Advances in Vocational and Technical Education (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/avte.2024.060223
ISSN 2523-5834 Vol. 6 Num. 2

Research on Learning Achievement Certification Model and Realization Path Based on Block-Chain Technology

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Keywords: Learning Outcome Certification Model, Higher Education, Digitization of Education, Certification of Learning Outcomes, Safeguard Measure

Abstract: Building a lifelong learning system that serves all people is the common goal of the sustainable development of global education. Building a lifelong learning system that serves all people is the common goal of the sustainable development of global education. Due to the advantages of practical use, convenience and transferability, alternative digital certificates provide a new strategy for the connection between the education system and the labor market in the Internet era, and the accumulation and transformation of personal lifelong learning results. Block-chain technology has the characteristics of decentralization, timing data, collective maintenance, programmability, immutability, traceability, etc., which has injected new impetus to the application of alternative digital certificates in modern lifelong education systems. Based on this, this paper builds a block-chain learning achievement authentication model that integrates the hybrid common mechanism, "master-slave multi-chain" data chain architecture and chameleon hash technology. At the same time, facing the "14th Five-Year Plan" development plan and the development goals of "China's Education Modernization 2035", the realization path of online learning achievement certification based on block-chain technology is designed, and the operational, practical and forward-looking safeguard measures are formulated. Due to the advantages of practical use, convenience and transferability, alternative digital certificates provide a new strategy for the connection between the education system and the labor market in the Internet era, and the accumulation and transformation of personal lifelong learning results. Block-chain technology has the characteristics of decentralization, timing data, collective maintenance, programmability, immutability, traceability, etc., which has injected new impetus to the application of alternative digital certificates in modern lifelong education systems. Based on this, this paper builds a block-chain learning achievement authentication model that integrates the hybrid common mechanism, "master-slave multi-chain" data chain architecture and chameleon hash technology. At the same time, facing the "14th Five-Year Plan" development plan and the development goals of "China's Education Modernization 2035", the realization path of online learning achievement certification based on block-chain technology is designed, and the operational, practical and forward-looking safeguard measures are formulated.

1. Introduction

In recent years, China has developed rapidly in the depth integration of information technology and education and teaching practice. In April 2018, the Ministry of Education issued the Education 2.0 Action Plan, pointing out that "we will actively explore effective ways to record, transfer, exchange, and authenticate intelligent learning effects based on new technologies such as block-chain and big data, form a ubiquitous and intelligent learning system, and promote the deep integration of information technology and intelligent technology into the whole process of education and teaching" [1]. In February 2019, the "China Education Modernization 2035" issued by the Central Committee of the Communist Party of China and The State Council further emphasized the "establishment and improvement of the national credit bank system and learning achievement certification system.". In the Qingdao Declaration, UNESCO also emphasizes "Seizing digital opportunities and leading the transformation of education", and is committed to the goal of education informatization to be achieved from now to 2030. Credit bank is a management mode and system that uses the characteristics of banks for reference to carry out unified certification and accounting of learners' various learning results in order to realize credit recognition, accumulation and conversion [2]. In order to build a lifelong learning system and a learning society, China has set up various credit banks (such as Open University credit bank, lifelong learning credit bank, continuing education credit bank, citizen credit bank, etc.) to improve the learning outcome certification and management system. However, the existing credit banks still have various problems, which not only hinder the credit transfer and system integration between different fields and different institutions, but also make the credit banks not enough for the public to understand and accept them. It is worth mentioning that the block-chain can provide technical support for the realization of decentralized, immutable, secure and trusted systems. Based on this, this study intends to integrate credit banking with block-chain technology, design a credit banking system based on block-chain technology, and explore the implementation mechanism of the system from different dimensions.

2. Literature Review

Since Eisner E.W first proposed the concept of "learning outcomes" in 1979, but more than a hundred years, learning outcomes have completed the three-step jump from "focusing on the improvement of teaching strategies" to "focusing on the assessment of educational quality" to "focusing on the connection and integration of education". It has quickly risen to the strategic height of "improving the lifelong education system and building a learning society". In recent years, many scholars at home and abroad have conducted a lot of research on issues related to learning outcome certification and management, which mainly include the following categories:

2.1. Definition of Learning Outcome Certification

Existing literature has different definitions of the connotation of learning outcome certification, and the representative ones are as follows: (1) From the conceptual level, it is mainly the certification of learning outcomes at the core or tangible level, that is, the certification of learning outcomes such as knowledge, skills and abilities or their external performance after learners participate in a certain stage of learning (Elken, 2015; Ying Yiya, 2019); (2) From the perspective of the form of achievement, it mainly includes formal learning outcome certification based on academic education, informal learning outcome certification based on certificate education, and non-formal learning outcome certification without certificates and credits (Rogers, 2016; Lin Yueru and Shi Weiping, 2022); (3) From the perspective of outcome structure, it is mainly the certification

of cognitive outcomes of general education and professional education and the certification of emotional outcomes of professional choice, attitude and values (Shiet al., 2020).

2.2. International Experience in Certification of Learning Outcomes

The development of learning outcome certification in foreign countries is relatively mature, which mainly has the following characteristics: (1) Most of them adopt national or regional policies and regulations to ensure the legitimacy, effectiveness and authority of learning outcome certification (Keevy & Chakroun, 2019); (2) Take non-formal and informal learning outcome certification as a key research object, while taking into account the mutual recognition of credits in various educational institutions (Wang Haidong and Deng Xiaohua, 2019); Establish a unified standard system and certification conversion rules, including national qualification frameworks in the EU and Commonwealth countries (Cedefop, 2019), standardized courses in South Korea and France, etc. (Zhang Weiyuan et al., 2020). (4) Establish a system of specialized management bodies and expert committees to coordinate research and practice (Chakroun & Keevy, 2018). (5) Using information means and platform tools to improve management efficiency (Li Li et al., 2022).

2.3. Research on the Impact of Block-Chain Technology on Learning Outcome Certification

It mainly includes three categories: (1) Case studies focusing on "empirical extrapolation". Through in-depth description and analysis of block-chain credit management and certification cases, the purpose is to analyze the problem (Alexander & Camilleri, 2017); ② Focus on the holistic model construction research. Based on a holistic perspective, quantified and non-quantified learning outcomes are recorded to build a block-chain model (Grather et al., 2018); ③ Development and research for local function realization. Based on a technical perspective, in-depth research is conducted on local functions, aiming to solve outstanding problems (Yang Bing et al., 2019).

2.4. General Review

Based on the above literature review, relevant studies have the following deficiencies: First, from the perspective of research, there are few studies on the certification of learning outcomes at the level of integration of consensus mechanism, smart contract and course quality evaluation. Most literatures are limited to the certification of learning outcomes by the underlying technology of block-chain, and the research is too technical and neglects the evaluation of course quality, resulting in low credibility and flexibility of the certification results. Second, in terms of research content, most relevant researches at home and abroad focus on the storage and recording of learning content and process, and lack in-depth research on application scenarios, data property rights and stakeholders [3]. In today's continuous iteration of block-chain technology, It will be an important direction for future research to build a block-chain learning achievement authentication model that integrates the hybrid common mechanism, "master-slave multi-chain" data chain architecture and chameleon hash technology. Third, in terms of research methods, most literatures only use one method or technology to conduct research, and quantitative research methods are single and lack of comprehensiveness. Therefore, it is particularly urgent to study the certification of learning results from an all-round and cross-integration of multiple methods.

3. Learning Outcome Certification Model Based on Block-Chain Technology

3.1. Characteristics of Block-Chain

Block-chain technology is a new distributed infrastructure and computing paradigm that uses block chain data structure to verify and store data, uses distributed node consensus algorithm to generate and update data, uses cryptography to ensure the security of data transmission and access, and uses smart contracts composed of automated script code to program and operate data. Each block contains information such as the data to be recorded, the root Hash of the current block, the root Hash of the previous block, and the time stamp. The block chain is formed by linking the root Hash values of the preceding and trailing blocks according to the time stamp sequence. The information recorded by the block depends on the application field, which can be digital asset transactions, clearing records, Internet of things records, etc., which are usually organized and recorded in a Merkle tree structure. Other information includes signature information, random values, and so on. Figure 1 is a schematic diagram of the block-chain structure [4].

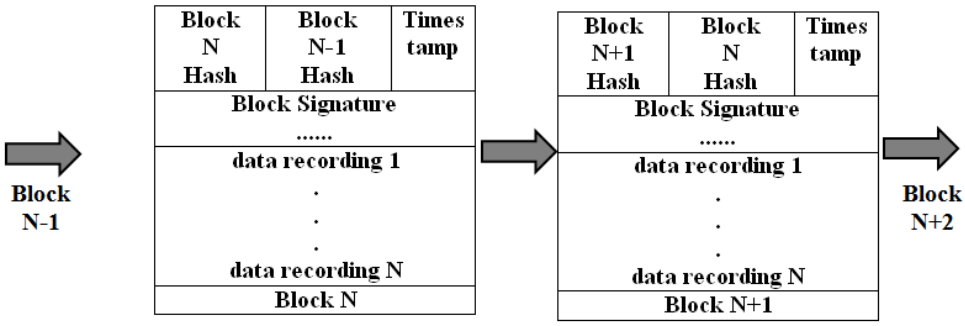

Figure 1: Schematic diagram of block-chain structure

There are three forms of block-chain: Public Block-chains, Private Block-chains, and Consortium Block-chains. Table 1 shows the main differences between the three different forms of block-chain.

Table 1: Main differences of different forms of block-chain

Morphological Category	Degree Of Decentralization	Authority And Scope	Bonus Reward
Public Block-Chains	Completely Decentralized	Can Be Accessed And Traded Globally	Individuals Are Financially Rewarded In Proportion To Their Contribution To The Consensus Process
Private Block-Chains	Decentralized	Write Permission Is In The Hands Of Only One Organization, Read Permission May Be Limited	Individuals Are Financially Rewarded In Proportion To Their Contribution To The Consensus Process
Consortium Block-Chains	Partially Decentralized	Read, Trading Permissions Can Be Set	Unknown

In this paper, a hybrid consensus mechanism combining proof-of-stake mechanism and practical Byzantine fault-tolerant algorithm is used to achieve identity information and learning achievement authentication, a "master-slave multi-chain" data chain architecture and smart contracts are used to achieve course quality evaluation, and chameleon hash technology is used to optimize some information in the block-chain network. Multiple signatures are used to ensure the security and

authenticity of the authentication process [5].

3.2. Smart Contract Implementation Mechanism

The implementation of smart contracts is mainly to match and verify learner information and learning outcomes, as well as automatically record and supervise learning process data and learning results. This model designs three types of smart contracts from the perspective of contract subjects, as shown in Table 2.

Table 2: Smart contract of online learning outcome certification model

Subject of contract	Contract name and function	Contract name and function
user side	User audit	After the user submits his personal identity information, the smart contract is checked against the corresponding database to ensure the correctness and validity of the user information
	User registration	Approved users will be registered to the network through smart contracts, and a unique address code will be automatically generated
	Result entry	All of the learner's learning records will be automatically recorded by the smart contract
Resource end	Write course information	According to the course resource information of the course resource provider, each course automatically generates a unique address code
	Curriculum evaluation	In addition to the course information provided by the course resource provider, the smart contract is digitized, labeled and semantic according to the course evaluation and learning time of each learner who chooses the corresponding course, so as to form the course evaluation
Query side	Result query	The smart contract displays the corresponding information content according to the permissions of different query objects

3.3. Data Model Structure Design

This paper designs a "master-slave multi-link" data link architecture. The main chain is the learning outcome chain, the student information chain and the course information chain are the subordinate chain, and the three chains organically combine to form the data model of online learning outcome certification. The model classifies and stores all kinds of data to evaluate both students' academic performance and course quality. Such a data architecture has the following advantages: First, students exist as a single chain, so the smart contract and consensus mechanism of the block-chain can automatically match students' personal information and learning outcome information, which can not only ensure accuracy and immutable, but also ensure the privacy security of students. Second, the latest Hash values of the student information chain and the course information chain are embedded as the data items of the learning outcome chain, so that the three chains can be organically combined, and then the three chains can work together to improve the efficiency of learning outcome certification [6]. The third is to separate student information, course information and matching data through three chains, which can reduce the redundancy of block information, reduce the difficulty of data management, and improve the throughput rate and consensus speed of the system. More importantly, the student information chain is the evaluation of learners, and the course information chain is the evaluation of courses. Through the information matching of the main chain -- learning outcome chain, the two-way assessment of online learning

results and course quality can be realized, and the certification results are more convincing and credible. The fourth is to promote the survival of the fittest online courses by evaluating different courses with the same content [7].

4. Safeguards for the Certification of Online Learning Results Based on Block-Chain Technology

The implementation of the recognition of learning results needs the cooperation between public education and market education, higher education and continuing education, certification agencies and certification agencies. Without a guarantee mechanism, the recognition of learning outcomes can be said to be disorganized. In recent years, in order to ensure the effectiveness of the recognition of learning outcomes and the maintenance and coordination of the learning outcomes conversion system in the later stage, various countries and regions have made continuous efforts from the aspects of laws and regulations, organizations, funding investment, quality control, etc., and built a relatively comprehensive guarantee mechanism for the recognition of learning outcomes.

4.1. Sound Laws and Regulations Provide a Solid System of Rules for the Recognition of Learning Outcomes

The establishment of learning achievement recognition system is a top-down government project, and the standard system of credit recognition and transfer must be promoted and implemented throughout the country. At the same time, the conversion of credit is related to the awarding of degrees and the recognition of academic qualifications. Therefore, credit recognition transfer must be established and operated under the national legal framework. All countries in the world also promote the implementation of policies through legislative reform. From the construction process of the learning achievement recognition system in various countries, we can find that laws and regulations are the embodiment of the national will to allocate, guide, control and coordinate the educational power and the development trend of the educational cause. Whether it is the establishment of a national credit bank or the establishment of a national qualification framework, the establishment of a unified standard qualification framework, the clarification of the rights and responsibilities of various organizations, the coordination of human, material and financial resources to promote the construction of the platform, legislation is the premise of institutionalizing the guarantee mechanism.

4.2. A Sound Organizational Structure Provides Reliable Organizational Support for the Recognition of Learning Outcomes

Learning outcome recognition is a complex system, in order to ensure its authority and credibility, in addition to the establishment of a special system, but also need to set up a special organization and personnel, in order to clarify responsibilities, overall coordination. The establishment of specialized organizations and personnel in the following aspects ensures the equivalence of qualifications from different educational institutions. On the one hand, the establishment of quality supervision agencies. The function of the institution is to assure stakeholders that even after graduates have completed their awarded qualifications at different educational institutions, they will achieve learning outcomes commensurate with the level of qualification through consistent assessment criteria. On the other hand, an inter institutional relationship committee can be established, such as determining the course requirements for student transfers and transfer parties, supervising the implementation of credit transfer and transfer agreements, and promoting admission, transfer, and transfer arrangements between the state's

polytechnics, colleges, and universities [8].

4.3. Stable Funding Investment Provides a Substantial Material Basis for the Recognition of Learning Outcomes

The effective operation of the learning achievement recognition system cannot be separated from the financial support. The establishment of evaluation institutions and personnel, the operation of credit information platform, and the credit loss subsidy caused by credit transfer between universities all require a large amount of funds. International experience shows that government, social self-financing and individual tuition are the three main sources of funding. First, the government takes responsibility. The second is social self-financing. Third, individual tuition. According to statistics, the federal government provided about $125 billion in financial aid to college students in 2016, aiming to encourage students to continuously improve their education through credit transfer.

4.4. Comprehensive Quality Control Provides Effective and Accurate Guidance for the Identification of Learning Outcomes

Quality control is the key and prerequisite for the circulation of learning results, and improving the transparency and recognition of education quality is the core task of quality assurance. The establishment of the quality control system should be carried out in accordance with the principle of "combining internal and external, regular and irregular". On the one hand, the formation of institutions self-rated core internal quality supervision. On the other hand, external quality supervision with the third sector review as the core should be formed. Almost all countries focus on teaching, research, student services, admissions systems, internal governance of institutions, etc., with greater emphasis on disclosure of negative content in audit reports, and greater attention to the degree of participation of employers and students [9].

4.5. Strict Information Disclosure Provides a Credible Dispute Resolution Mechanism for the Recognition of Learning Outcomes

Whether the results of learning outcome recognition are fair and just, and whether its gold content is equal to the results of formal education, is a great challenge to the departments of learning outcome recognition in colleges and universities. In order to make the learning results can be recognized by the public, educational institutions and employment units, it is necessary to establish a strict information disclosure system from two aspects to ensure the standardization of the learning results recognition process. First, strict information disclosure is an important principle for the recognition of learning outcomes. Secondly, a multi-body determination panel promotes dispute resolution [10]. Usually, most accreditation institutions take passing or not passing as the result. As long as the basic requirements of credit accreditation are met, the course can be exempted or the admission qualification can be obtained, and the informal learning results are not graded and the score is detailed [11].

5. Conclusions

Building an enduring learning system for all individuals is a joint goal for global education. Alternative digital credentials, with features like practical utility, convenience, and transferability, help bridge the gap between the educational framework and job market in the digital age, facilitating the accumulation and conversion of individual lifelong learning outcomes. Blockchain

technology has attributes such as decentralization, timestamped data, maintenance, adaptability, immutability, and traceability, providing a catalyst for the use of alternative digital credentials in contemporary lifelong education frameworks. Thus, this article proposes a blockchain - based learning accomplishment authentication model integrating a hybrid consensus mechanism, data chain architecture, and chameleon hash technology. Also, considering the national plans and objectives, the implementation path and safeguard strategies for online learning accomplishment certification using blockchain technology are outlined.

Acknowledgements

This work was supported by 2023 Research project of Shaanxi Open University (Shaanxi Business College) : Higher Continuing Education Digital Learning Achievement Certification Research (2023KY-A05); 2024 Xi'an Social Science Planning Fund Project: Research on Xi'an's Promotion of the Deep Integration of Innovation Chain, Industrial Chain, Capital Chain and Talent Chain (24GL04); 2023 National Open University Key Research Project Subproject: Implementation Status and Optimization Strategy of University Budget Management Integration (Z23B0017-1); 2023 National Open University Key Research Project: Open University Comprehensive Budget Performance Management Research (Z23B0017); 2024 Shaanxi Business College degree education and teaching reform research project; 2023 China Adult Education Association Social Learning Research Institute Project: Research on the Mechanism and Realization Path of Higher Continuing Education Online Learning Achievement Certification based on block-chain Technology (ZCXY2023030); 2022 Shaanxi Federation of Social Sciences Special Project: Research on Mechanism and Countermeasures of Digital Transformation Enabling Enterprise Performance in Shaanxi Automobile Manufacturing Industry (2022HZ1507); 2023 Research project of the Fifth Council Branch of China Vocational and Technical Education Society: Research on the Development of Undergraduate Vocational Education in Ethnic Areas (ZJ2023B124); 2023 Education and Teaching Reform research project of Shaanxi Open University: Research and practice on Ideological and political planning construction of Core courses of Finance and accounting majors in open education(sxkd2023zx04); Scientific Research Program Funded by Shaanxi Provincial Education Department (Program No.22JZ017); 2022 Yellow River Basin Open University Alliance Scientific Research Project, “Research on block-chain technology-based online training learning achievement certification mechanism and path optimization”(HHLMKT202226); 2021 China Association of Higher Education, “Online Teaching Effect Evaluation and Promotion Strategy Research of Higher Continuing Education in the Post-Epidemic Era”(21JXYB03); 2022 Project of Shaanxi Institute of Education Science, "Research on the Steady Development Path and Countermeasures of Shaanxi Vocational Undergraduate Education in the New Era" (SGH22Q277); 2021 Shaanxi Higher Continuing Education Teaching Reform Research Project, "Shaanxi Higher Continuing Education Online Teaching Evaluation and Improvement Strategy Exploration and Practice" (21XJY003); 2021 Shaanxi Higher Education Association Project, "Shaanxi Higher Continuing Education Online Teaching Evaluation and Promotion Strategy Research in the New Era" (XGH21309); 2022 Education and Teaching Reform Research Project of Shaanxi Open University, "Exploration on the Implementation of Block-chain technology-based Online Learning Achievement Certification Mechanism and Path" (sxkd2022yb10); 2022 Research Project of College Students of Shaanxi Business College of Industry and Commerce, "Investigation and Research on the Mechanism and Countermeasures of Enabling Enterprise Performance in Shaanxi Automobile Manufacturing Industry through Digital Transformation" (2022DXS-B08); 2023 Teaching Reform Research Topic of Shaanxi Vocational College of Industry and Commerce: Exploration and Practice of Ideological and Political Teaching Strategy, Mode and Implementation

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