

Research on the Construction of a Digital Credit Bank System for Vocational Education Students Based on Blockchain Technology

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Abstract: Against the backdrop of building a country strong in education, promoting high-quality development of vocational education stands as a core task. The credit bank serves as a critical institutional carrier linking academic education, non-academic training, and lifelong learning. China has completed the construction of basic platforms and pilot promotion for vocational education credits, yet practical operation is still plagued by inconsistent credit recognition standards, security risks of student information and credit data, and cumbersome cross-institutional credit mutual recognition procedures. Featuring distributed ledgers, cryptographic protection, consensus verification, and automatic execution via smart contracts, blockchain technology can target the operational drawbacks of traditional credit banks. On this basis, grounded in the national strategy for digital education development, this paper defines core concepts, sorts out the current status and dilemmas of credit bank construction, and explores the establishment of a blockchain-based digital credit bank system for vocational education students, aiming to provide valuable references for the development of vocational education credit banks.

Keywords: Blockchain technology; Vocational education; Digital credit bank; System construction; Learning outcome certification

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1. Introduction

The National Implementation Plan for Vocational Education Reform has arranged the construction of a national “credit bank” for vocational education, laying a fundamental foundation for tracing, querying, and converting learning outcomes. The Outline for Building a Country Strong in Education (2024–2035) further clarifies the establishment of a lifelong learning system based on qualification frameworks, centered on credit bank platforms and learning outcome certification. Traditional credit banks operate under a centralized management model, which creates numerous obstacles for centralized administration of diversified learning outcomes. Vocational institutions and training providers adopt inconsistent criteria for credit recognition;

data storage and circulation entail security risks; cross-agency credit mutual recognition lacks corresponding technical support, leading to unsatisfactory practical outcomes of credit banks. By adopting distributed bookkeeping and blockchain technology, credit banks can build multi-stakeholder trust and offer new solutions for the management, certification, and mutual recognition of credit data. Targeting vocational education students, this paper explores approaches to constructing a digital credit bank system supported by blockchain technology to drive the digitalization and credibility transformation of credit banks.

2. Definition of core concepts

2.1. Vocational education credit bank

Drawing on the management logic of financial savings, vocational education credit banks take credits as measurement units to uniformly register, archive, convert, and exchange various learning outcomes of vocational college students, including course learning, practical training, skill certificate acquisition, and competition awards ^[1]. This system breaks the restrictions of traditional vocational education in learning time, space, and forms, and bridges academic education and non-academic training. Students can accumulate credits according to their own learning progress, and accumulated credits can be used for course exemption, certificate exchange, and academic promotion. It acts as an important institutional tool to build talent development pathways in vocational education ^[2].

2.2. Core characteristics of blockchain technology

Blockchain is a distributed ledger technology (DLT) integrating distributed ledgers, point-to-point transmission, consensus mechanisms, cryptography, and smart contracts, maintained by multiple nodes with tamper-proof data.

Its core technical characteristics fall into five categories: First, data is stored across multiple nodes without a single centralized administrator. Second, once data is encrypted and uploaded to the chain, individual nodes cannot alter content arbitrarily. Third, public-private key paired encryption is adopted for identity verification and data protection. Fourth, multiple nodes jointly judge data validity. Fifth, preset code protocols can automatically execute corresponding processes once specific conditions are met.

3. Current status and practical dilemmas of vocational education credit bank construction

3.1. Significant differences in credit recognition standards impede cross-agency mutual recognition

Vocational colleges differ in talent training programs, curriculum settings, and credit accounting methods. As a result, identical learning outcomes are assigned distinct recognition standards and credit values across different colleges or training institutions. No universal reference framework for credit conversion has been formed between colleges or between colleges and vocational skill training institutions. Many educational entities hold low recognition of credits issued by external organizations due to curriculum resource protection and internal teaching management ^[3]. Independent credit systems operate separately among all educational providers. After students take courses across colleges or participate in training at external institutions, their accumulated credits cannot be smoothly recognized across entities, resulting in poor implementation of credit

mutual recognition.

3.2. Security risks exist in data storage and circulation

Most traditional vocational education credit banks adopt centralized servers for data storage. Sensitive data such as student identity information and credit acquisition/transformation records are aggregated in a single location. This storage mode easily triggers privacy leakage and malicious tampering of credit data in cases of cyberattacks, hardware failures, or human operational errors. Stakeholders of vocational education include higher vocational colleges, social training institutions, and skill evaluation agencies, whose management systems and data formats vary widely, hindering cross-platform data docking and causing delays in credit data circulation and updates ^[4]. Student information must be transmitted and verified across platforms during credit certification and cross-institutional conversion, while current workflows lack comprehensive security protection, failing to safeguard personal privacy fully.

3.3. Cumbersome procedures for credit certification and verification

Credit recognition, conversion, and inspection still rely heavily on offline manual workflows. Students need to prepare paper or electronic materials including transcripts, skill certificates, and training certificates on their own, while educational institutions conduct offline communication and multi-level approval for reviews, leading to lengthy and complicated overall procedures ^[5]. Manual review is also susceptible to subjective judgment of staff and inconsistent operational standards. Furthermore, there is no unified and complete channel to archive historical records of learning outcomes and credits, making it difficult for external parties such as employers and further education colleges to verify the authenticity and validity of credits rapidly.

3.4. Insufficient application scenarios and social recognition

When recruiting talent, employers prioritize academic diplomas and traditional vocational qualification certificates, paying little attention to credit outcomes from credit banks. Credit banks are mainly participated in by vocational colleges, with limited involvement from enterprises and industry associations. The scope of learning outcome recognition fails to cover all learning scenarios of vocational education. Some regional and institutional platforms only complete registration without launching actual credit conversion services, leaving the application value of platforms untapped.

4. Construction of blockchain-based digital credit bank system for vocational education students

4.1. Technical construction of layered architecture

The network layer serves as the basic operational carrier of the whole system, adopting a P2P distributed networking model and building node networks based on Peer nodes of Hyperledger Fabric. Connecting provincial education authorities, vocational colleges, skill training and evaluation institutions, cooperative enterprises, and other participants, the network layer establishes exclusive channels for data interaction between different platforms ^[6]. Operated under distributed logic, a single node failure will not disrupt the entire network, providing a stable underlying environment for credit data transmission and interaction.

The data layer acts as the core storage of credit data, constructing a distributed credit ledger via the SHA-256 hash algorithm and RSA asymmetric encryption technology. It stores student identity information,

detailed learning outcomes, credit accounting records, and conversion histories. All data is encrypted via hash functions to generate blocks connected in chronological order to form a chain structure. Authorized nodes within the consortium chain can access data within their permission scope, while sensitive information is encrypted for access only by authorized entities, balancing data transparency and privacy protection.

The consensus layer adopts the Raft consensus algorithm to verify the validity of credit data. After students submit learning outcomes, nodes including colleges, education authorities, and industry institutions conduct joint reviews. Data can only be written into blocks after all nodes reach consistent judgment results^[7]. This multi-stakeholder confirmation model strengthens the authority of credit management.

The contract layer adopts Go/Node.js/Java to develop chain codes covering credit recognition, credit conversion, credit review, and abnormal early warning scenarios. Compiled in accordance with national credit bank standards and vocational education credit management rules, contract codes preset learning outcome recognition criteria, credit conversion ratios, and review workflows to automatically execute operations once triggered, replacing manual work for standardized credit management.

The application layer develops visual interfaces for four types of users: students, colleges, enterprises and education authorities. The student terminal supports account registration, learning outcome submission, credit status inquiry and conversion application; the college terminal enables learning outcome review, course credit management and student credit file administration; the enterprise terminal allows viewing student credits and learning outcomes; the education authority terminal supports platform supervision, data statistics and standard formulation, meeting diverse credit management and usage demands of all stakeholders.

4.2. Construction of core functional modules

4.2.1. Student digital identity management module

After platform registration, the system generates an exclusive digital identity identifier for each student via asymmetric encryption technology, binding the digital identity with student school enrolment and identity information. The public key is used for identity verification and public inquiry, while the private key is kept by students themselves to authorize credit operations. The unique digital identity effectively prevents identity impersonation and protects student personal information security.

4.2.2. Learning outcome certification and storage module

This module covers all types of vocational education learning outcomes, including academic courses, enterprise training, 1 + X certificates, skill competitions, and industry certifications. After students upload supporting documents for learning outcomes, smart contracts complete preliminary verification following preset rules, and consortium chain nodes conduct consensus judgment. Qualified learning outcomes are converted into credits and recorded on the chain^[8]. Learning outcomes and credit information are permanently archived as evidence of students' learning experience.

4.2.3. Credit conversion and circulation module

Docked with the national lifelong education qualification framework, this module realizes credit conversion automatically via smart contracts based on unified credit conversion standards. Scenarios including cross-college study, certificate-to-credit exchange, and training outcome credit offsetting can complete automatic credit accounting and transfer through contracts^[9]. The module bridges credit circulation between colleges, training institutions, and enterprises, expanding credit application scenarios.

4.2.4. Credit traceability and verification module

The chain structure of blockchain fully records the whole process of credit generation, conversion, and review. Colleges, enterprises, and education authorities can access complete credit history through students' digital identities. External parties can verify the authenticity and validity of credits, replacing traditional manual verification and improving inspection efficiency ^[10].

4.2.5. Lifelong learning file management module

This module continuously records all learning outcomes and credit changes of students during their school years to establish complete digital learning files. The files include students' learning experience, skill improvement progress, and outcome certification results, serving as references for further education, employment, and skill evaluation, and providing authentic evidence for assessing vocational education talent training quality.

4.3. Platform docking and technical implementation

During system construction, official docking is realized with the National Smart Education Public Service Platform and the Vocational Education 1 + X Certificate Management Platform to obtain official data such as student enrolment information and certificate assessment results. Meanwhile, docking with higher vocational college educational administration systems and enterprise training management platforms automatically collects internal and enterprise-side data including course scores, training hours, and training outcomes to guarantee authentic data sources.

Unified standards for learning outcome classification, credit coding, and conversion ratios are formulated in line with national credit bank specifications, incorporating multi-source data into the system under unified rules. Smart contracts are developed to fit actual vocational credit management workflows and deployed online after multiple rounds of testing.

5. Conclusion

Vocational education credit banks constitute a key component of the lifelong learning system. Traditional credit banks suffer from practical issues such as poor adaptability of credit management, weak data security protection, and blocked cross-agency credit circulation. Based on the Hyperledger Fabric consortium chain, this paper integrates multiple key technologies and connects digital education platforms at all levels to build a five-layer technical architecture and five core functional modules, forming a comprehensive digital credit bank system for vocational education students. The system streamlines vocational credit management workflows, safeguards credit data security, and connects credit circulation across different stakeholders. In the future, platform functions can be continuously optimized in light of the characteristics of various vocational majors and application scenarios to promote wide-scale system implementation, advance the digital transformation of vocational education, and support the construction of a skill-oriented society and lifelong learning for all citizens.

Disclosure statement

The author declares no conflict of interest.

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