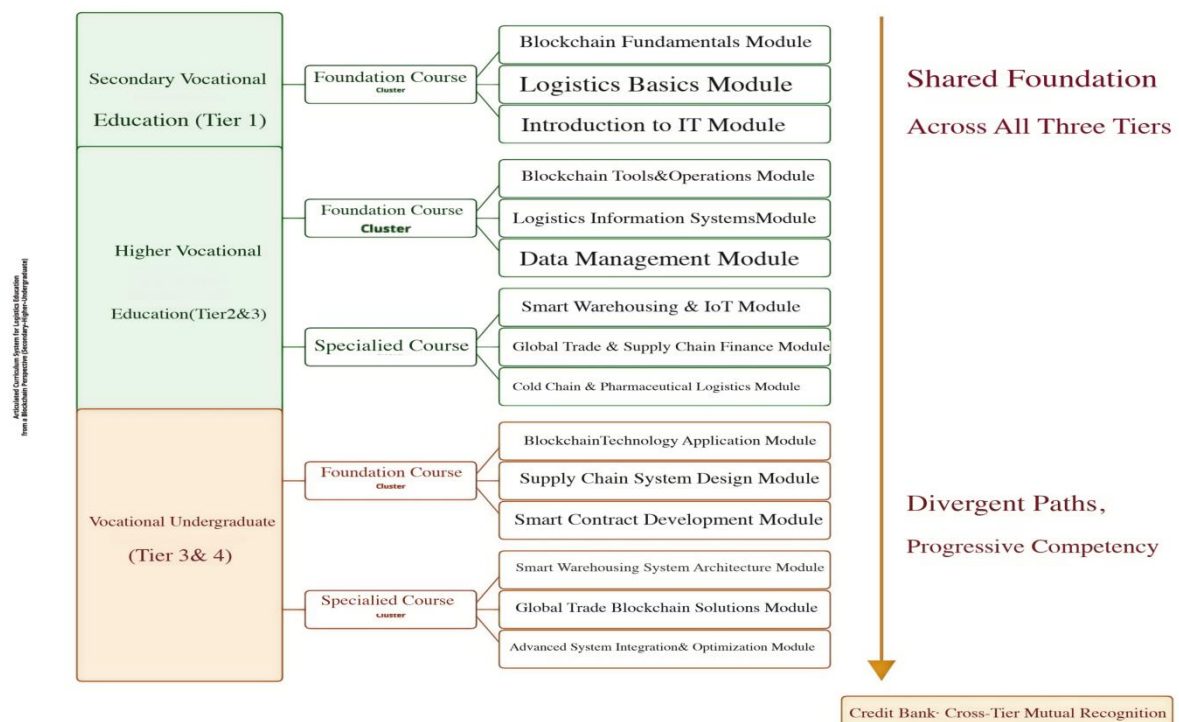


Figure 1: The Articulated Modular Curriculum Structure

In the light of Figure 1: The Articulated Modular Curriculum Structure. This diagram illustrates the three core components of the curriculum. A wide base representing the 'Core Foundational Modules' is shared by all three levels (Secondary, Higher, Undergraduate). From this base, two 'Specialized Pathway Modules' (e.g., Smart Warehousing, Global Trade) diverge at the Higher and Undergraduate levels. 'Competency Extension Modules' are shown as project-based electives that connect to all levels, increasing in complexity from bottom to top, aligning with the four competency tiers.

Core Foundational Modules (Shared Foundation): This compulsory set of modules is shared across all three educational levels, though the depth and complexity are adjusted for each. It covers fundamental knowledge in logistics management, information technology, and the basics of blockchain. For example, the 'Introduction to Blockchain in Logistics' course would be taught at all levels, but the secondary level would focus on concepts and use cases (Tier 1), while the undergraduate level would delve into consensus mechanisms and cryptographic principles.

Specialized Pathway Modules (Divergent Paths): Starting from the higher vocational level, students choose specialized pathways that align with specific career tracks. These modules provide in-depth knowledge and skills in areas where blockchain has a significant impact. Examples include:

Pathway A: Smart Warehousing & IoT Integration (Focus on blockchain for inventory management and device data integrity)

Pathway B: Global Trade & Supply Chain Finance (Focus on smart contracts for trade finance and cross-border compliance)

Pathway C: Cold Chain & Pharmaceutical Logistics (Focus on blockchain for temperature monitoring and regulatory compliance)

Competency Extension Modules (Progressive Competency): These are elective, project-based modules designed to deepen practical skills and foster innovation. They are aligned with the competency tiers. A secondary student might take a project on 'Tracing a Product with a Public Blockchain Explorer' (Tier 2), while an undergraduate student could undertake a capstone project on 'Designing a Smart Contract for Automated Demurrage Calculation' (Tier 4). These modules are often co-developed with industry partners to ensure they reflect real-world challenges.

This modular and articulated design ensures that students build a solid foundation, develop specialized expertise, and progressively advance their competencies in a coherent and uninterrupted learning journey. The integration of industry partners in the development of Competency Extension Modules is particularly critical, ensuring that the practical skills honed by students are directly applicable to the real-world challenges faced by logistics companies today. This approach fosters a tight feedback loop between industry and academia, a core tenet of the new vocational education standards.

4.3. A Blockchain-Based Educational Resource Platform

To support the integrated curriculum, we propose a decentralized educational resource platform. This platform leverages blockchain technology itself to overcome the challenges of resource fragmentation and credential fraud, creating a trusted ecosystem for collaboration and lifelong learning.

4.3.1. Four-Layer Architecture

In the light of Figure 2: Four-Layer Architecture of the Blockchain Educational Platform. This diagram shows a layered pyramid or stack. The bottom layer is 'Infrastructure Layer (Consortium Blockchain, IPFS)'. The next layer up is 'Core Engine Layer (Smart Contracts: Identity, Resources, Credit Bank)'. Above that is the 'Application Layer (Resource Authentication, Learning Records, Credit Transfer)'. The top layer is the 'User Interaction Layer (Web Portal, Mobile App)'.

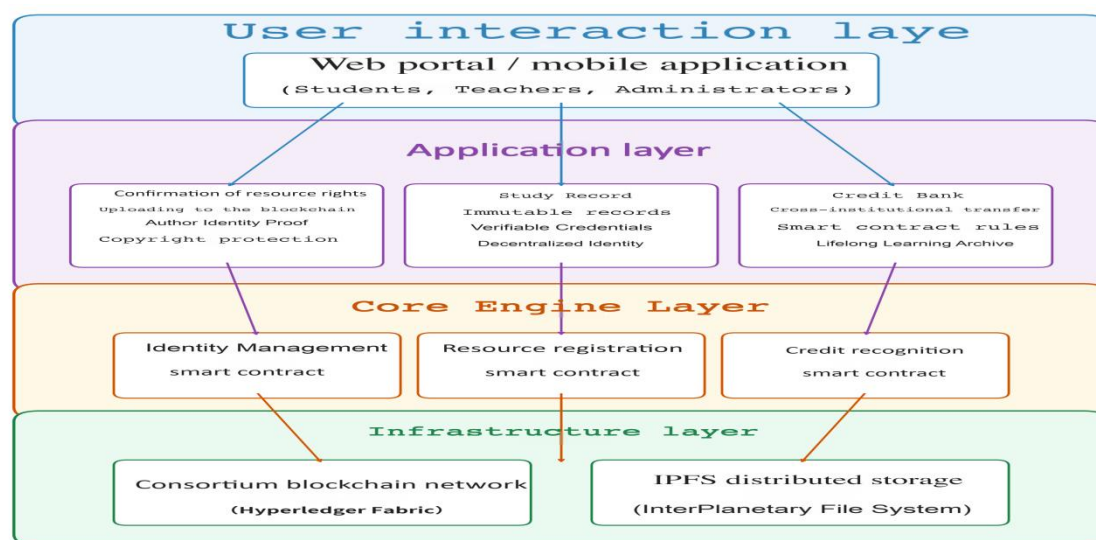


Figure 2: Four-Layer Architecture of the Blockchain Educational Platform

Infrastructure Layer: This foundational layer consists of the underlying blockchain network (e.g., a consortium chain managed by educational institutions and industry partners) and distributed storage solutions like the InterPlanetary File System (IPFS). Using IPFS for storing large files (e.g., videos, courseware) while keeping only their immutable hashes on-chain ensures efficiency and reduces storage costs.

Core Engine Layer: This layer contains the core logic of the platform, implemented as a set of smart contracts. These contracts manage key functions such as user identity and access control, resource registration (tokenization of educational assets), and the rules for credit recognition and transfer.

Application Layer: This layer provides the specific services and functionalities for end-users. It interacts with the core engine layer to execute the main use cases of the platform.

User Interaction Layer: This is the front-end interface (e.g., a web portal or mobile app) through which students, teachers, and administrators interact with the platform. It provides user-friendly access to the platform's functionalities without requiring users to have deep technical knowledge of blockchain.

4.3.2. Core Functionalities

The platform is designed to support three primary functionalities that are critical for an integrated educational ecosystem:

Decentralized Resource Authentication: When an educator uploads a new teaching resource (e.g., a case study, a lecture slide), it is registered on the blockchain. The platform generates a unique cryptographic hash for the content and stores it on-chain, along with the author's identity and a timestamp. This creates an immutable proof of origin and ownership, preventing plagiarism and enabling clear attribution. Other institutions can then confidently use and build upon these authenticated resources.

Immutable Learning Records: Each student is given a decentralized identity (DID) and a digital wallet. As they complete courses, earn certificates, or master competencies, a verifiable credential is issued and recorded on the blockchain. This creates a comprehensive, tamper-proof, and lifelong learning record that the student owns and controls, often referred to as a "personal data wallet" or "self-sovereign identity" (Any et al., 2024). Students can grant selective, time-bound access to potential employers or other educational institutions, streamlining verification processes from weeks to seconds and significantly reducing administrative friction (Cardenas-Quispe & Pacheco, 2025; Tepelidis et al., 2024). This functionality is not merely a convenience; it is a fundamental shift in the ownership of educational data, empowering individuals in their lifelong learning journey.

Cross-Institutional Credit Bank System: Leveraging the immutable learning records, the platform functions as a trusted "credit bank" (Ren et al., 2023; Wang, H. & Wang, Q., 2025). Smart contracts define the rules for recognizing and transferring credits between participating secondary, higher, and undergraduate institutions. When a student moves from a secondary to a higher vocational school, their earned credits (represented as tokens) can be seamlessly transferred and recognized, eliminating the need for manual, paper-based verification and ensuring a smooth academic transition.

5. Discussion

This section contextualizes the proposed framework by discussing its implications for solving curriculum fragmentation, its synergy with national educational reforms, and the practical challenges associated with its implementation.

5.1. How the Framework Addresses Curriculum Disconnection

The primary contribution of our proposed framework is its direct response to the systemic issue of curriculum disconnection across secondary, higher, and undergraduate vocational education (Zhang et al., 2026; Yang et al., 2024). The "Shared Foundation, Divergent Paths, Progressive Competency" model creates a robust, coherent structure that traditional, siloed approaches lack. The shared foundational modules establish a common knowledge base, ensuring that all students, regardless of their entry point, possess the fundamental literacies in logistics and blockchain. This directly counters the problem of content repetition and inconsistent starting points.

The introduction of specialized pathways at the higher and undergraduate levels allows for necessary differentiation, preparing students for distinct roles in the industry without losing the common thread. Most importantly, the entire system is unified by the four-tier competency model. This model acts as a 'golden thread,' providing a clear, continuous line of skill progression. A competency mastered at the secondary level (e.g., 'Cognitive Understanding') becomes the prerequisite for the next level of learning, creating a truly articulated and non-redundant educational journey. This structure transforms the educational pathway from a series of disconnected segments into a cohesive, integrated continuum.

5.2. The Role of Blockchain in Ensuring Educational Resource Integrity and Interoperability

Beyond structuring the curriculum, our framework leverages blockchain technology as an active agent in solving deep-seated infrastructural problems in education. The proposed educational resource platform addresses the critical need for trust and interoperability. By tokenizing educational assets and recording them on

an immutable ledger, the platform provides an unprecedented level of integrity and proof of provenance (Luo et al., 2023). This mechanism incentivizes the creation of high-quality content, as educators are assured of proper attribution. It also fosters a collaborative ecosystem where institutions can confidently share and build upon each other's resources, effectively breaking down the 'data islands' that currently plague the system.

Furthermore, the platform's ability to manage immutable learning records and facilitate a cross-institutional credit bank is a game-changer for articulation (Ren et al., 2023; Wang, H. & Wang, Q., 2025). It automates the historically cumbersome and fraud-prone process of credit transfer. A student's achievements, verified on the blockchain, become a portable and universally trusted form of educational currency. This technological backbone provides the trust layer necessary for the articulated curriculum model to function effectively in a multi-institutional environment, ensuring that the 'seamless' progression is not just a theoretical concept but a practical reality.

5.3. Aligning with China's New Vocational Education Standards

The proposed framework is not an abstract construct; it is designed in direct alignment with the strategic thrust of China's 2025 vocational education reform. The framework's core principles resonate strongly with the new standards:

Vertical Integration: The very essence of the articulated 'secondary-higher-undergraduate' model fulfills the standards' primary mandate for a vertically integrated vocational education system (Guan et al., 2025).

Competency-Based and Practice-Oriented: The four-tier competency model and the emphasis on project-based 'Competency Extension Modules' directly implement the standards' call for a shift towards CBE and increased practical training (Zhong & Juwaheer, 2024).

Industry Alignment: The entire framework was developed from a needs analysis of the logistics industry, ensuring that the competencies and curriculum content are relevant to the demands of the digital economy, another key requirement of the reform.

Digitalization of Education: By proposing a blockchain-based platform, the framework not only teaches a key digital technology but also uses it to modernize the educational infrastructure itself, embodying the spirit of educational digital transformation that the standards champion.

In essence, our framework can be viewed as a concrete implementation strategy for the new national standards within the specific context of logistics education.

5.4. Challenges and Mitigation Strategies

Despite its potential, the implementation of such an ambitious framework is not without challenges, as identified in our preliminary research and echoed in the literature. We identify three primary challenges and propose corresponding mitigation strategies.

Content Obsolescence: Blockchain technology is evolving at a breakneck pace. Curriculum content developed today could be outdated tomorrow.

Mitigation: The modular design of the curriculum is key. It allows for individual modules to be updated or replaced without overhauling the entire system. Furthermore, the blockchain platform itself can facilitate a dynamic 'living curriculum.' By creating a community of educators and industry experts on the platform, new content and case studies can be rapidly developed, peer-reviewed, and disseminated, creating a continuous cycle of content renewal.

Faculty Development: There is a significant shortage of educators who are proficient in both logistics and blockchain technology.

Mitigation: A large-scale, sustained faculty development program is essential. This should go beyond one-off workshops and include immersive training, industry externships, and collaborative course development with blockchain experts. The platform can support this by hosting 'train-the-trainer' modules and creating a community of practice where educators can share best practices and support one another.

System Integration and Governance: Building and managing a consortium blockchain involving multiple educational institutions and industry partners presents significant technical and governance hurdles.

Mitigation: A phased implementation approach is advisable, starting with a small pilot group of committed institutions. A clear governance model must be established from the outset, defining roles, responsibilities, and rules for participation. Technically, focusing on interoperability standards (like Decentralized Identifiers and

Verifiable Credentials) will be crucial to ensure the platform can interact with other systems in the future (Any et al., 2024). The initial focus should be on establishing a minimum viable product (MVP) that delivers core functionalities before expanding its scope.

6. Conclusion and Future Work

6.1. Principal Contributions

This study has designed a comprehensive, integrated framework to address the pressing need for a modernized and articulated logistics education system in the age of blockchain. The principal contribution is a tripartite solution that systematically aligns vocational education with the demands of the digital economy. First, the proposed four-tier competency model provides a clear, progressive pathway for skill development, translating abstract industry needs into concrete educational objectives. Second, the "Shared Foundation, Divergent Paths, Progressive Competency" curriculum structure offers a practical blueprint for overcoming the fragmentation that has long plagued vocational education, creating a seamless journey from secondary to undergraduate studies. Third, the conceptual architecture of the blockchain-based educational resource platform presents a novel approach to solving the infrastructural challenges of resource integrity and credential verification, leveraging the very technology being taught to transform the educational ecosystem itself.

6.2. Theoretical and Practical Implications

From a theoretical perspective, this research contributes to the literature at the intersection of education technology, curriculum studies, and supply chain management. It extends the application of Design-Based Research to the complex domain of multi-level curriculum integration and provides a new model for how emerging technologies can be woven into the fabric of educational design, both as a subject and a tool.

Practically, the framework offers significant value to multiple stakeholders. For educational policymakers, it provides a concrete model for implementing the vision of the new national vocational standards. For educational institutions, it offers a clear roadmap for curriculum reform, faculty development, and inter-institutional collaboration. For students, it promises a more coherent, relevant, and empowering learning experience with portable and verifiable credentials. Finally, for the logistics industry, it lays the groundwork for cultivating a talent pipeline that is genuinely equipped with the skills required to drive future innovation.

6.3. Limitations of the Study

It is important to acknowledge the limitations of this study. The framework presented is, at this stage, primarily conceptual and based on design principles, needs analysis, and expert consultation. Its real-world efficacy has not yet been empirically validated through a full-scale implementation. The proposed blockchain platform is an architectural blueprint, and its development and deployment will inevitably encounter technical and operational hurdles not fully anticipated in the design phase. Furthermore, the study is contextualized within the Chinese vocational education system, and while the principles are broadly applicable, direct translation to other national contexts would require significant adaptation.

6.4. Future Research Directions

The limitations of this study pave the way for a clear agenda for future research. The immediate next step, as outlined in our DBR methodology, is to move into the development and implementation phases. This will involve building the curriculum modules and a prototype of the blockchain platform, followed by a rigorous pilot study in a real-world setting. Future research should focus on empirically evaluating the impact of the framework on student learning outcomes, faculty adoption, and institutional collaboration. Longitudinal studies tracking the career progression of graduates from this program would provide the ultimate validation of its effectiveness. Additionally, further research could explore the economic and governance models required for a self-sustaining, large-scale blockchain consortium for education, as well as the technical challenges of ensuring interoperability and data privacy in such a system.

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