ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202606_9(6).0020

Ecological Reshaping of Blockchain Credit Banks Grounded in Philosophy of "Society as School"

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Abstract

The blockchain credit bank provides an implementation foundation for the philosophy of "society as school". The distributed nature of blockchain is highly consistent with Tao Xingzhi's educational philosophy of "society as school", but there is still an imbalance between "technical instrumental rationality" and "educational humanistic value". Therefore, this article studies the philosophical coupling mechanism between Tao Xingzhi's "society as school" and the distributed characteristics of blockchain. To promote the healthy development of the credit bank, through in-depth research on indicators such as the "education Gini coefficient" and "cultural dissemination contribution index" of the blockchain credit bank, and establishes a three-dimensional evaluation system for the blockchain credit bank, encompassing "hard infrastructure (technological support) + soft infrastructure (institutional coordination) + humanistic infrastructure (humanistic care).", and a "three-vertical and four-horizontal" digital education ecosystem model characterized by vertical integration and horizontal synergy is established. The concept of "Blockchain Credit Bank Maturity Index (BMI)" is proposed to scientifically quantify the level of regional education digitalization. A digital compensation algorithm is designed to inject humanistic care into the rigid blockchain data as an "intelligent layer". An innovative "dual-chain enhanced architecture of blockchain credit bank integrating digital compensation and cultural inheritance" is designed. This architecture not only records "what you have learned", but also evaluates "under what conditions, with how much effort you have learned, and what you have inherited for society", truly building a value Internet for lifelong learning in the future.

Keywords

Society as School; Blockchain; The Credit Bank System; Education Gini Coefficient; Maturity Index; Digital Compensation Algorithm.

1. Introduction

Under the strategic framework of "New Infrastructure" in China, the education sector is undergoing a profound transformation centered on digitalization[1]. In 2021, the Ministry of Education and six other departments issued the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-Quality Educational Support System"[2] (Jiaoke Xin [2021] No. 2). The opinion states that new infrastructure should provide a digital foundation for the high-quality development of education, and requires strengthening supervision and evaluation to achieve full-chain management of resource registration, flow, and evaluation.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202606_9(6).0020

Through extensive data analysis, it can be seen that the application of blockchain technology in education is gradually developing. Scholars' research on blockchain credit banks mainly focuses on the technical architecture, and currently still faces many challenges:

The construction of credit banks generally faces an imbalance between "technological instrumental rationality" and "educational humanistic value", which is specifically manifested as:

(1) Lack of value guidance: Most blockchain applications focus on improving efficiency, while neglecting the "social as a school" concept and the "humanistic value" of education, which are the essential aspects of education.

(2) Weak ecological collaboration: The existing credit bank pilot projects are fragmented and lack an overall ecological design. There is a high rate of redundant resource construction. For instance, the Wisdom Education Platform and the Online Open Course Sharing Platform of Zhejiang Higher Education Institutions have many duplicated course resources.

(3) Lack of fairness: In traditional credit banks or educational records, there is a fundamental problem: how to fairly assess and compare the learning outcomes from different backgrounds and under different conditions.

(4) Lack of quantitative assessment tools: There is a lack of evaluation systems for credit banks that utilize blockchain technology.

Therefore, we studied the philosophical coupling mechanism between Tao Xingzhi's "society as school" and the distributed characteristics of blockchain. We proposed the concept of "Blockchain Credit Bank's Maturity Index (BMI)", which covers indicators such as computing power density (PFLOPS per 10,000 people), data circulation rate, institutional collaboration degree, and educational Gini coefficient. Through entropy weighting, BMI can scientifically quantify the level of regional educational digitalization. We also constructed a three-dimensional evaluation system for the blockchain credit bank, encompassing "hard infrastructure (technological support) + soft infrastructure (institutional coordination) + humanistic infrastructure (humanistic care).. Through quantitative analysis, we revealed the maturity and shortcomings of educational digital transformation, providing precise decision-making basis for policy formulation. We innovatively designed a "dual-chain enhanced architecture integrating digital compensation and cultural inheritance for the blockchain credit bank", injecting fairness and humanistic care "intelligence layer" into the cold blockchain data.

2. Related Works

New Educational Infrastructure provides the necessary environment and tools for credit banks to achieve their goals, addressing core issues such as data silos, lack of trust, resource dispersion, and low efficiency faced by credit banks. Credit banks, in turn, offer an extremely important "application scenario" and "value export" for new educational infrastructure, allowing technologies such as 5G, AI, big data, and blockchain to truly serve the grand educational goal of building a lifelong learning system. Zhang B.[3] investigated the current situation of new educational infrastructure and proved that new educational infrastructure has played an important role in promoting rural revitalization. Zhou Y.[4]constructed a measurement scale covering three dimensions: network infrastructure, data governance, and teaching services. This scale can be used as an assessment tool for the digital resilience level of universities, providing quantitative basis for planning new infrastructure investment, improving governance mechanisms, and optimizing teaching services. It has significant practical significance for promoting the stable operation of the education system. Kayal T.K.[5] discovered a significant positive correlation between learning inequality, school infrastructure inequality, and social development inequality. Improving school facilities in areas with weak infrastructure will help reduce learning inequality in rural areas of India.Zhu W., and Chang

DF.[6] used the Gini coefficient to transform the relevant data on preschool education from 31 provinces in China, revealing the uneven distribution or extreme uneven distribution of certain indicators, providing useful information for further improving preschool education.

Blockchain[7] is a decentralized distributed ledger technology that links data blocks chronologically to form an immutable chain structure. The attributes of blockchain technology are highly congruent with Tao Xingzhi's[8][9] "society as school"[10] philosophy. Chuma K. G.[11] leveraged blockchain to dismantle data silos and facilitate collaborative innovation across government departments in South Africa. By analyzing the core advantages of blockchain technology, Wang H. and Wang Q.[12] probed into the coupling relationship and operational mechanism between blockchain technology and the national "Credit Bank" in the context of vocational education. Choudhary, A., Chawla, M., & Tiwari, N.[13] proposed a blockchain-enabled framework for an academic credit bank, which realizes transparent student mobility within or between higher education institutions via a structured system of credit recognition, accumulation, transfer, and redemption.

The credit bank system[14] is an educational management model that simulates banking functions. It certifies, stores, and converts learning achievements using credits as the unit of measurement, aiming to construct an "overpass" for lifelong learning. Zheng QX.[15] proposed a management model for the construction and practice evaluation of the digital-intelligent credit bank for labor literacy in higher vocational education, characterized by "one workshop, two cockpits, three links, and four interactions". The study concluded that an evaluation management model for the digital credit bank information system for labor literacy should be established by integrating the indicator system with big data and artificial intelligence. Chunwijitra S., Khanti P., Suntiwichaya S., et al.[16] developed a MOOC service framework that leverages MOOCs to provide supplementary support for students in traditional education and offers a credit bank composed of students' academic credentials to address the needs of the business sector. Taking the regional teacher training "credit bank" management system project as a case study, Wei L.[17]conducted a practical exploration of building a credit bank system based on blockchain technology, elaborating on the design and implementation process of the blockchain-based "Credit Bank".

3. Methodology

3.1. The coupling relationship between the distributed nature of blockchain and the "society as school" philosophy

Blockchain transforms the philosophy of "society as school" into an operational technical protocol, managing community learning resources through a decentralized autonomous organization (DAO).

The distributed nature of blockchain and the "society as school" philosophy both reject the "center-periphery" power structure. Both of them manifest the "complex system" feature in ontology - the system attributes do not originate from a central element, but from the dynamic interaction relationships among nodes. This network-based ontology opposes the centralized and hierarchical traditional structure. The isomorphism of the existence structure and the coupling points between the two are shown in Table 1.

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Table 1. Coupling Points between the Blockchain and the "School as Society" Philosophy

Dimension	The the blockchain	"Society as School" Philosophy	Coupling point
Existence mode	Node networking: No central control point, each node is equal	Social globalization: School walls disappear, and the entire society becomes a learning environment.	Structural isomorphism: Both oppose centralized monopolies and advocate flat networks.
Existence proof	Consensus verification: Existence is verified by all nodes in the network together.	Practical verification: The validity of knowledge is verified through social application.	Verification logic is similar: neither is determined by a single authority.
Space-time properties	Distributed ledger: Real-time synchronization across all time periods, without physical boundary restrictions.	Life is education: Learning is integrated into the entire process of life and is present everywhere.	Consistency in time and space extension: Both break the limitations of traditional time and space.
Source of knowledge	Multi-node collaboration for generation, no single entity monopolizing the truth	It is jointly constructed by multiple social entities, without a single authoritative source of knowledge.	Multi-subjectivity: Knowledge stems from differentiated practical nodes

3.2. The three-dimensional evaluation system for the blockchain credit bank, encompassing "hard infrastructure (technological support) + soft infrastructure (institutional coordination) + humanistic infrastructure (humanistic care)"

The evaluation system of the blockchain credit bank should include: hard infrastructure, soft infrastructure and humanistic infrastructure. The hard infrastructure serves as the skeleton, providing technical support such as computing power and network; the soft infrastructure acts as the meridians, achieving systematic collaborative operation through systems and standards; the humanistic infrastructure is the soul, ensuring educational equity and cultural inheritance through humanistic care. The three-dimensional evaluation system and indicators of the blockchain credit bank are shown in Table 2.

Table 2. Three-dimensional evaluation system and indicators of block chain credit bank

Dimension	Indicators
Hard infrastructure (technical support)	Computing power support: Computing power density (PFLOPS per 10,000 people).
	Network coverage: 5G network coverage rate (%).
	Perception devices: The penetration rate, performance and reliability of Internet of Things terminals.
	Platform empowerment: The degree of platform integration, the richness of open interfaces (APIs), and the ability to provide support to developers and supporters.
Soft infrastructure (institutional coordination)	Data governance: Standardization rate of metadata in the credit bank system (%), blockchain-based credit recognition agreement, comprehensiveness of data collection, ability to ensure data security and privacy protection.
	Intelligence level: The depth of penetration and application effect of AI and big data analysis technologies in core aspects such as teaching, evaluation, management, and service (such as personalized recommendations, intelligent grading, academic warnings, and scientific decision-making).
	Sustainable development: The degree of organization support, capital investment, standard and regulation implementation, innovative culture, and the soundness of the cybersecurity system.
Humanistic infrastructure (humanistic care)	Educational equity: Education Gini coefficient (0-1), Digital compensation algorithm.
	Cultural transmission: contribution value of cultural transmission (index).

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3.2.1. Education gini coefficient

The Educational Gini coefficient (EGC) is the application of the classic "income Gini coefficient"[18]in economics to the field of education. Its value ranges from 0 to 1, and it is used to measure the degree of equality in the distribution of educational achievements (or educational resources) among the population. It transforms the vague ethical concept of "educational equity" into a measurable objective indicator. The closer the value is to 0, the more equitable the educational distribution is; the closer the value is to 1, the more severe the educational inequality is.

The Gini coefficient is calculated based on the Lorenz Curve[19] (the distribution curve of credit).

(1) Statistical data: Obtain the credit data of the population aged 25 and above in the credit bank system (this age group was chosen because they usually have completed full-time education).

(2) Sorting: Arrange all individuals in ascending order of their credits.

(3) Draw the Lorentz curve: The x-axis represents the cumulative percentage of population (accumulated starting from the person with the least credits). The y-axis represents the cumulative percentage of credits.

If the Lorenz curve is a straight diagonal line, it means that for every 10% increase in the population, exactly 10% of the total credits are held by them, which is called the absolute equality line. However, the actual distribution curve: is usually a downward-curving line.

$$EGC = S_1 / (S_1 + S_2)$$

where , EGC is the education Gini coefficient**;** S_1 is the area between the absolute fairness line and the actual distribution curve; S_2 is the area between the actual distribution curve and the x-axis. As shown in Figure 1, the greater the curvature of the curve (the larger the area S_1), the higher the Gini coefficient, indicating greater unfairness.

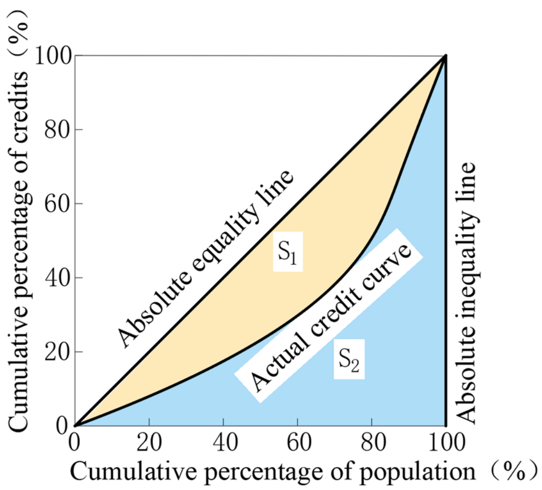

Figure 1. Lorentz curve

3.2.2. Digital compensation algorithm

In traditional credit banks or educational records, there is a core problem: how to fairly assess and compare the learning outcomes from different backgrounds and under different conditions?

Question 1: Inequality caused by environmental differences

For example: Student A studies at a top university, enjoying excellent resources, and scores 85 points. Student B studies in a remote mountainous area, relying on self-study and poor

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experimental conditions, and also scores 85 points. From the transcript, both have the same value. However, generally speaking, student B has made more efforts and overcome more difficulties, and the "learning effectiveness" of student B may have a higher value. The traditional system cannot reflect this difference.

Question 2: The "excessive rigidity" of blockchain

The advantages of blockchain lie in its immutability and the authenticity of data. It faithfully records the fact of "85 points". However, its disadvantage is that it is too rigid and lacks humanistic care and contextual judgment. It is unable to automatically identify and compensate for the unfavorable circumstances in which student B is placed.

To address these two issues, we have developed the "digital compensation algorithm". Its objective is not to modify the original data, but to introduce a regulatory mechanism when conducting credit evaluation or credit point conversion based on the original data. We have broken down this process into four steps:

Step 1: Establish a quantitative indicator system:

Transform these abstract concepts such as "resource scarcity" and "effort level" into measurable indicators.

(i) Resource Scarcity Index (RSI): This index measures the degree of resource scarcity in the learning environment. We can assess it using indicators of educational resources, such as the per-student education expenditure in schools/regions, the quality of teachers, and the completeness of equipment.

Data source: Regional education statistics, school assessment reports, and de-identified student family background surveys (must comply with privacy regulations).

Computational model:

Select key indicators: per-student education expenditure, proportion of teachers with senior qualifications, coverage rate of digital equipment, and library collection volume.

Compare each indicator with the national or provincial benchmark values, and calculate the relative percentages.

RSI = 1 - Regional educational resources comprehensive score / Baseline regional comprehensive score

The RSI value ranges from 0 to 1. The closer it is to 1, the scarcer the resources are.

For instance, if the overall score of student B's area is 30% of the benchmark area, then his RSI = 1 - 0.3 = 0.7.

(ii) Effort index (EI): This measures the amount of effort that learners put into the learning process. It can be calculated by combining indicators such as study duration, the number of repetitions, the completion rate of assignments, and the level of online learning engagement.

Data sources: Behavioral logs from the learning management system (requires authorization), data from the online learning platform, and process evaluation records.

Computational model:

Select key indicators: effective study duration (the part exceeding the basic requirements of the course), the number of times students repeatedly submit and improve their assignments/tests, the frequency of revisiting key knowledge points, and the depth of participation in forum discussions.

Compare each indicator with the median of the students of the same course during the same period.

EI = Individual comprehensive effort value / Median of comprehensive effort value of the student group

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202606_9(6).0020

The value of EI is usually greater than or equal to 0. The higher the value, the greater the degree of effort. Usually, an upper limit (such as 2.0) is set to avoid the influence of extreme values.

For instance, if the weighted data of student B's various effort behaviors is 1.5 times the median of the same period for all students, then his EI = 1.5.

Step 2: Design the compensation function

The compensation coefficient is a function of resource scarcity and effort level. The key to the design lies in reflecting the following principles:

(i) There is only scarcity, no effort, and no compensation (avoiding the notion that "the weak have the right").

(ii) When resources are abundant, even with great efforts, the compensation is still very low (to avoid excessive rewards for the advantaged group).

(iii) Under conditions of scarcity, efforts should receive significant compensation (reflecting the value of "going against the current").

The non-linear function design that conforms to this logic is:

$$CF = 1 + \alpha * RSI + \beta * (EI - 1)$$

where , CF is the compensation coefficient, which is greater than or equal to 1; α and β are weights, indicating the degree of our emphasis on resources and efforts, which are set by the expert committee based on the concept of social equity; RSI is the degree of resource scarcity, ranging from 0 to 1; EI is the effort index, ranging from 0 to 1.

Step 3: Calculation

Here, we set $\alpha = \beta = 0.2$.

We substitute the data of student B into the function to obtain the final compensation coefficient: $CF = 1.24 \approx 1.2$ (rounded to one decimal place)

Conclusion: Under this model, student B will receive approximately "a compensation coefficient of 1.2".

Step 4: Transparency and auditability of the algorithm

The logic of the algorithm, its parameters, and the results of each compensation calculation (as transactions) can all be recorded on the blockchain and made public to all participants or subject to audit by supervisory authorities. This ensures the transparency of the compensation process, avoiding "secret operations" and establishing trust in the algorithm.

The system generates a "compensation report" for each learner, for example: "Due to the fact that your resource conditions (70% lower than the national average) are relatively insufficient, your level of study effort is 1.5 times the median of other students. Therefore, your learning outcome has received a 20% fair value bonus."

3.2.3. Cultural dissemination contribution index

The cultural dissemination contribution index is designed to measure the extent to which an individual, institution, project or region has contributed to the protection, dissemination, innovation and development of cultural resources during a specific period. Its assessment framework consists of four dimensions, as shown in Figure 2.

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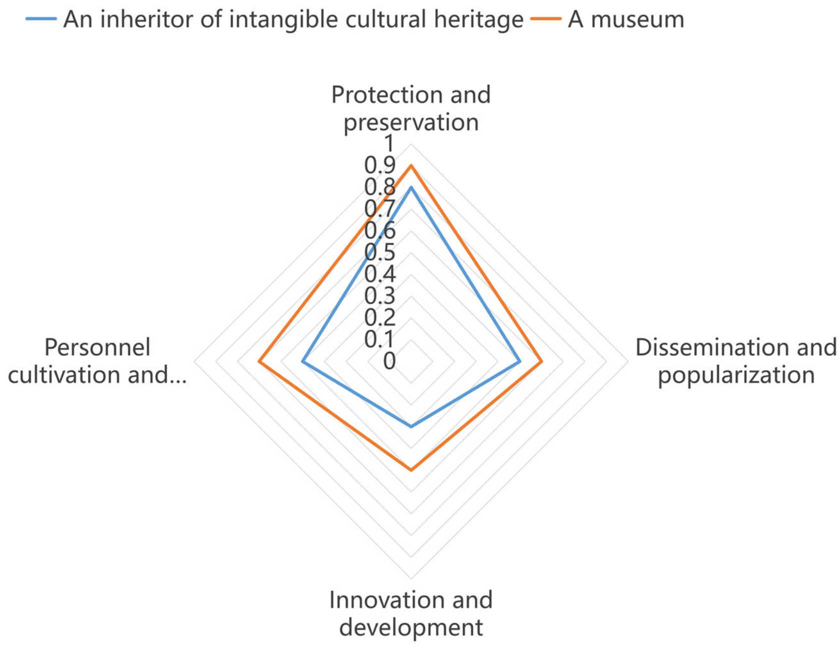

Figure 2. The assessment framework for cultural dissemination contribution index

(1) Protection and preservation: Measuring the fundamental contributions in the aspect of "preventing cultural extinction". Quantitative indicators include: the quantity and grade of restored cultural relics/ancient books, the duration of audio-visual recordings of endangered dialects/songs, the data capacity for digitized archiving of cultural resources, and the number of successful applications for intangible cultural heritage projects, etc.

(2) Dissemination and popularization: Measuring the contribution in the aspect of "expanding the radius of cultural influence". Quantitative indicators include: the number of cultural education activities/exhibitions and the number of participants, the number of views and interactions of new media content, the coverage rate of courses/materials, and the number of visitors to cultural venues.

(3) Innovation and development: Evaluate the contribution in terms of "promoting culture to keep evolving and creating contemporary value". Quantitative indicators include: the number and market response of new products, new works, and new IP created based on traditional cultural elements (such as cultural and creative product sales, film and television box office revenues), the number of projects combining traditional craftsmanship and modern design, and the important awards received.

(4) Personnel cultivation and community participation: Measuring the sustainable contributions in "ensuring the continuity of cultural heritage and empowering communities". Quantitative indicators include: the number and success rate of apprentices/graduate students trained, data on job creation and income growth in the community, and the size and service duration of the volunteer team.

The final "contribution index" is not simply the sum of the individual scores, but a weighted comprehensive score. Different dimensions are assigned different weights based on the cultural strategic priorities of different periods. For example, in an endangered intangible cultural heritage rescue project, the weight of "protection and preservation" should be increased. Application example:

(i) For individuals: An inheritor of intangible cultural heritage

Data source of contribution value: 100 class hours per year (human resource training), developing 2 new patterns and having them adopted by enterprises (innovation), leading the

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team to complete 500 hours of folk song collection (protection), receiving 1 million likes on the short video platform (dissemination).

Application of contribution index: The government can provide corresponding subsidies, studio support or honorary titles based on their "contribution index" to encourage their all-round development.

(ii) For institution: A museum

Data source for contribution value: 500,000 annual visitors (dissemination), launching 10 VR online exhibitions (innovation and communication), restoring 30 national-level cultural relics (protection), publishing 5 academic monographs (research).

Application of contribution index: Its annual "contribution index" can be used as an important reference for evaluating its performance and determining the amount of financial allocation.

As shown in Figure 2, the blue quadrilateral represents the assessment quadrilateral of the contribution index of an intangible cultural heritage inheritor, and the orange quadrilateral represents the assessment quadrilateral of the contribution index of a museum. The larger the area of the quadrilateral, the higher the contribution index of cultural dissemination.

3.3. Blockchain credit bank's maturity index (BMI)

BMI is a dynamic assessment tool that integrates the policy goals and technical characteristics of the new educational infrastructure. It serves as a comprehensive indicator for quantitatively evaluating the construction level of the blockchain credit bank. The qualitative assessment of the evaluation indicators of the blockchain credit bank shown in Table 2 is transformed into a quantifiable and comparable comprehensive index.

BMI employs a comprehensive algorithm of "entropy weighted[20] + linear weighted[21]" to scientifically quantify the level of regional educational digitalization, ensuring the objectivity of the index weights.

(1) Data standardization (range normalization of the original data):

$$x_{ij}^{'} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{2}$$

(2) Calculate information entropy (The information entropy of the *j*th indicator):

$$e_j = -\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad \text{where}, \ p_{ij} = \frac{x_{ij}^{'}}{\sum_{i=1}^{m} x_{ij}^{'}} \tag{3}$$

(3) Determine weight(The weight of the *j*th indicator):

$$w_j = \frac{1 - e_j}{\sum_{k=1}^{n}(1 - e_k)} \tag{4}$$

(4) Index synthetic:

$$BMI = \sum_{j=1}^{n} w_j \cdot x_{ij}^{'} \tag{5}$$

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where , *BMI* is the Education New Infrastructure Construction Maturity Index, where 0 ≤ BMI ≤ 100, the larger the *BMI* value, the more balanced and mature the development of each dimension of new infrastructure is, as shown in Table 3. x_{ij} is the original indicator value of the *j*th item of the *i*th sample (such as region/time point); min(x_j) is the minimum value of the *j*th indicator in all samples; max(x_j) is the maximum value of the *j*th indicator in all samples; m is the total number of samples; $x_{ij}'$is the standardized indicator value; p_{ij} is the standardized value proportion of the *i*th sample under the *j*th indicator; e_j is the information entropy of the *j*th indicator; w_j is the weight of the *j*th indicator; 1- e_j is the information utility value of the *j*th indicator, with a larger utility value indicating a more important indicator; *n* is the total number of indicators.

Table 3. Meaning of BMI values

BMI	Meaning of BMI values
90-100	The development of all aspects of new infrastructure is balanced and highly mature, becoming the core driving force for educational transformation and forming an innovative ecosystem.
70-89	All dimensions are developing well, with extensive application of data-driven and intelligent technologies, which can effectively support systematic innovation.
50-69	The infrastructure has been completed, data silos have been largely connected, the platform has been initially integrated, and cross-departmental and cross-business application collaboration has begun to be realized.
30-49	Infrastructure construction has been carried out, but there are issues such as the application of chimneys and data silos, resulting in limited synergy effects.
0-29	Infrastructure construction has just begun, being unorganized and scattered, lacking unified planning and standards.

3.4. The dual-chain enhanced architecture of the blockchain credit bank

Based on the evaluation system of the blockchain credit bank, design its core system.

(1) The dual-chain integration basic architecture of the blockchain credit bank：

The dual-chain integration architecture of the blockchain credit bank, through the division of labor and collaboration between the storage chain and the token chain, addresses the problem in traditional credit banks where it is difficult to balance "data credibility" and "incentive effectiveness".

Storage chain: Based on Hyperledger Fabric[22], it ensures that credit records are immutable and traceable, and supports cross-chain mutual recognition.

Token Chain: Based on ERC-1155[23], it issues educational tokens (EDU-Token) to encourage participation in learning (for example, 1 EDU-Token = 1 hour of public transportation discount; completing the rural revitalization course earns 50 EDU-Token, which can be exchanged for agricultural product e-commerce training resources). It also promotes resource sharing.

Cross-chain interaction layer: Build relay chain[24] based on Cosmos SDK[25] to realize two-way anchoring of value and data. The interaction process is completed in 4 steps: credit generation, cross-chain triggering, token issuance, and reverse verification.

(2) Intelligent contract module

The intelligent contract module was designed to achieve automatic certification of informal learning outcomes (such as live-streaming e-commerce skills → credit conversion algorithm), realizing a self-circulating ecosystem of "incentive - quality - feedback", providing a reliable technical foundation for the lifelong learning system.

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(3) Dual-chain enhanced architecture integrating digital compensation and cultural dissemination

The dual-chain enhanced architecture integrating digital compensation and cultural dissemination is shown in Figure 3. The specific integration scheme is as follows:

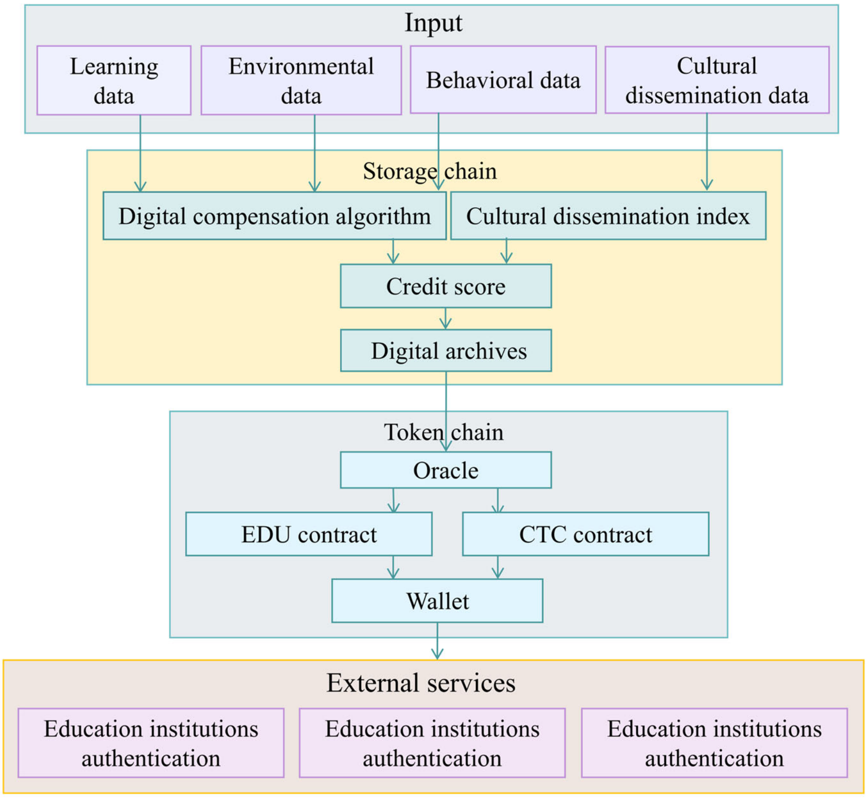

Figure 3. Dual-chain enhanced architecture integrating digital compensation and cultural dissemination

(i) Extend intelligent contracts on the storage chain:

Add "digital compensation algorithm contract": The input consists of the original credits, environmental factors, and effort level factors, while the output is the compensated credits.

Add " cultural dissemination contribution index contract": Input is the record of cultural communication activities, and output is the index value.

(ii) Data sources:

Environmental factors and effort level data can be obtained from external systems through a oracle (for example, from the education management information system, the learning behavior analysis platform).

Records of cultural heritage activities can be submitted to the blockchain by certified cultural institutions (such as museums, intangible cultural heritage centers).

(iii) Cross-chain interaction:

The compensated credits and cultural heritage contribution indices on the blockchain can be mapped to the token chain through the cross-chain interaction layer and converted into token rewards. For example, the compensated credits can be proportionally converted into EDU tokens, while the cultural heritage contribution index can be converted into a special cultural heritage token (which can be called CTC-Token).

(iv) Incentive integration:

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On the token chain, a comprehensive incentive pool is designed, including both EDU tokens and CTC tokens, to be included in the incentive system. Learners can obtain tokens not only for learning achievements but also for cultural heritage contributions.

(v) Visualization and query:

Provide query interfaces for learners and institutions to view original credits, compensation coefficients, compensated credits, cultural heritage contribution indices, etc.

3.5. "Three-vertical and four-horizontal" digital education ecosystem model

The "three-vertical and four-horizontal" digital education ecosystem model is shown in Figure 4.

Vertical integration: National main chain (standard formulation) → Provincial sub-chain (regional adaptation) → Institution and educational institution nodes (execution and feedback);

Horizontal collaboration: Education department (policy) ←→ Institutions and educational institutions (resources) ←→ Enterprises (technology) ←→ Community (scenario).

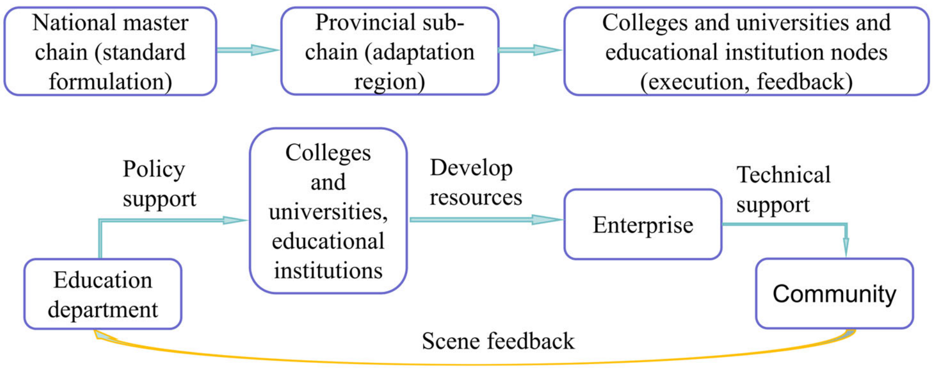

Figure 4. Digital education ecological model

4. Results and Discussion

By analyzing the coupling points between "society as school" and the distributed characteristics of blockchain, it reveals the high consistency between Tao Xingzhi's "society as school" and the distributed characteristics of blockchain. Tao Xingzhi advocated that knowledge should serve the common people and that education should be accessible to all, regardless of class. Blockchain, through technical means, eliminates the monopolistic privileges of centralized institutions and supports the educational concept of "society as school". Both are committed to building a "de-privileged" educational ecosystem, advocating the democratization of educational resources through "decentralization", and have a high degree of consistency in educational ethics, jointly maintaining the educational ecosystem.

The concept of the Blockchain Credit Bank Maturity Index (BMI) breaks away from the traditional infrastructure assessment's "technological determinism", and for the first time incorporates the humanistic inclusiveness indicator, the education Gini coefficient, to define the Blockchain Credit Bank Maturity Index (BMI), and constructs a three-dimensional evaluation system for the credit bank that includes "hard infrastructure (computing power/network) + soft infrastructure (system/standard) + humanistic infrastructure (fairness/inclusiveness)". This expands the theoretical connotation of infrastructure. The construction of this system provides a system ecological guarantee for the development of the blockchain credit bank and also sets construction requirements for it.

The digital compensation algorithm, based on reliable objective data, quantifies "resource scarcity" and "effort level", and converts them into fair adjustments to learning outcomes. It

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202606_9(6).0020

translates the value of educational equity into rigorous, transparent, and auditable mathematical language and makes appropriate, quantitative positive adjustments to the "evaluation" of learning outcomes to pursue a deeper, result-oriented credit evaluation system. The digital compensation algorithm is not only a technological innovation but also an educational concept revolution - from merely pursuing "data authenticity" to a higher level of "value fairness", enabling the credit bank to not only record learning but also recognize effort and reward striving, truly becoming a powerful tool for promoting educational equity and social mobility. The digital compensation algorithm injects a "smart layer" of fairness and humanistic care into the cold blockchain data.

The cultural transmission contribution index can scientifically measure the degree of contribution made by an individual, institution, project, or region to the protection, dissemination, innovation, and development of cultural resources within a specific period.

The enhanced dual-chain architecture integrates the "digital compensation algorithm" and the "cultural inheritance contribution index" into the dual-chain architecture, marking the system's upgrade from a basic record platform to an intelligent value evaluation engine, achieving three breakthroughs:

(i) Technological breakthrough: Blockchain upgrades from a "trusted database" to an "intelligent value calculation platform".

(ii) Evaluation breakthrough: Evolving from a "one-size-fits-all standard" to a "contextualized fair evaluation".

(iii) Incentive breakthrough: Expanding from "academic incentives" to "cultural inheritance incentives".

Each learner receives two types of on-chain assets:

(i) An immutable digital archive (Storage chain): containing original records, compensation coefficients, and inheritance indices.

(ii) A tradable value token (Token chain): representing quantified rights of learning value and cultural contribution.

The "three verticals and four horizontals" digital education ecosystem model incorporates government departments, educational institutions, and communities into the construction system, forming a closed loop from policy formulation to community application scenarios and application feedback, providing a favorable ecological environment for the high-quality and high-level operation of the blockchain credit bank.

5. Conclusion

This study investigates the philosophical coupling mechanism between Tao Xingzhi's "Society as School" educational philosophy and the distributed nature of blockchain, revealing a high degree of alignment between the distributed characteristics of blockchain and Tao's "Society as School" doctrine. The blockchain-based credit bank serves as a foundational implementation framework for operationalizing the "Society as School" philosophy.

To facilitate the sound development of the credit bank, a three-dimensional evaluation system for blockchain credit banks—encompassing "hard infrastructure (technical support) + soft infrastructure (institutional coordination) + humanistic infrastructure (humanistic care)"—is constructed through in-depth analysis of metrics such as the "Educational Gini Coefficient" and "Cultural Dissemination Contribution Index". Additionally, a "three-vertical and four-horizontal" digital education ecosystem model featuring "vertical integration and horizontal collaboration" is established. The concept of the "Blockchain Credit Bank Maturity Index (BMI)" is proposed to scientifically quantify the level of regional educational digitalization. A digital

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202606_9(6).0020

compensation algorithm is designed to embed an "intelligent layer" of fairness and humanistic care into the rigid structure of blockchain data.

An innovative "dual-chain enhancement architecture for blockchain credit banks integrating digital compensation and cultural inheritance" is developed. This system not only records "what you have learned" but also evaluates "under what conditions, with what level of effort you learned, and what you have contributed to social cultural inheritance", addressing the imbalance between "technical instrumental rationality" and "educational humanistic value".

Future research will explore other unresolved issues related to credit banks, such as the cross-chain circulation and verification of credit assets, the quality equivalence certification between MOOCs and courses offered by prestigious universities, and—most notably—the recommendation of personalized lifelong learning pathways for learners based on trusted on-chain big data of learning trajectories. These efforts aim to realize a truly future-oriented value internet for lifelong learning.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We would like to thank for the financial support provided by the Key Research Base of Philosophy and Social Sciences of Hangzhou for Higher Vocational Education (Center for Higher Vocational Education on Tao Xingzhi's Educational Thought) (grant Number: 25JD079).

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