Construction Pathways for the National "Credit bank" for Vocational Education Based on Blockchain Technology

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Abstract: With the advancement of industrial society towards the knowledge economy era, building a lifelong education system has become a global trend. The biggest challenge encountered is how to scientifically recognize various achievements in lifelong learning. Over the past 20 years, "Credit bank" that have emerged overseas have become powerful tools to solve these problems. By analyzing the core advantages of blockchain technology, in the paper, it explores the coupling relationships and mechanisms of action between blockchain technology and the national "Credit bank" for vocational education. The overall framework of the national "Credit bank" for vocational education based on blockchain technology is designed from five levels of network layer, data and storage layer, core blockchain platform layer, interface and channel layer, application and service layer. And following the main principles of systematicity, scientific nature, reliability and standardization, the construction pathways of the national "Credit bank" for vocational education based on blockchain technology are proposed from the aspects of sharing and safety management of vocational education resources, learning account management, credit mutual authentication, accumulation and conversion, learning process recording and monitoring, information query, certificate issuance and quality assurance. The goal is to achieve the authentication, accumulation and conversion of different types of learning outcomes in vocational education.

Keywords: Vocational Education; "Credit Bank"; National "Credit Bank"; Blockchain Technology; Construction Pathways

1. Introduction

From "Opinions on Accelerating the Development of Secondary Vocational Education" issued by the Ministry of Education in 2005, which first formally proposed the "Credit bank" in the field of vocational education, and "Action Plan for Innovative Development of Higher Vocational Education (2015-2018)" presented "Promote the gradual implementation of the credit system in vocational colleges, have the accumulation and authentication of different types of learning outcomes, and establish the ‘Credit bank’", to "Implementation Plan for National Vocational Education Reform" (The twenty articles on Vocational Education) proposed to establish national standards for vocational education and accelerate the construction of the national "Credit bank" for vocational education, "Guiding Opinions on the Formulation and Implementation of Professional Talent Training Plans for Vocational Colleges" (Department of Vocational and Adult Education in Ministry of Education, [2019]13) proposed "Encourage vocational colleges to actively participate in the pilot program of the national ‘Credit bank’ for vocational education", and then to "Vocational Education Law of the People's Republic of China" explicitly stated "Establish the national ‘Credit bank’ for vocational education, promote the authentication, accumulation and conversion of various learning outcomes in vocational education", which has become the core and theme of China's vocational education reform and development in the new era.

The concept of "Credit bank" is originated from American community colleges in the 1880s, and the Korean Educational Development Institute proposed the "Credit bank system" in 1995. "Credit bank" is an educational management model and system that simulates the functional characteristics of a bank, with credits as the unit and information platform as the support. It uniformly certifies and accounts for various learning outcomes of learners according to

common reference standards, achieving credit authentication, accumulation, and conversion [1,2]. As the most universal underlying framework technology nowadays, the characteristics of security, transparency and tamper proof information in blockchain technology can meet the demands of the era of openness and public trust of the national "Credit bank" for vocational education, realize the sharing and security management of vocational education resources, traceability of learning processes, credibility and efficiency of learning achievement authentication and conversion, and other key issues that urgently need to be addressed in the construction of the national "Credit bank" for vocational education.

2. Current research status at home and abroad

The construction of a national "Credit bank" is an important guarantee to ensure the authority and credibility of the "Credit bank" and to serve as a "bridge" for lifelong education [3], while the national "Credit bank" for vocational education is a pioneering, partial breakthrough and necessary historical stage of the national "Credit bank" in the field of vocational education [4]. The national "Credit bank" for vocational education has both institutional and institutional attributes. From an institutional perspective, it is a large and precise management system. Its effective operation not only requires support from policies and regulations, operational mechanisms and quality monitoring systems, but also relies on deep integration with information technology.

2.1 Research on the theory of "Credit bank"

(1) Research on conceptual and connotation. The research on "Credit bank" can be traced back to the course selection system and credit system. Its concept is mainly defined from three perspectives of education system, model and management institution [5-7]. Essentially, it is the authentication, accumulation and conversion of learners' learning outcomes in the context of lifelong learning, with credit, quality and equality as the core of its connotation [8-10]. (2) Research on functional elements and main features. The main functions of the "Credit bank" are to deposit, lend and exchange credits, with the core functions being credit accumulation, mutual authentication and conversion [11,12]. "Credit bank" have some basic characteristics, such as lifelong, open, fair, systematic and service-oriented nature [13,14]. (3) Research on theoretical basis and framework system. The theoretical research basis of the "Credit bank" are some theories such as lifelong education, free learning, educational equity, multiple intelligences, and humanism theory [15-17]. Qi proposed a theoretical analysis framework of "credits-information technology-learning achievement certification-lifelong learning" [18]. Ma pointed out that the "Credit bank" is a systematic and comprehensive concept that can be studied from multiple perspectives, such as learning outcome orientation, human resource development, market economy and social culture [19].

2.2 Research on the construction of "Credit bank"

The research results mainly involve the construction mode, policies and regulations, organizational structure, operational mechanism, technical platform, quality assurance and service system of the "Credit bank". The construction mode can be divided into two types: top-down and bottom-up. Policies and regulations focus on unified qualification authorization, rigorous standard system and clear operating procedures. The research on operational mechanisms mainly covers the framework system of learning outcomes, the credit standard mechanism centered on courses, the credit certification mechanism, "deposit-loan-exchange" credit linkage mechanism and the integrity mechanism [20-22]. Among these, the qualification framework, curriculum standards, credit certification, accumulation and conversion standards and rules, and personal lifelong learning accounts have received widespread attention [23,24]. The research on technology platforms mainly focuses on the characteristics of the "Credit bank", such as wide distribution of resources, complex business processes, frequent information exchange, and high requirements for security and openness, then Cloud computing, Big data, SOA (Service-Oriented Architecture), SSH (Secure Shell) and other technologies are selected for architecture design [25,26].

2.3 Research on the Current Situation, Bottleneck Problems and Countermeasures of the Construction of "Credit Bank" in China

Although the construction of the "Credit bank" for vocational education in China started early,

progress has been slow. The pilot "Credit bank" projects in Beijing, Shanghai, Jiangsu, Guangdong and Yunnan, as well as the Open University of China, have made certain progress in exploring the certification and accumulation of different types of learning outcomes such as continuing education and community education. In particular, the Open University of China has initially established a national "Credit bank" with a learning outcomes framework as the core, a "framework + standard" as the technical path, a learning outcomes mutual authentication alliance as the operating platform, and a learning outcomes certification service system and information platform as the service carrier. However, there are some shortcomings in terms of interoperability, authority, efficiency and security. Especially in the field of education, the "information barrier" of horizontal obstruction and vertical fragmentation, the immutability and authentic traceability of credits, the credibility of credit mutual authentication, the efficiency of credit authentication and conversion and other issues have become technical bottlenecks in achieving the "Credit bank", which cannot be fundamentally solved through institutional construction alone [27-30]. As a disruptive information technology that has emerged in recent years, core technologies, mainly including distributed ledger technology, asymmetric encryption algorithms, consensus mechanisms, time series data and smart contracts, of blockchain can effectively break through the above "bottleneck" problems [31-32].

2.4 Research on the Application of Blockchain Technology in Educational Informatization

Related research has focused on learning process recording, educational resource sharing management, degree certificate management, learning quality assessment, digital copyright protection, learning outcome certification and other aspects [33-36]. Practical applications mainly include: EDUCTX, which is a European credit conversion and accumulation system based on the Ethereum blockchain; Blockcerts, which is a digital certificate system based on the Bitcoin blockchain and possessing traceable and tamper proof properties developed by the Massachusetts Institute of Technology in the United States; Sony Education Services Platform, which is based on blockchain technology and capable of permanently storing learning data; "Micro Authentication" of UK Open University, which is based on blockchain technology that can convert different types of learning outcomes; Blockchain student file management system of the University of Melbourne, which has lifelong learning personal accounts; EDC distributed ledger system, which is based on blockchain technology to store learning records of learners from different educational and training institutions [37-39].

2.5 Literature Review

The research on the "Credit bank" has received increasing attention from scholars both domestically and internationally. However, the theoretical system surrounding the national "Credit bank" for vocational education has not yet been formed, and the basic theoretical research on the connotation and extension, essential characteristics, and implementation mechanism urgently needs to be strengthened. At the same time, through the practical application and research results of educational informatization, blockchain technology has enormous potential value and broad application prospects in the authentication, accumulation and conversion of learning outcomes. Therefore, it is necessary to actively explore the application of blockchain in vocational education informatization, and strengthen the research on the framework design and construction path of the national "Credit bank" for vocational education based on blockchain technology.

3. Theoretical Foundations

3.1 Definition of Related Concepts

3.1.1 "Credit bank"

"Credit bank" is a management model that simulates or draws on the functional characteristics of banks, allowing students to freely choose their learning content, learning time and learning location.

3.1.2 National "Credit bank"

National "Credit bank" is an educational management system that simulates the operation mode of a bank, aimed at authenticating, accumulating and converting various learning outcomes of learners, to promote lifelong learning and the construction of a learning society [4,40]. Its core functions include integrating learning outcomes, enhancing employment competitiveness, optimizing the allocation of educational resources, and providing flexible and diverse learning support

to the public through a unified certification system [3,41].

3.1.3 National "Credit bank" for vocational education

The core function of national "Credit bank" for vocational education is to break down the barriers of traditional education and achieve credit accumulation and conversion cross institutional and cross disciplinary. The system not only supports academic education, but also covers non-academic education, such as vocational qualification certificates and skills training certificates. Through it, learners can freely convert credits between different educational institutions, avoiding the waste of repetitive learning and providing convenience for lifelong learning.

3.2 The Core Technology of Blockchain

Blockchain is a decentralized and distributed ledger with block-chain storage, immutability, security and trustworthiness. It integrates technologies, such as distributed storage, peer-to-peer transmission, consensus mechanisms and cryptography [42]. By continuously appending data blocks-chain, it records transactions and information, ensuring data security and transparency.

3.2.1 Distributed ledger technology

The core principle of blockchain is distributed ledger technology. Traditional ledgers are typically maintained by a centralized administrator, whereas blockchain technology disperses the ledger across multiple nodes. Each node has the authority to modify and verify the ledger, thereby achieving decentralized storage and transaction confirmation.

3.2.2 Asymmetric encryption algorithm

Asymmetric encryption algorithm is one of the core security technologies of blockchain, which achieves data encryption and decryption through the pairing of public and private keys. Its core application scenarios are mainly including, information encryption: the sender uses the receiver's public key to encrypt information, ensuring data transmission security; digital signature: the private key generates a signature to verify the integrity of the information and prevent tampering; login authentication: the user's private key encrypts the login information, and the server verifies the identity with the public key.

3.2.3 Consensus mechanism

In blockchain networks, consensus mechanism is a key protocol that ensures that all participating nodes can reach a consensus state. Through the mechanism, nodes in the blockchain network can jointly verify the validity of transactions and update the blockchain state in an environment of mutual distrust. The implementation of the mechanism ensures the decentralization, security and immutability of blockchain networks.

3.2.4 Time series data

Narrowly speaking, blockchain is a chain like data structure that combines data blocks in chronological order and ensures immutability and unforgeability through cryptographic means. The time series data of blockchain is mainly used to record transaction history, verify data integrity and maintain system security.

3.2.5 Smart contract

Smart contract is an automated protocol defined in code form, stored on the blockchain, and executed by the blockchain network. Its core function is that when the preset conditions are met, the smart contract will be automatically triggered and the transaction or operation will be completed.

4. Framework Design for the National "Credit Bank" for Vocational Education based on Blockchain Technology

4.1 Analysis of the Coupling Mechanism between Blockchain Technology and the National " Credit Bank" for Vocational Education

Referring to the connotation and characteristics of "Credit bank", combined with the characteristics and current situation of domestic vocational education, the main functions of the national "Credit bank" for vocational education include [43-45]: (1) User management. The service targets of the "Credit bank" are divided into institutional users and individual users. Institutional users mainly include Vocational colleges, applied undergraduate universities, the Open University of China, Vocational education and training evaluation organizations, and related institutions participating in the "1+X" system pilot, while individual users mainly include college students, social learners, etc. User management mainly implements the management of institutional user learning accounts and individual user learning accounts. (2) Vocational education resource management. It mainly involves the collection, integration, sharing and copyright management of vocational

education resources, etc. (3) Learning process management. It mainly involves record of learners' learning information, query of learners' learning reputation and proof of learners' learning outcomes. (4) Learning outcome management. It mainly realizes the registration, certification and storage of learners' personal learning outcomes, as well as the credit authentication, accumulation and conversion. Among them, credit authentication, accumulation and conversion are the core functions of the national "Credit bank" for vocational education. Through credit authentication, the credit earned by students is confirmed and recorded in their credit accounts. By credit accumulation, the credit is stored and managed to ensure the security and stability. Through credit conversion, students can achieve the circulation and authentication of credit between different schools and institutions. (5) Learner profile management. It mainly realizes the recording, statistics and querying of learners' lifelong learning profiles.

So, there is a strong intrinsic connection between blockchain technology and the national "Credit bank" for vocational education, whose coupling mechanism is as follows in Figure 1 [46-48]. (1) The "permanently store data" feature of distributed ledger technology can realize the functions of user account management and learning achievement management in the national "Credit bank" for vocational education. Among them, it can realize the management of personal and institutional user account information, which is a strong support, and realize credit storage function of credit accumulation in learning outcome management, which is a weak support. The "decentralized" feature of distributed ledger technology can realize the collection, integration and sharing of vocational education resources, which is a strong support. (2) Asymmetric encryption algorithm can effectively ensure the security of user management accounts, copyright management of vocational education resources, credit authentication of learning outcomes, information security during credit accumulation and conversion processes and preventing malicious tampering, which are strong supports. At the same time, it can support the anti-tampering of learning information records in learning process management, which is a weak support. (3) Consensus mechanism can achieve the authenticity and credibility of vocational education resource management, learning process management and learning outcome management, while also preventing the forgery of user account information and learner profile information to a certain extent. (4) Time series data can effectively support the traceability and verifiability of information and data in learning process management and learning outcome management, which are strong supports. (5) The automation and efficient completion of transactions through smart contracts are beneficial for user account management, vocational education resource management and learner profile management, which are weak supports.

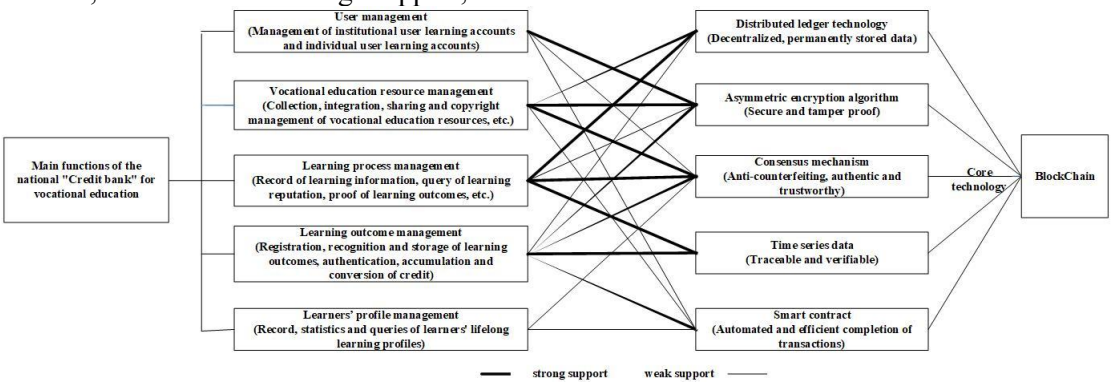

Figure 1. Coupling Mechanism between Blockchain Technology and the National "Credit Bank" for Vocational Education

4.2 Framework Design for the National "Credit Bank" for Vocational Education based on Blockchain Technology

4.2.1 Design objectives

Firstly, credible storage and immutability. Ensure the authenticity, uniqueness and non-repudiation of all learning outcomes (credits, certificates, skill badges, etc.). Secondly, interconnectivity and breaking "information silos". Establish unified standards and data exchange protocols for different institutions,

training organizations and enterprises to eliminate information barriers. Thirdly, efficient circulation and intelligent conversion. Automate the authentication and conversion of credits through smart contract to enhance efficiency and reduce human intervention and disputes. Fourthly, privacy protection and authorized access. Safeguard learners' personal privacy while ensuring data transparency and verifiability, with data usage rights belonging to the learners. Finally, incentivized learning and value realization. Introduce a token economy model to positively incentivize learning achievements, exploring the "financial attributes" and "asset attributes" of credits.

4.2.2 Design framework

The overall framework for the national "Credit bank" for vocational education based on blockchain technology is designed across five layers [49-52]: network layer, data and storage layer, core blockchain platform layer, interface and channel layer, application and service layer, as shown in Figure 2.

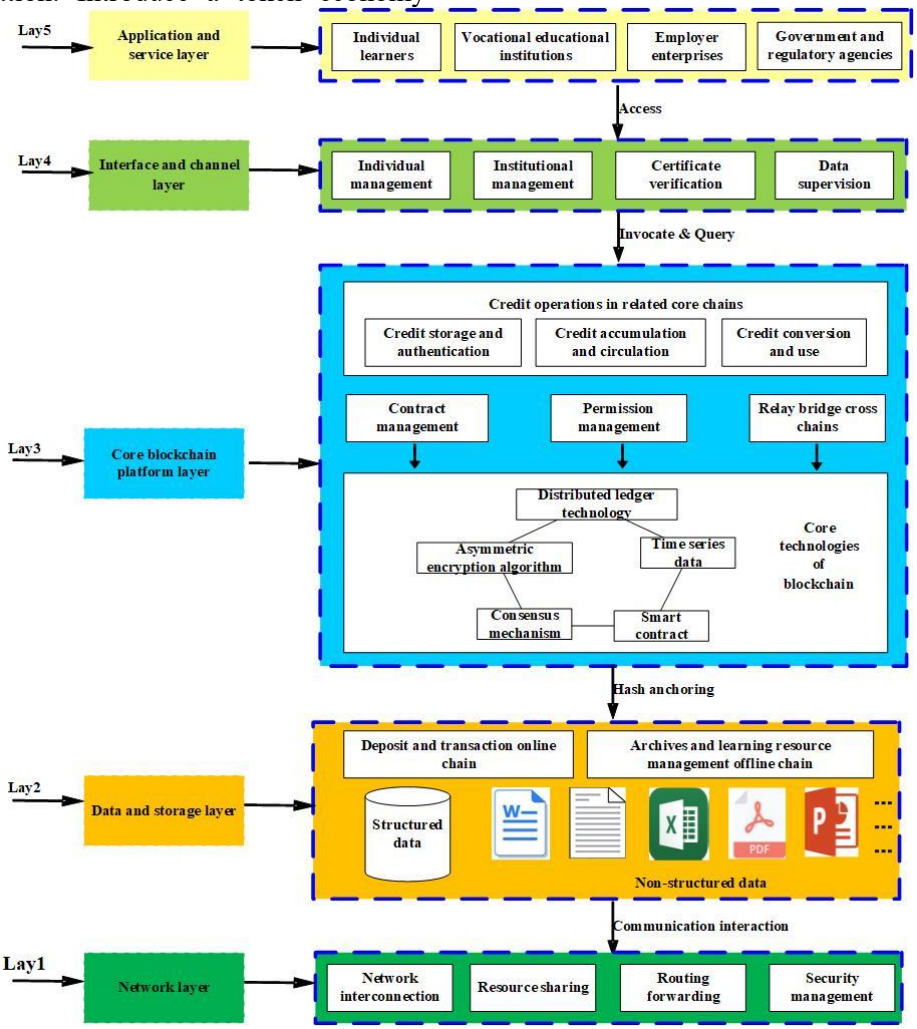

Figure 2. Total Frame of the National "Credit Bank" for Vocational Education based on Blockchain Technology

Layer 1: Network layer

The layer is the guarantee for interactive communication of the national "Credit bank" system for vocational education, and can also provide data transmission guarantee for executing storage.

(1) Network interconnection. Interconnect the communication networks of all nodes (individual learners, vocational education institutions, government departments, enterprises, etc.).

(2) Resource sharing. Collect vocational education resources from all vocational education institutions (Vocational colleges, Vocational training institutions, etc.) and integrate them to achieve sharing.

(3) Routing forwarding. Achieve data propagation and data sharing.

(4) Security management. Mainly include network security and information security, to ensure the security of network communication

and the security of information transmission.

Layer 2: Data and storage layer

The lay adopts a hybrid storage model of "online chain + offline chain" to balance efficiency, cost and security of the system.

(1) Online chain storage (certification). Firstly, store the core hash of credits (such as credit ID, learner DID, issuing institution, timestamp, credit value). Secondly, store transaction hashes for key operations (such as issuance, conversion and query authorization). Through online chain storage, it can realize tamper proof, traceable, open and transparent.

(3) Offline chain storage. Firstly, store detailed learning records (such as assignments, portfolios, exam papers, video recordings). Secondly, store abundant learning resources. Through offline chain storage, it can realize low storage cost and large capacity. Because of storing the hash value of offline chain data on the chain, any tampering with offline chain data will be immediately detected, ensuring the security and trustworthiness of offline chain data.

Layer 3: Data and storage layer

The layer is the "trust engine" and technical core of the system. It is recommended to use consortium chains (such as FISCO BCOS, Ant Chain, Fabric, etc.), where only authorized nodes can participate in accounting.

(1) Contract management. Firstly, credit issuance contract management. Define the criteria for credits (such as name, level, duration and affiliation), which can only be invoked by authorized institutions. Secondly, credit conversion contract management. Built in officially recognized "exchange rules", automatically realizing credit authentication and conversion between different institutions and types of learning outcomes. Thirdly, identity management contract management. Manage the digital identities (DID) of all participants in the system to ensure unique and trustworthy identities. Finally, authorization and query contract management. Manage learners' query authorization for enterprises and institutions to protect personal privacy.

(2) Permission management. Based on PKI (Public Key Infrastructure) or national encryption algorithms, assign different data access and operation permissions to different roles (learners, institutions, enterprises, governments, etc.).

(3) Relay bridge cross chains. It is a key component, which is used to connect the "Credit chain for vocational education" with other possible blockchain systems (such as the " Credit chain for general education" and "Industry certificate chain"), achieving greater data and value exchange on a larger scale.

Layer 4: Interface and channel layer

The layer provides access to the system for different users, ensuring convenient and secure interaction.

(1) Individual management. Manage personal digital identities and credit wallets for individual learners.

(2) Institutional management. Provide educational institutions with functions such as batch credit issuance, student management and data queries.

(3) Certificate verification. Provide a simple QR code scanning or certificate ID input interface, allowing enterprises to complete certificate verification in seconds.

(4) Data supervision. Provide a visual data big screen for government agencies to dynamically monitor the credit issuance and conversion situation of various regions and institutions.

Layer 5: Application and service layer

The layer is where the system interacts with end users.

(1) Individual learners. Querying, depositing, converting and displaying their credits and digital certificates through mobile apps or websites, they are the owners of credit assets.

(2) Vocational educational institutions (mainly including: Vocational college, Vocational training institutions, etc.). Serving as the "issuers" of credits, they are responsible for certifying assessed learning outcomes (courses, certificates, work experience, etc.) as standardized credits and recording them on the blockchain for verification.

(3) Employer enterprises. They are the "users" of credits. After obtaining authorization, they quickly and reliably verify the qualifications, skill certificates and credit records of job applicants or employees, thereby improving recruitment efficiency.

(4) Government and regulatory agencies (mainly including: The Ministry of Education, The Ministry of Human Resources and Social Security, etc.). Serving as the "rule makers and overseers" of the system, they are responsible for setting credit standards, reviewing the qualifications of educational institutions, overseeing the operation of the entire system, and collecting macro-level data to support policy

decision-making.

5. Construction Pathways for the National "Credit Bank" for Vocational Education based on Blockchain Technology

Following the requirements of systematicity, scientific nature, reliability and standardization, and focusing on the core functions of authentication, accumulation and conversion of learning outcomes, research is conducted on the construction path of a national "Credit bank" for vocational education based on blockchain technology from some aspects of learners' account management, sharing and security management of vocational education resource, recording and monitoring in learning process, authentication, accumulation and conversion of credit, information query, certificate issuance and quality assurance, etc.

5.1 Sharing and Safety Management of Vocational Education Resources

Based on the achievements of the construction of the "Credit bank" for vocational education in the early stage, it is to achieve secure sharing of vocational education resources across different regions (east regions and west regions), levels (secondary vocational, higher vocational and undergraduate) and types (educational and non-educational). Based on the national unified qualification framework, the main steps are as follows: Firstly, using distributed ledger technology, asymmetric encryption algorithms and other technologies of blockchain to gradually complete the sharing and management of vocational education resources divided by different regions (eastern regions→western regions→east-west regions collaboration), different levels (secondary vocational schools → higher vocational colleges → vocational education undergraduate university → middle and high school undergraduate connection), and realizing the decentralization and distributed storage, security management and tamper proof of formal learning outcomes in vocational education. Secondly, using consensus mechanisms, time series data and other technologies of blockchain to reach consensus on the authentication and conversion needs of formal learning outcomes, and building an internal "Credit bank" within the vocational education system. Finally, integrate vocational education resources from relevant training institutions, use smart contracts, time series data and other technologies of blockchain to code informal learning outcome authentication and conversion standards applicable to various education and training institutions, establish a learning outcome library that binds unified credit authentication, accumulation and conversion standards and rules, and achieve the authentication and conversion of formal and informal learning outcomes in vocational education, that is, synergy between academic certificate with vocational certificate.

5.2 Learning Account Management

Learning account management mainly includes the registration, establishment and maintenance of learning account.

Personal learning account is mainly used to record personal learning outcomes' information, credit authentication information and related conversion information. Individual users register and fill in their basic personal information in the system. They confirm that the account creator matches the relevant information through real name authentication and other means. After registration is approved, the account establishment is completed. At the same time, maintenance operations such as adding, deleting and modifying personal learning account information could be performed.

The institutional learning account is mainly used to record information on learning outcomes owned by the institution, personnel participating in relevant outcome training and assessment, personnel holding relevant outcomes, and related conversion information. Institutional users can establish accounts on the system by registering, inviting registration and assigning accounts to staff. Relevant colleges and training evaluation organizations participating in the 1+X certificate system pilot can directly obtain their institutional information from the vocational skill level certificate information management service platform, and the system will automatically establish institutional accounts for them.

5.3 Authentication, Accumulation and Conversion of Credit

5.3.1 Credit storage and authentication

The learning outcomes are mainly divided into several categories: (1) Degree education outcomes. Course credits, graduation certificates or degree certificates obtained from formal universities, vocational colleges, etc. (2) Non-degree education outcomes. Vocational

qualification certificates, skill level certificates, training program completion certificates obtained from vocational training institutions, etc. (3) Indefinite learning outcomes. Abilities acquired through self-study, work experience, project research, volunteer service, competition awards, etc., need to be certified and converted into credits through specific ability assessments (such as interviews, replys, work reviews, skill assessments).

The authentication process of learning outcomes is [53]: Step1, learners submit relevant proof materials and applications. Step2, the system review and recognize according to established standards. Step3, after authentication, the corresponding credits are deposited into personal learning accounts.

5.3.2 Credit accumulation and circulation

(1) Credit accumulation. Learning outcomes from different times, locations and types can be continuously deposited into an account for accumulation as long as they are certified.

(2) Credit circulation. All credits and information will be stored securely in the cloud for a long time, and learners can log in and query them at any time. It achieves the 'one-time acquisition, lifelong validity' of learning records.

(3) Credit conversion and use

Credit usage is the ultimate goal, not the credit accumulation. The main uses include: (1) Exchange of academic certificates. When the accumulated credits meet the standards and requirements of a certain educational level (such as associate degree or undergraduate degree), the learner can apply to exchange the corresponding academic certificates [54]. This is the most popular feature of the system. (2) Proof of enrollment. Some educational institutions may recognize learning outcomes from the system as a basis for exemption from courses or direct admission. (3) Proof of career development. Various certificates and credits accumulated in the learning account can serve as authoritative proof of an individual's lifelong learning ability and skill level when seeking employment or promotion [55]. (4) Personalized learning path. The system can recommend subsequent learning courses and paths based on the learners' existing credits to avoid repetitive learning.

5.4 Recording and monitoring in learning process

Through standardized recording, technical monitoring and analytical evaluation, the learning process is recorded and monitored, to ensure that every learning effort of learners is traceable. It truly breaks down the barriers of time, space and form in learning, and builds a trustworthy, transparent and flexible lifelong learning overpass.

In general, the system needs to record the complete learning trajectory of learners from start to finish, mainly including the following types of data.

5.4.1 Identity and registration information

(1) Unique ID of the learner. Bound to user account in the system.

(2) Learning project or course information. Include metadata such as course name, offering institution, competency unit, credit value, expected learning duration, etc.

5.4.2 Learning process behavior data

Learning process behavior data records all key behaviors of learners on the system, which is a key of recording and monitoring in learning process. The data mainly include:

(1) Login and access data. Login time and frequency, total online time, and duration of stay in various modules of the course (such as videos, documents, forums).

(2) Content learning progress data. Opening time, reading duration, page turning or scrolling records of document reading, and whether annotations or notes are taken.

(3) Interaction and participation data. Number of posts and replies in the discussion forum, the quality of post content, and the number of likes or adoption.

(4) Practice and evaluate data. Submission time, scores, number of attempts, and error records for the class homework.

(5) Achievement data. Scores and completion times in the final exam.

5.4.3 Environmental and integrity data (for preventing cheat)

(1) Learning environment. For final assessments with invigilation requirements, IP addresses and camera surveillance footage (with authorization required) may be recorded.

(2) Behavior abnormal detection. Quickly jumping to course pages within a short period of time, frequent switching between multiple tabs, and other abnormal learning behaviors.

The system is based on the xAPI (Experience API) standard and uses the format of "Actor-Verb-Object" to record learning experiences. All records are sent and stored in a dedicated database called "LRS (Learning

Record Repository)", and the massive process data of LRS is analyzed. In addition, it is necessary to interface with various learning platforms (such as MOOCs platforms, Enterprise training systems, Virtual simulation training platforms, etc.) and automatically and securely synchronize the learning data generated by these platforms to the LRS of the system through standardized API interfaces.

6. Conclusion

The construction of a national "Credit Bank" for vocational education is a complex and long-term systematic project, which is an unavoidable key issue and historical task in the reform of national vocational education in the new era. The national "Credit Bank" for vocational education based on blockchain technology follows the design concept of "communication and sharing, safety and convenience, personalized customization and lifelong education". By effectively authenticating, accumulating, and converting different types of learning outcomes in vocational education, it opens up channels for learners' skill improvement, continuous growth and lifelong learning. It lays the foundation for vocational colleges to strengthen education and teaching reform, improve evaluation mechanisms and enhance the quality of talent cultivation. It provides support for deepening the supply-side reform of vocational education, to stimulate innovative activities and development momentum of vocational education, and promote the modernization level of vocational education.

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