Influence of Blockchain Technology Application in Education on Online Teaching Resources Sharing

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Abstract—Currently blockchain technology has been considered as one of the cutting-edge applied science and technology in educational information construction. Blockchain technology can effectively solve such problems as information security and trust crisis in the current application of big data in online education by virtue of its characteristics of decentralization, traceability, multi-party consensus mechanism, and high trust. Blockchain technology is conducive to protecting online educational resources, strengthening the transparency of online teaching resources, simplifying the copyright transaction process, and thus enhancing the scientific and technological innovation ability of teachers. Studies regarding the blockchain technology application in education were analyzed, and the influences of the four aspects of the blockchain technology application in education on online teaching resource sharing were explored. Results showed that the Cronbach α coefficient of the questionnaire designed in this study was 0.856, and the KMO value was 0.859, indicating its good reliability and validity. The cross-institutional learning record storage space, learning certificate management mechanism, and collaboratively developed educational ecosystem of the blockchain technology application in education obviously promoted online teaching resource sharing at a significance level of 5%. The obtained conclusions have important reference values for strengthening the integration of educational resources under blockchain technology, improving the application mechanism of online digital educational resources, and improving the accurate service quality of online educational resources.

Keywords—blockchain technology, application in education, online teaching resources, resource sharing, questionnaire survey, linear regression, variance test

1 Introduction

With the vigorous development of cloud computing and big data technology, certain results have been achieved in the construction of online college teaching resources. Blockchain is an innovative application mode of computer technology in the Internet age, which is the result of the integration of database, cryptography, network technology, and so on. Institutions of higher learning have basically adopted online

learning methods, and the online teaching resources generated by teachers and schools are increasing in geometric series. However, schools are currently subjected to the problem of "data islands", and no unified educational big data standards have been formulated during educational information construction. The construction, updating, and sharing of online teaching resources need the participation, coordination, and support from many participants, such as resource providers and resource management institutions. Therefore, the construction of blockchain-based online teaching resource sharing mechanism can help solve the trust problems such as data authenticity and non-repudiation in the process of educational big data analysis, and improve the sharing degree of online teaching resources.

As an educational method in the new era, the student-centered and individualized education concept has been widely recognized. The academic development of everyone needs to be supported by a large quantity of high-quality online education resources. There are sufficient digital teaching resources for learners (users) to learn in terms of quantity, but from the angle of quality, the available resources to learners are not extremely selective. Due to the replicability of data resources, it is difficult to guarantee the credibility, integrity, and data privacy of digital resources while users gain access to them, which is becoming a key issue for the rational sharing of data and the timely updating of resources by resource builders. Especially in colleges and universities, online teaching resources are mainly managed by the academic affair office, library, educational technology center, and secondary colleges, which leads to scattered storage of teaching resources, diversified platforms, and difficult unified management of information resources, thus undoubtedly increasing the burden on learners and making them unable to find learning resources conveniently and quickly. Resources can be easily duplicated and wasted due to the lack of communication within the department. Blockchain has indicated the new direction for the co-construction and sharing of college teaching resources due its characteristics of decentralization, distrust, collective maintenance, security, openness, anonymity, and autonomy.

2 Theoretical bases and hypotheses development

2.1 Theoretical bases

Blockchain is an information system that integrates hardware and software, where hardware is a group of servers, each of which serves as a node. Blockchain technology has exhibited good distributed data storage characteristics such as decentralization, point-to-point transmission, trustworthiness, consensus mechanism, tamper-proof encryption and anti-counterfeiting, smart contract, transparency, anonymity, and collective maintenance. The core idea of blockchain lies in decentralization. The obligations and rights of any node in the blockchain system are equal, ensuring that every node has the ability to vote with computing power. Under the centralized network system, system operation and maintenance can be conducted collectively to improve the maintenance efficiency. The point-to-point data transmission characteristics of blockchain technology can realize the direct sharing of teaching resources between different nodes, including teaching courseware applied in higher education and teaching, and improve the sharing degree and utilization efficiency of higher education evaluation resources.

Blockchain technology can realize higher education resources sharing, scholarship supervision, credit recognition and achievement encouragement, professional upgrading, and digital transformation, elevate the level of digitalization, networking, and intelligence, improve the students' logical thinking and innovative and entrepreneurial ability, as well as enhance their learning efficiency.

2.2 Hypotheses development

The Internet education industry is an upgrade of traditional education, which greatly promotes the development of social education. Blockchain technology, which is not an independent technology, has strong compatibility and can be effectively integrated with big data, artificial intelligence, and the Internet of Things, thus greatly improving the security and privacy of the Internet education industry and successfully creating an intelligent learning environment.

In the cross-institutional learning record storage space of blockchain technology, Scott [1] thought that if cooperating closely through virtual integration, organizations can cope with the complexity of new products, and trust is needed in effective inter-organizational cooperation. Benisi et al. [2] determined that blockchain is a new method to create a distributed network. A distributed storage network comprised a group of people who are willing to rent their unused hardware storage space. Maulani et al. [3] stated that blockchain innovation can be conducted in different kinds of teaching spaces. Blockchain education innovation is a young discipline, but it has great potential to help loose training fields. Ren et al. [4] deemed that blockchain technology is applied to data storage and data connection, and the utilization efficiency of various storage resources can be improved thanks to the storage performance of blockchain. Fan et al. [5] thought that blockchain can improve the efficiency of economic and social operation by virtue of its decentralized characteristics. Blockchain technology can reduce the redundancy of various stored data. Therefore, it can be seen that if used, blockchain technology can establish a large data space for cross-institutional learning record storage, which makes online teaching resource sharing more convenient, diverse, and real-time, and this is conducive to online learners' efficient online learning whenever and wherever possible. Therefore, hypothesis H1 was proposed.

H1: Cross-institutional learning record storage space has an obvious positive effect on online teaching resource sharing.

In terms of the learning record big data sharing mechanism of blockchain technology, Ocheja et al. [6] thought that the learning log (BOLL) of blockchain technology is a platform that enables learners to move their learning records from one institution to another safe and verifiable format. This mainly solves the cold start problem facing the learning data analysis platform when trying to provide personalized experience for new learners. Li and Han [7] proposed a blockchain-based education record storage and sharing scheme, which combines blockchain, storage server, and encryption technology to create a reliable and secure environment, thus effectively realizing the timely sharing of learning records. Alkouz et al. [8] proposed a new decentralized framework, which uses blockchain to manage EPPR, and accesses consumers' education records through education record editors. Ocheja et al. [9] deemed that blockchain can provide good

technical support for learners' academic data visualization. The uniqueness of education requires blockchain technology to support the students' learning activities, improve teaching methods, and simplify management procedures. Li et al. [10] thought that MOOC advocates completing the learning process through online devices. Therefore, as powerful evidence of the learning process, electronic learning records (ELRs) propose a secure storage and sharing scheme of ELRs in a blockchain-based MOOC learning system, which has better performance than other similar schemes. The advantage of blockchain technology lies in the realization of a secure data resource sharing mechanism, which can effectively share learners' learning records in online learning platforms built by various educational subjects such as countries, provinces, and schools, and enhance learners' willingness to use different online learning platforms to learn resources and teachers' willingness to share teaching resources in various online learning platforms. Therefore, the second hypothesis H2 in this research was put forward.

H2: The learning record big data sharing mechanism has an obvious positive effect on online teaching resource sharing.

In the aspect of learning certificate management mechanism of blockchain technology, Agustin et al. [11] determined that blockchain technology is applied to e-certificates, to verify and distribute hosted e-certificates in each journal issue, and blockchain tools are used as the place to issue e-certificates, which ensures the security of e-certificates and realizes the verification and data management of e-certificates. Lutfiani et al. [12] indicated that blockchain technology is used to verify the authenticity of degree certificates. In the development of blockchain technology, blockchain software is applied to systems using digital signature schemes and timestamps, and the authenticity of certificates is checked through credible sources. Rahardja et al. [13] thought that the blockchain technology can be used to issue digital certificates effectively, and with various advantages, it can help educational institutions to establish a widely accessible authentication system infrastructure to support the transparency and accountability of educational institutions, to determine the validity of certificates. Jeong and Choi [14] designed a recruitment performance appraisal certificate management platform based on blockchain. This information platform built using blockchain technology will be used in recruitment and application management, career management, and personal history maintenance, which will effectively improve the efficient use of personal learning certificates in personal careers. Hsu et al. [15] analyzed the diploma management system based on blockchain developed by many universities, and proposed a blockchain deployment framework, which comprised educational authorities and institutions to make the identity of diploma issuers credible. According to numerous literature results, the security mechanism provided by blockchain technology can build a certificate management mechanism and realize the credible recording of certificate information. Through good learning certificate management, the sharing of online teaching resources can be obviously improved. Therefore, the third hypothesis H3 of this research was presented.

H3: The learning certificate management mechanism has an obvious positive effect on online teaching resource sharing.

Raimundo and Rosário [16] thought that blockchain has become an important concept in the interface between information communication technology and higher

education and is being used to establish new intervention measures to improve the common way of sharing, transmitting, and protecting knowledge data and students' personal records. Grech and Ariño [17] determined that blockchain has long been regarded as an opportunity to promote the core process of the education department in urgent need of reform. Advocates of blockchain and educational policymakers have established a good educational ecosystem in governance, independent sovereignty, interoperability, and the choice of blockchain platform, to enhance the value of blockchain to university governance. Ma and Fang [18] believed that blockchain technology can provide a wide range of benefits for the development of higher education. After comprehensively summarizing the latest application of blockchain in the field of education, he determined that a benign educational ecosystem with government, university administrators, and teachers as the main body needs to be built to integrate blockchain technology and higher education efficiently. Guo and Ye [19] indicated that blockchain technology is a relatively new technology, and the educational application based on blockchain is of great value to China's reform and innovation. To promote the popularization of blockchain technology in institutions of higher learning, it is necessary to build a shared education ecology and change the shared education model, to improve the management efficiency of colleges and universities. All the above documents show that an integrated education system with comprehensive opening, national participation, and collaborative construction should be established for the blockchain technology application in education, which can change the status quo of the educational information system serving a single institution and school. Therefore, the fourth hypothesis H4 of this research was proposed.

H4: The collaboratively developed educational ecosystem has an obvious positive effect on online teaching resource sharing.

3 Methodology

3.1 Questionnaire design

Based on the existing research on blockchain technology, educational application, and online teaching resource sharing, a questionnaire titled "the influence of blockchain technology application in education on online teaching resource sharing" was designed in this research, which mainly comprised the following aspects, with a total of 27 questions. The first aspect was about the measurement of educational application of blockchain technology. Fedorova and Skobleva [20] believed that blockchain technology provides technical support for educational application, and the educational application based on blockchain technology can be realized through four aspects: cross-institutional learning record storage space, learning record big data sharing mechanism, learning certificate management mechanism, and collaboratively developed educational ecosystem, which respectively correspond to four, five, four, and four questions. The second aspect was the measurement of online teaching resource sharing, which was implemented by designing five questions by reference to the research of Zheng and Kadry [21]. In the third aspect, the descriptive statistics of the respondents mainly included 5 questions: the gender, title, age, and colleges/universities of the respondents, and their familiarity with blockchain technology. All questions were measured by the five-point Likert scale.

3.2 Respondents

Jiangsu Province is a powerful province of higher education and economy in China. Jiangsu Province also issued the *Action Plan for the Application and Promotion of Blockchain (2021–2023)* to encourage colleges and universities to adopt blockchain technology to improve the quality of education and share teaching resources. The Suzhou-Wuxi-Changzhou metropolitan area in Jiangsu Province (including Suzhou, Wuxi, and Changzhou), which is located in the Yangtze River Delta, has an early start of the digital economy, with relatively perfect digital infrastructure. The blockchain application has entered a higher stage. Colleges and universities in Suzhou, Wuxi, and Changzhou possess good teacher resources, and blockchain technology-aided education and teaching in colleges and universities are relatively advanced. Therefore, a questionnaire survey was conducted in this research among teachers from Soochow University, Suzhou University of Science and Technology, Jiangnan University, Wuxi College, Changzhou University, and Changzhou Institute of Technology in the Suzhou-Wuxi-Changzhou metropolitan area. The questionnaire design was implemented on an online questionnaire design website extensively used in China. The QR code generated online was distributed to the teachers from the six aforesaid colleges and universities via the research project channel on WeChat, which lasted for three days. Within the specified time, a total of 296 questionnaires were collected. After excluding the invalid questionnaires, 219 questionnaires were valid, with an effective recovery rate of 73.98%. The specific descriptive statistical results of respondents are shown in Table 1.

Table 1. Frequency analysis results

Name	Option	Frequency	Percentage (%)
Gender	Female	56	25.57
	Male	163	74.43
Title	Teaching assistant	26	11.87
	Lecturer	76	34.70
	Associate professor	82	37.44
	Professor	35	15.98
Age group	20–30	35	15.98
	30–40	79	36.07
	40–50	66	30.14
	50–60	39	17.81
College/university	Soochow University	13	5.94
	Suzhou University of Science and Technology	29	13.24
	Jiangnan University	42	19.18
	Wuxi University	52	23.74
	Changzhou University	70	31.96
	Changzhou Institute of Technology	13	5.94
Familiarity with blockchain technology	No	66	30.14
	Yes	153	69.86

4 Results analysis

4.1 Reliability and validity tests

Reliability analysis is mainly used to study the reliability and accuracy of answers to quantitative data, which is an important step in questionnaire research. The Cronbach's α coefficient is generally used to represent the reliability, as shown in Formula (1).

$$\alpha = \frac{k}{k-1}(1-\frac{\sum_{i=1}^{k} S_i^2}{S_x^2}) \tag{1}$$

where k represents the number of questions to be measured; S_i represents the variance of the score for the i-th question; S_x represents the variance of the total score of the test. The Cronbach's α coefficient indicates the consistency between the scores of each item in the scale. If it is higher than 0.8, it means high reliability. If it is between 0.7 and 0.8, the reliability is good.

Table 2. Reliability test results

Variable Type	Variable Name	Variable No.	Number of Questions	Cronbach α	Cronbach α
Independent variable	Cross-institutional learning record storage space	A	4	0.708	0.856
Independent variable	Learning record big data sharing mechanism	B	5	0.880	
	Learning certificate management mechanism	C	4	0.764	
	Collaboratively developed educational ecosystem	D	4	0.835	
	Online teaching resource sharing	Y	5	0.885	

Table 2 shows that the reliability coefficient of this questionnaire was 0.856, which was greater than 0.8, indicating the high reliability quality of the data.

After the reliability analysis, the validity analysis was continued. Validity research was used to analyze whether the research items were reasonable and meaningful, and factor analysis was used as the data analysis method for validity analysis. The KMO test is based on comparing the relative sizes of simple correlation coefficient and partial correlation coefficient between original variables, as shown in Formula (2).

$$\mathrm{KMO} = \frac{\sum\sum_{i\neq j} r_{ij}^2}{\sum\sum_{i\neq j} r_{ij}^2 + \sum_{i\neq j} \alpha_{ij}^2} \tag{2}$$

where r_{ij} denotes the correlation coefficient and α_{ij} is the partial correlation coefficient. The larger the calculated KMO value, the more suitable it is for principal component analysis.

Table 3. Validity analysis results

Measurement Question No.	Factor Loading Coefficient					Common Degree
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
A1	0.135	0.206	–0.016	0.052	0.713	0.572
A2	0.221	0.048	–0.096	0.115	0.627	0.467
A3	–0.032	0.156	0.019	0.044	0.742	0.578
A4	0.093	0.045	0.036	0.058	0.730	0.548
B1	0.161	0.789	0.051	0.051	0.225	0.704
B2	0.333	0.755	0.041	0.086	–0.013	0.690
B3	0.237	0.754	0.017	0.077	0.241	0.688
B4	0.225	0.795	0.008	0.008	0.099	0.692
B5	0.175	0.791	0.038	0.096	0.059	0.671
C1	0.115	0.072	0.007	0.744	–0.019	0.573
C2	0.096	0.075	0.046	0.776	–0.053	0.622
C3	–0.002	0.155	0.066	0.764	0.278	0.689
C4	0.003	–0.037	0.150	0.720	0.150	0.565
D1	–0.063	0.048	0.815	0.062	–0.012	0.675
D2	0.043	0.090	0.812	0.061	0.075	0.678
D3	0.080	–0.033	0.813	0.179	–0.079	0.706
D4	0.100	0.013	0.810	–0.025	–0.031	0.668
Y1	0.795	0.222	0.032	0.108	0.077	0.699
Y2	0.770	0.233	0.008	0.063	0.073	0.657
Y3	0.798	0.185	0.029	0.062	0.071	0.681
Y4	0.789	0.240	0.012	0.039	0.140	0.702
Y5	0.792	0.176	0.114	0.008	0.136	0.690
Characteristic root value	3.508	3.363	2.702	2.366	2.278	3.508
Cumulative variance interpretation ratio	15.947%	31.232%	43.512%	54.268%	64.622%	15.947%
KMO value	0.859					–
Bartlett sphericity value	2019.987					–
df	231					–
p value	0.000					–

Table 3 shows that the corresponding commonality values of all research items were higher than 0.4, indicating that the research item information could be effectively extracted. The KMO value was 0.859, which was greater than 0.6, and the data could be effectively extracted. The variance interpretation rates of the five factors were

15.947%, 15.285%, 12.281%, 10.755%, and 10.354%, respectively, while the cumulative variance interpretation rate after rotation was 64.622% > 50%. Result manifested that the information content of the research item could be effectively extracted. The corresponding p value of the Bartlett test was 0.00, which is less than 0.05, indicating the excellent validity of this questionnaire.

4.2 Linear regression

Table 4. Linear regression results

Variable No.	Standardization Coefficient	T	P	95% CI	VIF
constant	–	3.962	0.000**	0.746 ~ 2.205	–
A	0.203	2.443	0.015*	0.035 ~ 0.317	2.003
B	0.127	1.638	0.103	–0.022 ~ 0.241	1.730
C	0.135	2.136	0.034*	0.015 ~ 0.359	1.162
D	0.194	2.413	0.017*	0.030 ~ 0.288	1.872

Note: *p < 0.05, **p < 0.01.

Table 4 shows that the model passed the F-test, which means that at least one of the independent variables would have an influence on the dependent variables. All VIF values in the model were less than 5, meaning no collinearity problem. The D-W value was close to 2, indicating no autocorrelation in the model and no correlation between sample data.

(1) H1 holds. Cross-institutional learning record storage spaces have an obvious positive effect on online teaching resource sharing. The main reason is that the blockchain technology can provide online learners with learning record storage and authentication services, wherein schools and non-academic education institutions can record the learning behaviors and learning results of teachers, students, and social workers across systems and keep them permanently, and technically solve the problem of academic fraud and the disconnection of school-enterprise information in employment. In accordance with the relevant national education standards, the blockchain stores unified data codes, data tables, and field formats, and cleans and aggregates previous data to achieve sharing. The trusted sharing model of online teaching resources is reliable in the case of multi-agent participation, which ensures the information resources safety of platform users and provides users with a safe and credible platform for sharing high-quality online teaching resources, thus facilitating network resources to exert real values in online teaching resource platforms.
(2) H2 is not true. The learning record big data sharing mechanism has an obvious positive effect on online teaching resource sharing. The main reason why this conclusion does not hold may be that the universities surveyed have not formed a learning record big data sharing mechanism, which leads to obscure sharing of online teaching resources. At the same time, a potential reason is that each school has multiple online teaching systems from various manufacturers, which, however,

are in inconsistent data formats, accompanied by the problem of data islands. In the current school business system, the requirements of process data collection are not uniform, the relationship between data entities and data fields is complex, and some key data cannot be collected accurately, making data cleaning difficult. Online teaching resources in numerous colleges and universities are mainly constructed and managed by administrative institutions and teachers, which easily leads to the inconsistency of resource ownership. The chaotic management of online teaching resources makes it impossible for learners to gain an effective learning entrance effectively and quickly when accessing resources, which results in the inconspicuous sharing of online teaching resources. Therefore, this conclusion also focuses on inspiring our university administrators to attach importance to the application of blockchain technology in teaching, and they should support a good teaching resource sharing system, break the obstacles of resource sharing caused by administrative management, and reorganize the educational resources of various educational platforms in the school, which greatly shortens the time for users to find learning resources and strives for more learning time for users.

(3) H3 is established. The learning certificate management mechanism has an obvious positive effect on online teaching resource sharing. This conclusion is consistent with most research results. The main reason is that China has a large population base of higher education, but there are also many fake institutions of higher education, especially the falsification of academic certificates and the difficulty in certification, which hinders the fair development of higher education. By adopting the security mechanism provided by blockchain technology, a certificate management mechanism can be constructed to realize the credible record of certificate information. The core information of the certificate is linked, while the unique identification of the electronic version of the certificate file is produced by Hash algorithm and linked together, forming the data fingerprint of the student to obtain the certificate on the blockchain. It is very beneficial for the government, universities, and individuals to submit the digital fingerprint of the certificate to the blockchain for verification and certification, provide certification reports, and serve schools, enterprises and individuals.

(4) H4 holds. The collaboratively developed educational ecosystem has an obvious positive effect on the sharing of online teaching resources. The establishment of this conclusion is also in line with the research expectation. The main reason is that blockchain technology is a new technology, which needs various subjects (including government, education management departments, universities, teachers, and students) to establish an integrated education system that is fully open, participatory, collaborative, and can change the status quo of educational information system serving a single institution and school. The new education system can provide numerous open education resources, and meanwhile, establish learners' files, set learning goals for each student, and enhance the students' learning motivation through virtual points. Students will get certain score points after completing the stage goals, which are equivalent to the school learning results. Communities, enterprises, institutions, and even individuals become educational service providers, using blockchain to ensure the authenticity of educational processes and

results, and the certificates issued are circulated throughout the network, thus proving the students' online learning experience.

4.3 Analysis of variance

Table 5. Familiarity with blockchain technology on online teaching resource sharing

Online Teaching Resource Sharing	Familiarity with Block Chain Technology (Mean ± Standard Deviation)		F	P
	Unfamiliar (n = 66)	Familiar (n = 153)		
4.12 ± 0.79	4.36 ± 0.69	4.556	0.034*	4.12 ± 0.79

Note: *$p < 0.05$.

Table 5 shows that the familiarity with blockchain technology influenced online teaching resource sharing at a significance level of 0.05 ($F = 4.556$, $p = 0.034$). This is mainly because blockchain technology has entered the education and teaching of colleges and universities with a new technical form and teaching means, which is also novel for college teachers and requires them to take the initiative to learn. With the development of computer technology, therefore, related teaching methods are constantly changing. Some teachers who are familiar with blockchain technology share their teaching experiences and create related teaching methods online, which makes these teachers upload video resource pages on the online educational resource sharing platform without information security concerns, and will share more resources with huge data online. In practical professional teaching, teachers who are familiar with blockchain technology will effectively check the students' learning status by increasing the application of blockchain technology, thus improving the teaching level and promoting them to share online teaching resources in a wide range and for a long time. This conclusion also inspires our university administrators to pay attention to the training of university teachers with respect to the basic knowledge of blockchain and the blockchain technology application in education, and build an online learning system of mutual trust and sharing, in which more good teaching resources can be shared.

5 Conclusion

The blockchain technology application in education can contribute to fairer and more efficient utilization of online resources, the comprehensive expansion of educational space, and the comprehensive improvement of educational governance pattern. Blockchain technology turns resources into kinetic energy of knowledge appreciation, and it is also a decentralized network technology framework, which has been applied to higher education learners in recording learning experiences, managing learning resources, utilizing online educational resources, and protecting copyrights to a certain extent. The influences of the four aspects related to the blockchain technology application in education on online teaching resource sharing were analyzed in this study, and the following results were achieved: (1) The reliability coefficient value of this

questionnaire was 0.856 and the KMO value was 0.859, reflecting the excellent reliability and validity of the questionnaire; (2) Cross-institutional learning record storage space, learning certificate management mechanism, and collaboratively developed educational ecosystem all obviously promoted online teaching resource sharing at the significance level of 5%; (3) The familiarity with blockchain technology influenced online teaching resource sharing at a significance level of 5% ($F = 4.556$, $p = 0.034$). The focus is on the influence of blockchain technology on online educational resource sharing, and in-depth research is suggested on building an educational resource sharing platform based on blockchain system verification, and strengthening the management of students and improving the teaching timeliness with blockchain technology.

6 References

[1] Scott, J. E. (2000). Facilitating interorganizational learning with information technology. Journal of Management information systems, 17(2), 81–113. https://doi.org/10.1080/07421222.2000.11045648

[2] Benisi, N. Z., Aminian, M., and Javadi, B. (2020). Blockchain-based decentralized storage networks: A survey. Journal of Network and Computer Applications, 162, 102656. https://doi.org/10.1016/j.jnca.2020.102656

[3] Maulani, G., Musu, E. W., Soetikno, Y. J. W., and Aisa, S. (2021). Education management using blockchain as future application innovation. IAIC Transactions on Sustainable Digital Innovation (ITSDI), 3(1), 60–65. https://doi.org/10.34306/itsdi.v3i1.525

[4] Ren, Y., Leng, Y., Qi, J., Sharma, P. K., Wang, J., Almakhadmeh, Z., and Tolba, A. (2021). Multiple cloud storage mechanism based on blockchain in smart homes. Future Generation Computer Systems, 115, 304–313. https://doi.org/10.1016/j.future.2020.09.019

[5] Fan, X., Niu, B., and Liu, Z. (2022). Scalable blockchain storage systems: Research progress and models. Computing, 104(6), 1497–1524. https://doi.org/10.1007/s00607-022-01063-8

[6] Ocheja, P., Flanagan, B., Ueda, H., and Ogata, H. (2019). Managing lifelong learning records through blockchain. Research and Practice in Technology Enhanced Learning, 14(1), 1–19. https://doi.org/10.1186/s41039-019-0097-0

[7] Li, H. and Han, D. (2019). EduRSS: A blockchain-based educational records secure storage and sharing scheme. IEEE Access, 7, 179273–179289. https://doi.org/10.1109/ACCESS.2019.2956157

[8] Alkouz, A., Haj Yasien, A., Alarabeyyat, A., Samara, K., and Al-Saleh, M. I. (2021). EPPR: Blockchain for educational record sharing and recommendation using the Ethereum platform. International Journal of Grid and Utility Computing, 12(3), 347–356. https://doi.org/10.1504/IJGUC.2021.117882

[9] Ocheja, P., Flanagan, B., Ogata, H., and Oyelere, S. S. (2022). Visualization of education blockchain data: Trends and challenges. Interactive Learning Environments, 1–25. https://doi.org/10.1080/10494820.2022.2026406

[10] Li, D., Han, D., Zheng, Z., Weng, T. H., Li, H., Liu, H., ... and Li, K. C. (2022). MOOCsChain: A blockchain-based secure storage and sharing scheme for MOOCs learning. Computer Standards & Interfaces, 81, 103597. https://doi.org/10.1016/j.csi.2021.103597

[11] Agustin, F., Aini, Q., Khoirunisa, A., and Nabila, E. A. (2020). Utilization of blockchain technology for management e-certificate open journal system. Aptisi Transactions on Management (ATM), 4(2), 133–138. https://doi.org/10.33050/atm.v4i2.1293

[12] Lutfiani, N., Apriani, D., Nabila, E. A., and Juniar, H. L. (2022). Academic certificate fraud detection system framework using blockchain technology. Blockchain Frontier Technology, 1(2), 55–64. https://doi.org/10.34306/bfront.v1i2.55

[13] Rahardja, U., Aini, Q., Budiarty, F., Yusup, M., and Alwiyah, A. (2021). Socio-economic impact of blockchain utilization on digital certificates. Aptisi Transactions on Management (ATM), 5(2), 106–111. https://doi.org/10.33050/atm.v5i2.1508

[14] Jeong, W. Y. and Choi, M. (2019). Design of recruitment management platform using digital certificate on blockchain. Journal of Information Processing Systems, 15(3), 707–716. https://doi.org/10.3745/JIPS.03.0121

[15] Hsu, C. S., Tu, S. F., and Chiu, P. C. (2022). Design of an e-diploma system based on consortium blockchain and facial recognition. Education and Information Technologies, 1–25. https://doi.org/10.1007/s10639-021-10840-5

[16] Raimundo, R. and Rosário, A. (2021). Blockchain system in the higher education. European Journal of Investigation in Health, Psychology and Education, 11(1), 276–293. https://doi.org/10.3390/ejihpe11010021

[17] Grech, A., Sood, I., and Ariño, L. (2021). Blockchain, self-sovereign identity and digital credentials: Promise versus praxis in education. Frontiers in Blockchain, 4, 616779. https://doi.org/10.3389/fbloc.2021.616779

[18] Ma, Y. and Fang, Y. (2020). Current status, issues, and challenges of blockchain applications in education. International Journal of Emerging Technologies in Learning (IJET), 15(12), 20–31. https://doi.org/10.3991/ijet.v15i12.13797

[19] Guo, Z. and Ye, M. (2021). The development and value of blockchain technology + higher education under the background of China's higher education reform and innovation. Advances in Educational Technology and Psychology, 5(8), 45–49. https://doi.org/10.23977/aetp.2021.58013

[20] Fedorova, E. P. and Skobleva, E. I. (2020). Application of blockchain technology in higher education. European Journal of Contemporary Education, 9(3), 552–571. https://doi.org/10.13187/ejced.2020.3.552

[21] Zheng, W., Muthu, B., and Kadry, S. N. (2021). Research on the design of analytical communication and information model for teaching resources with cloud-sharing platform. Computer Applications in Engineering Education, 29(2), 359–369. https://doi.org/10.1002/cae.22375

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