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Research on Application Scenarios of Blockchain Technology in the Field of Teaching and Scientific Research in Colleges and Universities

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Abstract: With the continuous enhancement of colleges and universities' demand for digital governance, blockchain technology, featuring immutability, traceability, multi-party co-construction, and smart contracts, provides a new technical path for education and scientific research management in colleges and universities. This study focuses on the practical application of blockchain technology in the field of teaching and scientific research in colleges and universities, proposing implementable typical application scenarios from aspects such as teaching management, scientific research management, inter-university cooperation, and industry-university-research collaboration. Research shows that blockchain technology has strong applicability, feasibility, and application value in the field of teaching and scientific research in colleges and universities. It provides a new technical paradigm for the modernization of teaching and scientific research governance in colleges and universities and is an important supporting force for the digital transformation of colleges and universities.

Keywords: Blockchain technology; field of teaching and scientific research in colleges and universities; application scenarios

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1. Overview

Traditional technical systems struggle to establish a "cross-subject trusted" collaborative environment. However, blockchain technology, with its multi-party consensus mechanism, immutability, and transparency-traceability, has become an ideal technical foundation for building cross-subject trusted collaborative systems, establishing a "trusted digital order" among multiple participants[1-2]. Especially in the field of college education and scientific research that requires ensuring data authenticity, achievement integrity, process transparency, and automatic execution of rules, blockchain technology has inherent advantages. Meanwhile, the construction of trusted environments for inter-university scientific research collaboration, university-enterprise joint R&D, and international scientific research cooperation based on consortium chains can solve problems such as unequal identities, opaque information, and complex achievement distribution in traditional collaboration[3]. Based on this, there is a high degree of compatibility between the digitalization of teaching and scientific research in colleges and universities and blockchain technology. Realizing the in-depth integration and innovative application of blockchain technology in the field of teaching and scientific research is of great significance.

2. Typical application scenarios of blockchain technology in the field of teaching and scientific research in colleges and universities

2.1. Application scenarios in teaching management

2.1.1. Trusted certification of students' academic performance and learning processes

In teaching activities, data from links such as score entry, credit recognition, and course assessment are important bases for teaching quality management. However, in traditional workflows, there is a risk of human error or even data tampering. Through the integration of blockchain technology, automatic on-chain certification of course scores and trusted governance of learning process records can be realized[4]. At each link of score entry, review, and release, relying on blockchain, a hash fingerprint can be automatically generated and written into the ledger, ensuring the immutability of data from a technical perspective. A complete record of academic performance chains is established, providing a more objective, comprehensive, and reliable data foundation for the evaluation of talent training quality.

2.1.2. Copyright protection and access authorization of teaching resources

In college teaching activities, teachers continuously produce a large number of original teaching resources. Traditional resource management methods usually lack strict copyright protection mechanisms, and teachers' original content is often reprinted, modified, or used commercially without authorization. The introduction of blockchain technology can provide systematic technical guarantees for the confirmation, authorization, and usage supervision of teaching resources[5].

When college teachers upload original teaching videos or courseware, the system can automatically calculate the hash value of the file content, generate a unique digital fingerprint, and write it into the blockchain to form an immutable copyright certificate. Automatic management of access authorization can be realized through smart contracts. Teachers or teaching administrators can set resource usage rules on the chain[6]. Once an access or download behavior is triggered, the smart contract will automatically execute authorization or rejection operations according to preset conditions, avoiding management loopholes caused by human intervention.

2.1.3. Trusted governance of teaching quality evaluation

Traditional teaching evaluation processes often rely on centralized systems, with problems such as easy modification of student evaluations, unverifiable supervisor records, and lack of basis for quality analysis, leading to reduced credibility of teaching evaluation results. Introducing blockchain technology into teaching quality management can effectively solve these long-standing governance problems.

When students submit course evaluations, blockchain can automatically generate a unique identifier for each evaluation and write it into the chain. Any attempt to modify or delete evaluation content afterward will leave traces on the chain, technically avoiding the possibility of operations not allowed by rules. Teaching supervisors' classroom observation records, classroom inspection results, etc., can also achieve full-process traceability through blockchain, forming a traceable and auditable historical track. When teaching management departments need to retrieve supervisor records, they can directly verify the integrity and non-tampering of records from the chain, thereby enhancing the seriousness and credibility of supervision [7]. At the same time, by setting analysis rules through smart contracts, multi-source data such as student evaluations and supervisor records can be automatically summarized and cross-checked to generate teaching quality analysis reports, which helps improve the credibility of evaluation data and the scientificity of governance decisions.

2.2. Application scenarios in scientific research management

2.2.1. On-chain certification and version management of original scientific research data

The scientific research process involves various types of key data such as original experimental data, on-site observation

records, and algorithm code versions. These contents are not only the basis for the credibility of scientific research achievements but also important bases for project acceptance and achievement evaluation.

The timestamp mechanism in blockchain technology can realize versioned management of scientific research data. Each adjustment of experimental data will automatically generate a new on-chain record, which is connected into a complete scientific research process chain in chronological order. Researchers can trace back the data state at any time point, ensuring that each stage of the scientific research process is verifiable and trackable. In addition, smart contracts can provide automated support for data management, making scientific research data management more standardized, scientific, and automated.

2.2.2. Whole-process intelligent management of scientific research projects

Traditional scientific research project management has a long process chain, multiple participating subjects, and frequent cross-departmental data flow, which is prone to problems such as opaque processes, insufficient supervision, and unclear responsibility definition.

In the project application stage, each project application form, attached materials, research plan, and other contents can be written into the blockchain after submission, ensuring that any subsequent modifications are immediately identified. In the expert review link, each review record can be traced and audited. In terms of fund management, the school can set fund disbursement conditions according to the phased goals of the project [8-9]. At the same time, all expenditure details will be written on the chain with timestamps, forming a complete record of fund usage flow, ensuring that every fund is "traceable and fully trackable".

2.2.3. Governance of academic misconduct and paper traceability system

Traditional academic misconduct detection often relies on final paper comparison or manual review, which is difficult to effectively monitor the entire process of paper formation and publication, and cannot accurately track the occurrence links of data fraud, plagiarism, and duplicate publication.

For data fraud, blockchain can automatically identify unreasonable modifications in data by combining smart contracts and data comparison mechanisms. By generating an on-chain hash fingerprint for each paper, the system can quickly determine whether it is highly consistent with existing achievements. In addition, for confirmed academic misconduct incidents, transparent academic credit records can be formed through on-chain publicity. Such records cannot be deleted and can be used as important references for teacher recruitment and promotion, project application, student training, and other links, helping to form an effective academic credit constraint mechanism.

2.2.4. Trusted circulation platform for scientific research data sharing

Under the current scientific research data management model, there are obvious data barriers between different universities, laboratories, or research teams. In the process of data sharing, there may be risks such as leakage, uncontrollable use, and unclear responsibilities, which limit the efficiency of scientific research collaboration and the reusability value of scientific research achievements.

Building a scientific research data sharing platform based on a consortium chain can establish a multi-party participating data exchange network[10]. The platform can be jointly maintained by universities, scientific research institutions, laboratories, and relevant cooperative parties. Each participant has an independent identity and authority on the chain, thereby realizing cross-organizational trusted collaboration. Before sharing data, the on-chain smart contract will automatically verify the authority of the data provider and user, ensuring that data is used within the authorized scope. In addition, usage payment or point incentive mechanisms can be realized through smart contracts.

2.3. Inter-university and industry-university-research collaborative innovation scenarios

2.3.1. Construction of inter-university scientific research collaboration consortium chain

Inter-university scientific research collaboration often faces problems such as high communication costs, opaque project

processes, and complex benefit distribution, resulting in low efficiency of joint scientific research. The introduction of consortium chains can effectively change this situation.

The consortium chain can serve as a common trust base between universities to realize the joint application and whole-process management of cross-university scientific research projects[11]. Multiple universities can jointly submit project materials, share review results on the consortium chain, and solidify the research tasks, time nodes, and responsibility boundaries of all parties on the chain. Any modifications will be synchronously recorded on the chain, ensuring that the cooperation process is open and transparent, and responsibilities are clearly verifiable. In terms of benefit and resource distribution, smart contracts can be used to realize automatic settlement of scientific research funds, transformation benefits, or scientific research points.

2.3.2. Trusted collaboration mechanism for university-enterprise joint r&d

Cooperation between universities and enterprises often has problems such as ambiguous ownership of intellectual property rights, high risks of R&D data sharing, and complex achievement distribution, leading to increased cooperation costs and insufficient trust. The introduction of blockchain technology can effectively alleviate these pain points and provide a trusted governance foundation for joint R&D.

Blockchain can smartly contract cooperation agreements. Once deployed, smart contracts cannot be arbitrarily modified, ensuring that both parties automatically execute according to unified rules during the cooperation process, reducing disputes caused by inconsistent understanding of agreements. In response to the risk of R&D data sharing, blockchain can realize “safe and controllable data sharing” by combining technologies such as encrypted access mechanisms, secure multi-party computation, and zero-knowledge proofs [12]. Enterprises can authorize universities to use processed data for scientific research without exposing sensitive source data; universities can also provide scientific research achievement transformation for enterprises without disclosing specific achievement details, balancing cooperation needs and knowledge asset protection. In addition, each key behavior of joint R&D can be recorded in an immutable whole process through blockchain. This on-chain governance mechanism can provide a reliable basis for subsequent audits, responsibility definition, and achievement confirmation, enhancing the trust of both parties in the cooperation process.

2.3.3. Construction of trusted environment for international scientific research cooperation

International scientific research cooperation often involves different legal systems, scientific research norms, data security standards, and management mechanisms. Traditional cross-border collaboration often faces problems such as restricted data circulation and opaque achievement sharing mechanisms. By building an international scientific research cooperation network based on a consortium chain, these challenges can be effectively alleviated.

Using blockchain combined with privacy computing technology can realize “data usable but not visible”, thereby meeting the data supervision requirements of different countries and enabling the efficient flow of scientific research data within a compliant framework. Secondly, blockchain can transparently visualize the entire process of research activities in international cooperation [13]. Experimental records, version updates, meeting minutes, etc., of all participating parties can be written on the chain with timestamps and immutability, providing a trusted basis for cross-institutional project review, progress supervision, and responsibility division, reducing asymmetric information and misunderstandings in cooperation. In terms of achievement sharing, smart contracts can automatically execute cooperation agreements. By setting pre-automatic execution conditions, unfairness and disputes caused by various external factors are avoided, enhancing the stability and trust of international cooperation projects.

3. Challenges in the implementation of application scenarios

Although the application of blockchain technology in the field of teaching and scientific research in colleges and universities has broad prospects, it still faces multiple challenges in practical implementation. Firstly, at the legal and

regulatory level, data on-chain involves personal privacy, sensitive scientific research information, and achievement copyrights, and its immutability is in certain conflicts with existing laws and regulations; the legal effect, dispute resolution, and responsibility definition mechanism of smart contracts are also not yet perfect. Universities need to formulate relevant mechanisms and plans, and promote the improvement of the rule system of smart contracts together with regulatory authorities and legal experts. Secondly, technical costs and organizational collaboration are also thresholds. Universities have limited budgets and are not easy to bear the system construction and operation and maintenance expenses based on blockchain technology. In addition, cross-departmental collaboration processes are rigid, and data is difficult to unify and integrate, requiring the establishment of a collaborative governance mechanism involving multiple functional departments. Furthermore, insufficient teacher and student cognition and training restrict the promotion of scenarios to a certain extent. Some teachers and students have an inadequate understanding of blockchain technology and suffer from skill anxiety, making it difficult to deeply participate in the construction of core application scenarios. Universities need to improve teachers' and students' awareness and willingness to use through special training, demonstration platform construction, and other initiatives. Only through the coordinated advancement of system guarantees, resource co-construction, and cognitive improvement[14-15] can blockchain technology be truly implemented in the field of teaching and scientific research in colleges and universities.

4. Conclusion

As an important representative of the new generation of information technology, blockchain technology is bringing profound impacts on the field of teaching and scientific research in colleges and universities. By building a trusted data system, transparent governance structure, intelligent processes, and an open collaborative platform, blockchain technology will become an important infrastructure for the digital transformation of teaching and scientific research in colleges and universities. This study shows that blockchain technology is not only a separate technical tool but also a new path to promote the modernization of teaching and scientific research governance in colleges and universities. It has broad application value in score management, academic assessment, scientific research data certification, achievement confirmation, scientific research project management, inter-university cooperation, and copyright protection of teaching resources.

Therefore, in the digital era, blockchain technology will continue to promote the transformation of education and scientific research management in colleges and universities from experience-based governance to data-driven and intelligent governance, and become an important support for building an open, collaborative, and trusted ecosystem of teaching and scientific research in colleges and universities.

Disclosure statement

The author declares no conflict of interest.

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