Development Status, Trends and Challenges in the Field of “Blockchain and Education”

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Abstract. Blockchain, as the underlying technology of bitcoin, has gradually attracted the attention of the industry. At present, it has been used in many fields such as the financial industry and the service industry, and has great potential for application in the field of education. This article briefly introduces the blockchain technology, and at the same time explores and analyzes the development of the blockchain technology. This article starts with the relevant core literature in the field of “blockchain + education” in China, and understands the development trends of the blockchain technology. The research hotspots in the education field focus on the in-depth analysis of the research on blockchain technology in the field of education resource sharing and education information management, so as to grasp its current research status. Finally, based on the implementation of the blockchain technology in the implementation of the project, it discusses the facing challenges and proposes a new path for innovation and development looking forward to provide a reference for the deep integration of blockchain and education.

Keywords. Blockchain; education; research status.

1. Introduction
In November 2008, Japanese scholar Nakamoto proposed a decentralized digital currency, namely Bitcoin [1]. Since then, blockchain as the underlying core technology of Bitcoin has attracted widespread attention from many researchers in the international community. Blockchain, as an emerging internet application technology, has been widely promoted since 2014. A large number of countries or institutions have actively explored the research and application of blockchain technology. In 2018, it reached the tipping point, which was called “The first year of blockchain technology”. At present, blockchain technology has been successfully applied in the financial industry, service industry, and commerce, and has promoted the innovation and development of these industries.

At the end of 2016, China issued the “Thirteenth Five-Year National Informationization Plan” [2], which clearly stated the goal of “strengthening the advanced layout of strategic frontier technologies”, and included blockchain technology in China’s national informationization plan, and designated it as one of the strategic cutting-edge technologies. In August 2017, the State Council issued a document to promote the pilot application of new technologies based on blockchain [3], artificial intelligence, etc. In 2018, China will continue to promote the construction of national standards for blockchain technology and participate in international standard development work. Various policies released one after another show China’s emphasis on blockchain technology [4]. In October 2016, the “China Blockchain Technology and Application Development White Paper” stated by the Ministry of Industry
and Information Technology: “The characteristics of the transparency of the blockchain system and the non-tamperable data are fully applicable to student credit management, further employment, academic, qualification certification, product certification academic cooperation and other aspects are of great value to the healthy development of education and employment [5]”. With the continuous development of education informationization, blockchain technology as a strategic frontier technology will definitely have a huge impact on China’s education field.

This article briefly introduces blockchain technology, and slightly explores the overall development of blockchain technology. Based on the analysis of 34 domestic core literatures, the development trends and hotspots of “Blockchain + Education” are analyzed, and the research on blockchain technology in the field of education resource sharing and education information management are deeply dissected. According to the above researched, discussed the facing challenges and proposed a new path of “blockchain + education” innovation and development.

2. Blockchain Technology

2.1. Introduction to Blockchain Technology
In November 2008, the Japanese scholar Nakamoto proposed the concept and definition of blockchain in Bitcoin: A Peer-to-Peer Electronic Cash System [6]. In essence, blockchain refers to combining encryption technology to encapsulate data into blocks, interconnecting blocks through a chain structure, using consensus mechanisms to reach a unified consensus on the results of transactions, and creating a distributed infrastructure and decentralized operating environment [7] to verify the correctness and validity of the information and generate the next data block.

The block includes a block head and a block body. The block head is responsible for connecting to the next block through the main chain. The block body is responsible for storing data information. Each time a block and chain is formed, the system will automatically add a timestamp to blocks. These blocks are connected in chronological order to form a blockchain database [8].

There are three forms of blockchain: private chain, alliance chain, and public chain. Private chain: writing permission is only in the hands of an organization, and the read permission may be restricted. Alliance chain refers to the blockchain whose consensus process is controlled by pre-selected nodes, and is considered to be “partially decentralized”. Public chain: anyone can read the blockchain information, send transactions and confirm, and participate in the blockchain of the consensus process.

2.2. Characteristics of Blockchain Technology
Blockchain technology has the following characteristics:

Decentralization: blockchain or distributed ledger technology is an application mechanism that does not need to rely on a central institution to identify and verify a certain value or transaction.

Data Sharing: blockchain technology can establish an open mechanism for data sharing among different organizations, encourage data owners to open data, and give appropriate incentives or praise for the open behavior of data sharing to promote open data sharing between organizations.

Digital Currency: blockchain will provide strategic basic technology for the establishment of fiat digital currencies.

Consensus Mechanism: the consensus mechanism mainly refers to the authentication principle of how to reach consensus among all nodes in the network to determine the validity of a transaction information and ensure the authenticity of the information.

Traceability: all data information in the blockchain is stored in a chain block structure with a time stamp, which has strong traceability and verifiability.

2.3. Development Trends of Blockchain Technology
In addition to the application of blockchain technology in the financial industry, service industry, and business fields, other areas have also gradually used this technology to innovatively build various decentralized systems, or to improve business models based on the original. The smart contract system
based on blockchain technology can automatically implement the contract function by changing the code without human intervention. Some also use the blockchain in the field of health and hygiene, just like storing financial data. Medical information is stored in the blockchain, and users can control the accessibility of the health blockchain. Unauthorized people cannot snoop on privacy medical data [10]. An intelligent voting system based on blockchain technology. This voting system can enhance the security of voting data and avoid operations such as tampering and deletion of votes, thereby promoting the fairness of votes and protecting the legitimate rights and interests of voters. In the field of Internet of Things, blockchain technology can enable autonomous communication among devices and help them manage energy and correct errors [11].

3. Research Dynamic of “Blockchain + Education”
In order to understand the research and development in the direction of “blockchain + education” and clarify the current status of research and development in the direction of “blockchain + education”. This study selected 5 domestic Chinese CSSCI journals, including Journal of Distance Education, Modern Education Technology, Modern Distance Education Research, China Distance Education, and Higher Education Exploration, and searched using “blockchain” or “blockchain technology” and “education” as keywords. After excluding invalid documents such as conferences and reports, we have obtained 34 relevant research papers on “blockchain + education” that has been published in China in recent years. The search revealed that the first publication of the article in the direction of “Blockchain + Education” was January 15, 2017, and the time span of the retrieved article was January 2016 to January 19, 2020. The publication status of these 34 articles is: 12 articles published in 2017, 9 articles published in 2018, 10 articles published in 2019, and 3 articles published as of January 19, 2020. From the publication of the article, it can be concluded that the number of papers published in the “Blockchain + Education” research direction in the first three years was less, and the number of papers will increase in 2020. The research and application of the topic of “blockchain + education” in China is far behind the research and application of blockchain technology in China's financial industry, commerce, and service industries. As far as the current research status of blockchain technology is concerned, its application in pedagogy is mostly in its infancy or only stays in the forward-looking concept, but it undoubtedly has a positive reality in promoting the application of blockchain in pedagogy significance.

In order to grasp the frontier hotspots of “blockchain + education” and identify new developments in the research field, we used CiteSpace software. CiteSpace software is a document data visualization software developed by Chinese-American Chaomei Chen. It aims to analyze the historical research of published literature through related research included in the literature database to reflect the development of this research area [12]. We used the keyword co-occurrence function of CiteSpace software (when two or more keywords co-occur in the same article are referred to as keyword co-occurrence). The above-mentioned 34 documents in the field of “Blockchain + Education” in China National Knowledge Infrastructure (CNKI) database were analyzed to obtain the frequency information of each keyword in the documents in specific fields. This article replaced these Chinese keywords with corresponding English, and created a .txt file. Using python script code and a third-party excellent library-Word Cloud, the keywords were used to visualize the word frequency information of the text in order to make it more intuitive to show the relationship among keywords (figure 1). The keywords reflect the core theme and main content of the article to a certain extent. With the feature of keywords, we can analyze the research hotspots in the field of “blockchain + education”.

It can be seen from figure 1 that blockchain technology keyword is significant first-level high-frequency word. Keywords such as artificial intelligence, decentralization, big data, education informationization, credit banking, smart technology, smart education, and open education resources are secondary high-frequency words. These high-frequency words have obvious advantages in keywords, indicating that they are important concepts in the field-- close research directions for future researchers in this field. At the same time, it also shows that it is the research hotspots in this field.
Figure 1. Word Cloud map of keywords in 34 CSSCI papers in the field of “blockchain + education” in China: The size of the Chinese keyword font in the map indicates the frequency of occurrence. Among them, blockchain technology has become the highest frequency keyword.

Table 1 shows the relationship between keyword and centrality. In table 1, the most centrality of keywords is blockchain technology, and its centrality is 0.60. The keywords with lower centrality are education information, smart contract, online education, and smart education. The centrality of these keywords is less than 0.1. With the deep integration of information technology and education, this part of the less central keywords will be the future research hotspots in the field of blockchain and education. This shows that blockchain is still in its early stage in the field of education. Some researchers are limited to theory, which also shows that the blockchain technology will have great research and application prospects in the field of education.

| Number | Centrality | Year | Keyword                                      |
|--------|------------|------|----------------------------------------------|
| 1      | 0.60       | 2016 | Blockchain Technology                        |
| 2      | 0.38       | 2018 | Decentralized                                |
| 3      | 0.36       | 2017 | Big Data                                     |
| 4      | 0.25       | 2017 | Credit Bank                                  |
| 5      | 0.15       | 2017 | Artificial Intelligence                      |
| 6      | 0.06       | 2018 | Educational Information, Smart Contract, Online Education, Open Education, Smart Education |

4. Discussion

4.1. Research on the Application of Blockchain Technology in the Field of Educational Resources Sharing

Fang et al. [13] researched the application of smart learning robots for large-scale learning services for families, schools and communities, serving students in elementary and middle schools, mobile learning system with unlimited terminals that integrates formal learning and informal learning management based on blockchain technology. The application can break the fixed nature of the learning place, start the flexibility of learning resources, record the learning process of the learners, and monitor the learning quality of the learners, thereby playing a deep personalized intelligent learning support role in a large-scale learning service system. Quan [14] designed an open and
decentralized resource circulation model through the study of blockchain technology, that is, a dual-blockchain combination with smart contracts. Under this model, the circulation object is managed through the digital resource registration chain, the business control is automatically completed by the smart contract, and the circulation ledger is managed by the circulation information chain to build an open, self-growth, and self-managed circulation system. This system can not only promote the circulation of digital resources between supply and demand sides, but also protect the legitimate rights and interests of resource providers, and also realize the management and monitoring of circulating resources. Liu [15] aimed at the urgent need to protect the resource property rights existing in the sharing process of domestic educational resources, the quality of resources is not optimistic, and the construction method of resource pools needs to be transformed. Adopting the blockchain network topology and learning from the blockchain’s consensus verification technology, an educational resource sharing framework including a resource storage layer, a resource evaluation layer, and a resource interconnection layer was designed. The resource storage layer is used to protect resource property rights and improve legal policies. The resource evaluation layer uses digital signatures to ensure data integrity and validity. The network sharing layer is responsible for sharing resource pools between institutions. Li et al. [16] introduced the principle and development status of blockchain technology, introduced the process of the birth and development of the technology, the principle of its technical composition, and then specifically discussed the application of blockchain in education. They believe that it is possible to use the blockchain technology to build a decentralized knowledge base. For Internet resource platform users such as MOOC, Google Scholar, Wikipedia, etc., they do not need to enter the official website by a URL. It can be used as a distributed learning record storage in education. Tao [17] discussed the use of blockchain technology to build an educational platform. The distributed management of educational resources can effectively achieve the sharing of educational resources, making it impossible for learners who cannot receive traditional education to receive equally education and gain a block education transcript through the blockchain education platform.

4.2. Application Research of Blockchain Technology in Education Information Management

Central University of Finance and Economics, together with Century Internet and Microsoft Corporation, jointly developed the “Campus Blockchain” project. This project used blockchain technology to help students record all their academic achievements while at school, forming a lifelong, non-tampered, unforgeable, decentralized credit chain, and it is convenient for employers to obtain and verify [18]. Wu et al. [19] believed that the digital badge authentication system using the blockchain as the underlying protocol can irrevocably record the student’s learning record, and reward the student’s stage learning results in the form of block currency during the learning process, inspiring the student’s internal motivation for learning finally earned a digital badge certificate.

With the continuous development of new information technologies such as big data, the internet of things, cloud computing, and artificial intelligence in the “Internet +” era, the construction of traditional digital campuses has been upgraded to the construction of smart campuses. Many international universities have begun to focus on the construction of smart campuses. A lot of fund has been invested in the construction of smart campuses in some universities. New York University opened a blockchain-related course in 2014, which covered all the technical foundations of blockchain. Stanford University launched a new course on blockchain technology in 2015, as well as an experimental course to allow students to create their own bitcoin application systems. The University of Cambridge Emerging Financial Centre launched a blockchain course at the end of 2016, focusing on the intersection of blockchain technology and economics. Cornell University has great advantages in blockchain research. It conducted blockchain research in distributed systems, game theory, cryptography, programming languages, and security, and offers courses in blockchain technology. MIT launched the MIT Math Currency Program in 2013, offering courses on cryptocurrencies for students. The University of Nicosia applied blockchain technology to university education earlier in the world and established a blockchain technology course. The university also boldly tried to set up a
master degree program in blockchain technology. The outstanding features of each school in “Blockchain + Education” are shown in table 2.

| University name                        | Significant advantages of “blockchain + education”                                      |
|----------------------------------------|------------------------------------------------------------------------------------------|
| Massachusetts Institute of Technology, Stanford University, University of Edinburgh, Cornell University, Imperial College London, Cambridge University, New York University, University of Cumbria, Princeton University, University of Nicosia, University of Nicosia | Attach importance to Blockchain Technology, Focus on business potential, Free distant e-learning project, Master of Science Program |

4.3. Other Applications of Blockchain Technology in Education

In 2015, Sony Corporation used blockchain technology to build a platform serving global education institutions—“Sony Global Education [20]”. The platform enables a network structure among schools. And the learning process and learning effects of learners are shared among the learners themselves, teachers, parents, and schools. Learning progress is transparently displayed among schools, teachers and parents, reducing intervention of the national education administrative department in the learning process of learners and the evaluation of effects, which promotes education fairness and improves the efficiency of education management. At the same time, Sony’s global education platform uses blockchain technology to record and manage school student information, students’ platform learning effects, learning certificates and other information are stored through blockchain technology. School administrators, recruitment companies, and other stakeholders can verify the authenticity of its certificate in the blockchain, fake counterfeit certificates and diplomas will be blacklisted. This kind of certificates and diplomas can be verified, tamper-proof, and can be shared by multiple parties. It overturns the problem that traditional paper certificates and diplomas are easy to fake and difficult sharing issues. This initiative promotes education equity and guarantees the interests of employers. BitDegree is also an online course platform using blockchain technology. Students can access and query academic records and teaching rewards recorded in the blockchain. Companies can also recruit outstanding teachers through the platform based on the information shared by the blockchain. In 2017, the Australian National University, University of British Columbia, Boston University, Delft University of Technology, and the Swiss Federal Institute of Technology have signed code sharing agreements, which will use blockchain technology to build a knowledge base with each school as the core node to build a shared school system [21].

5. Conclusions

Blockchain-based technology has the characteristics of subverting traditional technologies such as decentralization, data sharing, and currency digitization, which has resulted in many research results in the field of education resource sharing, education information management, and online education platforms. However blockchain also faces challenges.

- Poor regulatory policies for blockchain technology: blockchain technology can not avoid risk outside the system and risk inherent in the financial field, and the government should formulate clear regulatory policies to protect the early development of the blockchain.
• Blockchain has security vulnerabilities: while using blockchain technology to achieve digital resource sharing, we must also pay attention to the information security issues of users who obtain resources.

• The blockchain technology itself has flaws: there is an upper limit on the number of blocks that can be accommodated on the blockchain. And the computing efficiency of blockchain is currently limited.

• Questioning the prospects of the application of blockchain technology in education: Encouraging resource owners to share open data is a difficult problem in the initial stage of applying blockchain technology to the field of education.

Path innovation that promotes the development of educational innovation using blockchain technology.

• Consolidate the foundation for development and attach importance to technological innovation. The experience of developed regions shows that increasing R & D investment in blockchain-related technologies, accelerating the original innovation and application innovation of blockchain technology, and mastering the core technical resources of the blockchain industry are the keys to capture the commanding heights of regional economic development in the blockchain era.

• Encourage policies and increase support. Blockchain technology is a strategic frontier technology, and its development and application directly determine the development quality and competitiveness of future education. Government departments at all levels should learn from advanced practices in developed countries and regions, and in accordance with China's blockchain technology and application development situation, promptly issue blockchain technology and industrial development support policies.

• Focus on talent training. The government should combine the development direction, development goals, and main tasks of China’s education informationization to clarify the supply and demand of big data and blockchain-related professionals, increase the training of talents, and occupy the advantages and opportunities of cutting-edge blockchain talent resources.

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