Application of Blockchain Technology in Higher Education

Oraphan Amnuaysin
Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University, Thailand, *orapan_amn@nstru.ac.th*

Thananan Areepong
Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University, Thailand, *thananan_are@nstru.ac.th*

Sasitorn Issaro*
Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University, *sasitorn_iss@nstru.ac.th*

*Corresponding author E-mail: sasitorn_iss@nstru.ac.th

Received: 20 September 2022; Revised 28 September 2022; Accepted 6 October 2022

ABSTRACT*: Blockchain technology is a highly reliable computing technology based on algorithms and decentralized data storage using cryptography principles and distributed consensus mechanisms. In addition, the data stored in the blockchain system can be hard to modify. It ensures no alteration of data, privacy, reliability, transparency, and security to all its forms of data exchange. Blockchain technology is gaining attention and is fast developing to play a crucial role in the education system and society in the future. The paper aims to provide a literature review and research that examines the application of blockchain in educational institutions, analyzing the practical application cases of using this technology. The results of the study revealed that the application of blockchain technology in education had applications as follows: certificate management, maintaining a collaborative learning environment, assessing students' professional competency, interacting with students in the e-learning system, educational record management, academic portfolio creation, fees, and credit transfers, copyright management and assessment for learning management. This paper, therefore, presents an analysis of the opportunities and limitations associated with the application of blockchain technology in the implementation of the primary missions of higher education.*

Keywords: blockchain technology, blockchain in education, application blockchain

1. Introduction

The application of technology to education has continued to serve as a tool to develop human resources or manpower planning. It is a fundamental engine in driving the new economy through innovation emphasizing technology, creativity, and the service sector. It will help upgrade the country's development into the Thailand 4.0 era according to the 20-year National Strategic Plan and the 12th National Economic and Social Development Plan. Higher education institutions consequently play a very vital role in applying technology as a base to develop their primary role in carrying out four important missions: graduate production, research and development, academic service, and preservation of arts and culture. Technology has been used in education since the beginning, including computer technology in teaching and learning, videos, multimedia, games, animation as a learning media in the form of information systems. Later, there was the development of information technology and communication, resulting in internet technology linking the work of information systems such as; automated library systems, research database systems, registration systems, financial and supplies information systems, human resource management systems, etc. At present, Thailand has entered the era of digital education technology; various educational institutions have digitized their educational environment. It can be seen from the development of online teaching systems and digital learning platforms such as MOOC systems, combined online and offline learning and the Internet, as well as the application of cloud computing technology. It combines computing resources with Internet technology to make processing and resource allocation more efficient. Thus, digital technology is an essential tool to develop to be Thailand 4.0.

Currently, the world's education system is transforming new technologies and digitizing the educational environment. Education is becoming simultaneously an open and private format, while population growth will be a major challenge of the education sector. It is estimated that by 2035 there will be 2.7 billion students worldwide. The number of students will increase due to countries in Asia and Africa where about 90% of the population is under the age of 30. The advantages of digital education technology enable them to monitor how well students are gaining new insights and skills, revise the learning process promptly, and make education more personal and flexible. It is estimated that the four cutting- edge technologies in education systems that will cost more by 2025 are virtual reality, artificial intelligence, robotics and blockchain (Fedorova & Skobleva, 2020).

Blockchain technology is a shared data storage technology; there is a decentralized data record where all members receive the same set of information. The data on the blockchain is authenticated by multiple participants in the network. This saves time and simplifies the audit process and results in money savings. Blockchain technology gained popularity after it was first introduced as the core technology behind the Bitcoin digital currency proposed by Satoshi Nakamato in 2008 (Daraghmi et al., 2019). Later in 2015, M. Swan wrote a book titled Blockchain: Blueprint for a new economy, stating that blockchain is used not only in finance but also in fields such as; Public administration, healthcare, education, science, culture and the arts. Thus, the development of national artificial intelligence and digital economy transformation strategies has been adopted by developed countries (Fedorova & Skobleva, 2020). Blockchain brings credibility, transparency, and security to all forms of information exchange. As it is a technology that can migrate from a centralized data logging system to a distributed system ensuring no data changes and privacy is maintained. High-reliability processing using algorithms creates trust in financial transactions, contractual agreements, and change of ownership and certification laws (Capece et al., 2020). A handful of educational institutions are using it at the moment. This paper presents a systematic review that aims to provide a literature review of blockchain technology, blockchain in education, and applications of blockchain technology for higher education institutions.

2. Literature review

2.1 Blockchain technology

Blockchain technology is a new and rapidly evolving data storage technology that is gaining attention for its role in education and society in the future. The adoption of blockchain technology in education so is a big challenge. Blockchain technology is a distributed and decentralized peer-to-peer network; All transactions are performed by participants and stored in a single immutable public ledger (Daraghmi et al., 2019) The aim is to eliminate third-party intermediaries and allow users to transact directly (Samah et al., 2019). The decentralized form of peer-to-peer networking authorizes all computers to be equal depending on user usage: serverless and unsupervised. Decentralized operation based on user location consists of host computers with self-processing capabilities distributed across areas. It allows each host to process independently if some hosts are down. So, it doesn't affect the overall performance of the system. Data or services will not be lost, allowing the system to continue working and is less likely to crash or fail. Blockchain is a distributed technology in which each node in the network stores a valid copy of the chain, thus always ensuring data availability. There is security because there is no single point of control. If an attacker produces a denial of service, it must bypass all nodes in the network to complete the attack. Decentralization empowers network contributors to differentiate blockchains, ensuring redundancy. It contrasts with centralized systems operated by trusted third parties. Decentralization helps to guarantee service availability, reduces the risk of failure, and ultimately improves service trust with guaranteed availability. Immutability is a permanent record of transactions in the ledger which remains distributed between nodes and cannot be changed. Immutability is the hallmark of blockchain from a centralized database system that takes it to the next level for data integrity in the ledger. Data is resistant to computer-intervention with cryptographic links. A cryptographic link between each chronologically arranged record and block creates a chain of integrity across the entire blockchain. A digital signature verifies the integrity of each record using hashing techniques and asymmetric key cryptography. Any change to the block or transaction record violates the integrity and ultimately invalidates the integrity of the record and block (Hewa et al., 2021). Data on the blockchain is authenticated by multiple participants in the network, which helps make it reliable, easy to verify, anti-spoofing. It also saves time, simplifies the audit process, saves money, and puts effort into making other processes more efficient (Capece et al., 2020). The advantages of blockchain technology are as follows: the decentralized open data, the absence of forgeries, the safe storage of information and reduction of transaction expenses related to data check-up, the control and verification, tracking of transactions, mechanism of consensus, cryptocurrency, and smart contracts. It is a self-regulation program transmitted through the blockchain nodes, enabling the interaction of the contractual parties in a real-time mode without any third-party mediation. It reduces the loss associated with commissions and internal audits (Capece et al., 2020). All recordings are managed by a group of nodes being not owned by a single entity. Therefore,

it is almost impossible to forge and update records on all network objects. All these blocks will require proof of encryption for the signature and verification of transactions. The node starts the procedure by making a block. Each node on the network checks the blocks for verification. The verified block is added to the chain archived by the entire system. Not only makes it a protective record, but it's a unique record (Hameed et al., 2019). Consensus is a set of rules and arrangements for implementing a blockchain. Any new record or transaction within the blockchain means the creation of a new block. Each record is tested and digitally signed to ensure authenticity before adding this blog to the network (Villegas-Ch et al., 2020).

Table 1. Features of blockchain technology

Features	Reference
Absence of forgeries	(Daraghmi et al., 2019), (Capece et al., 2020), (Fedorova & Skobleva, 2020)
Distributed	(Daraghmi et al., 2019), (Samah et al., 2019), (Hewa et al., 2021), (Villegas-Ch et al., 2020)
Decentralized	(Daraghmi et al., 2019), (Samah et al., 2019), (Hewa et al., 2021), (Fedorova & Skobleva, 2020), (Villegas-Ch et al., 2020), (Tahiru, 2021)
Immutability of the Ledger	(Daraghmi et al., 2019), (Samah et al., 2019), (Hewa et al., 2021), (Tahiru, 2021)
Transparency	(Samah et al., 2019), (Hewa et al., 2021), (Hameed et al., 2019), (Villegas-Ch et al., 2020), (Fernández-Caramés & Fraga-Lamas, 2019), (Tahiru, 2021)
Safe storage of information	(Hewa et al., 2021), (Fedorova & Skobleva, 2020), (Hewa et al., 2021), (Villegas-Ch et al., 2020)
Trust	(Samah et al., 2019), (Capece et al., 2020), (Hewa et al., 2021), (Villegas-Ch et al., 2020), (Tahiru, 2021)
Verification	(Capece et al., 2020), (Fedorova & Skobleva, 2020), (Hewa et al., 2021), (Villegas-Ch et al., 2020)
Mechanism of consensus	(Fedorova & Skobleva, 2020), (Daraghmi et al., 2019), (Hameed et al., 2019), (Villegas-Ch et al., 2020)
Smart contract	(Fedorova & Skobleva, 2020),(Hameed et al., 2019)

From Table 1, the synthesis of blockchain technology properties from research articles and the related paper in the Scopus concludes that the features of blockchain technology have nine key elements: the absence of forgeries, distributed, decentralized, immutability, safe storage of information, reliability, verification, mechanism of consensus, and smart contract.

2.2 Components of a Blockchain

There are four main components of a blockchain: 1) Block is a form of data storage, where each block is always linked to the previous block with its Hash Function value and strung together to form a chain; 2) Chain is a connection of blocks, making it difficult to forge and modify, and can verify the integrity of every block throughout the chain, which can be traced back to the initial block or genesis block. A copy of the account information is distributed to everyone in the system; 3) Consensus is the formulation of agreements and consensus among the members of the Blockchain network, whereby members must agree to the rules together with mechanisms to control the integrity of the data across all nodes through different algorithms. It ensures that the data is accurate, consistent, and uniform that is stored consistently and in the same storage order; and 4) Validation is a system-wide review of all nodes in the Blockchain system to ensure that no errors occur from any part (Digital Government Development Agency, 2019).

Blockchain architecture consists of 1) Node is the user or computer within the blockchain architecture. 2) Transaction is the construction of the smallest block of the blockchain system including data records etc., which serves as the purpose of the blockchain. 3) Block is the structure data used to maintain a set of transactions distributed to all nodes on the network. 4) Chain is a sequence of blocks in a specific order. A miner or validator must validate a specific node that undergoes a block validation process before adding anything to the blockchain structure. 5) Consensus is a set of rules and arrangements for blockchain operations. Any new recordings or transactions within a blockchain means creating a new block. Each record is tested and digitally signed to ensure its authenticity. Before adding this block to the network, it must be obtained. 6) Verification is done by most of the nodes in the system (Villegas-Ch et al., 2020)

Nakamoto invented blockchain combining three technologies: peer-to-peer networks, cryptography, and distributed consensus. Blockchains are systems made up of computer networks known as nodes. Each computer keeps a complete copy of the blockchain ledger; it is all the data of every block. When a node creates a transaction, it notifies the network.

Other nodes on the network verify the transaction and combine it with others to create a block. The first node creates a new block meeting the rules set by the agreed consensus protocol. It informs the block's validation network. If it complies with the rules, it will integrate into the existing blockchain (Murray, 2019).

Blockchain is a distributed and decentralized database that stores the data chain contained in a sealed block in a secure and immutable way. The chain of blocks, also called a ledger, has continued to grow. Therefore, the new block will be appended to the end of the ledger. Each new block contains a reference to the content of the previous block. Block content can be pre-defined or randomly generated by blockchain users. However, the data is structured as a transaction, called the pre-defined structure of the blockchain, and sealed with encryption. Public key encryption or cryptography mechanisms are used for security. So, it is consistent, irreversible, and irrevocable distributed ledger content. Before sealing the block, the data uses a one-way cryptographic hash function to ensure anonymity, immutable, and brevity of blogs, ledgers, and content are replicated and synchronized among members. That joins many people in the P2P network becomes a distributed ledger (Turkanović et al., 2018).

Blockchain structure is a list of transaction blocks that are linked and sorted, each identified by a hash function. The hash of each transaction is computed by a multistep process that involves calculating multiple hashes until a single last hash called a Merkle root. Additionally, each block stores a hash of the previous block's header. Therefore, the blocks are linked together. This method prevents block changes without modifying all subsequent blocks. All network participants maintain the blockchain. Each person must prove what amount of work is involved and what is significant in building each block (Proof of Work, POW). Since the building of blocks depends on the previous block, it is not possible to modify a given block without adjusting all subsequent blocks (Turkanović et al., 2018).

A block is a data structure that includes the block header with the previous block hash value. The timestamp is the same as the Merkle root and the payload that contains the relevant transaction data. Typically, a transaction consists of the sender's public key, data, and the hash value of the previous transaction. The data section allows the blockchain to store various electronic assets such as records, certificates, copies, property rights, and licenses. All blocks are linked in the sequence of hash values in the blockchain. The chain of blocks replicates in a distributed blockchain network and is stored by subnodes (Daraghmi et al., 2019)

The blockchain architecture consists of the main components: Nodes are users or computers within the blockchain architecture. Transactions are the smallest building blocks of a blockchain system, and records, data, etc. serve as the purpose of the blockchain. A block is a data structure used to maintain a set of transactions distributed to all nodes in the network. A chain is a sequence of blocks in a particular order. A miner is a specialized node that undergoes a block validation process before adding anything to the blockchain structure. Consensus is a set of rules and arrangements for creating a new block; each record is tested and digitally signed to ensure its authenticity before this block is added to the network (Villegas-Ch et al., 2020).

Table 2. Components of a Blockchain

Components of a Blockchain	Digital Government Development Agency, 2019	(Villegas-Ch et al., 2020)	(Murray, 2019)	(Turkanović et al., 2018)	(Lizcano et al., 2020)	(Daraghmi et al., 2019)	Summary of Synthesis
Block	✓	✓	✓	✓	✓	✓	✓
Chain	✓	✓	✓	✓	✓	✓	✓
Consensus	✓	✓	✓	✓	✓	✓	✓
Validation	✓	✓	✓	✓	✓	✓	✓

From Table 2, it can be concluded that the blockchain technology components consist of 1) Block is a data container, where each block is always linked to the previous block with the previous block's Hash Function value. 2) Chain is the block's connected data chain, essentially remembering every transaction of everyone in the system and saving new information in a distributed ledger. A copy is sent to every node in the system that a transaction has occurred. This makes it difficult to forge, modify and can be traced back to the initial block or genesis block for every block throughout the chain. 3) Consensus is the process of defining rules and conditions that govern the integrity of the data. The data is stored accordingly and has the same storage order, such as Proof-of-Work, Proof-of-Stake. To operate a blockchain when creating a new block. Each record is tested and digitally signed to ensure its validity, and 4) Validation Before

this block is added to the network, most nodes in the system must be validated, make a confirmation, and verify the correctness of the information throughout the system.

Additionally, blockchain is related to a shared data storage technology known as Distributed Ledger Technology. It is decentralized data logging, data exchange interconnection, and mutual authentication. This results in data transparency, reducing fraud, reducing errors, and making data more reliable. The decentralized network operates on a Peer-to-Peer which does not depend on the central. All involved persons or those who wish to keep the transaction will keep the various records for themselves. In addition, all involved parties help to verify and copy the information stored not just by anyone like the centralized network.

2.3 The operation of blockchain technology

The operation of blockchain technology relies on Distributed Ledger Technology (DLT) where all data is linked throughout the system. When a new transaction occurs, it must be announced to all machines in the system.

In addition, such transactions must be verified (Consensus) from the entire network before data can be recorded into the block. Therefore, Blockchain technology does not need an intermediary to store the transactions. Instead, all data is stored under the blockchain technology structure and distributed to all members of the network. If someone attempts to create a fake transaction, the data will conflict with the local data of other members of the network because all machines must have the same information. So, the system will not allow the creation of such a list. Only items accepted by everyone in the network can be saved into the Blockchain system. Data that has already been logged into the Blockchain cannot be changed or modified retroactively. As a result, Blockchain technology is recognized as a highly reliable storage technology.

The working principle of blockchain technology is that the database is shared among all Node1s in the network, and the working of blockchain technology does not have a central machine or server. A single person cannot control the decentralized network, but every node will receive a copy of the database. The database will be automatically updated as new data emerges. The copyright database of everyone in the network must be correct and match that of other members in the network. In addition, block data logging is based on the principle of cryptography and consensus from network members together before adding data to the block and adding it to the blockchain system. In order to protect and guarantee the data security of the blocks, each blockchain establishes a set of audit rules known as the Consensus Protocol or Consensus Mechanism for use in the network. The basic working principle of Blockchain technology must consist of at least four main steps:

1. Creating a block containing instructions requests a transaction.
2. Broadcast distributes this new block to all nodes in the system and records transactions to the ledger for every node to update if new blocks are created.
3. Validation is any other node in the system that confirms and checks that block's data is valid for validation conditions. Consensus is considered part of the validation process.
4. Add to chain is to bring a block to line up from the previous block.

For example, Mr. A wants to send money to Mr. B, so Mr. A ask to create a block of transaction data to send money online. Blocks are distributed to all nodes in the network. The person in the network approves the transaction as valid.

A block containing financial data can then be added to the chain, providing a reliable and transparent record of transactions**.**

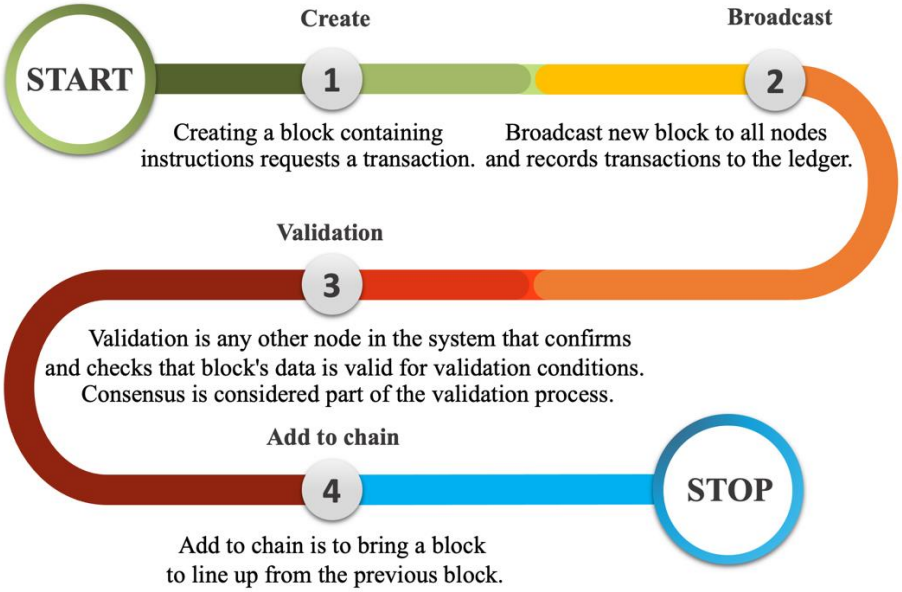

Figure 1. Blockchain technology working process

2.4 Blockchain in Education

The application is developed with blockchain technology for education. It can be divided into 12 main categories: 1) Applications related to certificate management. 2) Applications that measure competence and management of learning outcomes can measure and assess student performance based on qualitative and quantitative parameters. 3) Applications related to maintaining a collaborative learning environment and creating a collaborative environment for all parties: students, faculty, and departments. For example, U-learning provides an interactive multimedia system to promote an effective communication system between teachers and students. The school learning environment is improved by using blockchain as a School Information Hub (SIH), etc. 4) Applications related to protecting learning objects from destruction and unauthorized alteration. 5) Applications related to fees and credit transfers include recording in credentials or fees between institutions, organizations, or universities due to the high blockchain security and reliability. For example, the EduCTX system enables token-based authentication in the transfer process. These tokens can be in terms of any digital format for the unit, such as course certificates and diplomas. 6) Applications related to digital parental consent. Instead, traditional parental consent is collected electronically. 7) Applications related to competition management that use blockchain technology to facilitate competition management and increase efficiency and transparency. 8) Application related to assessment students' professional competence for employment guidance purposes. 9) Applications related to copyright management maintain ownership rights when using blockchain, such as the CHiLO decentralized learning system to protect the copyright and ownership of e-books. 10) Applications related to student interaction in e-learning systems address any issues associated with student interactions in e-learning environments. For example, to improve learning engagement, it rewards in the form of virtual currency to the highest-ranked learners. 11) Applications related to authentication using document security licensed blockchain techniques, such as a decentralized application for auditing called "dAppER." The system was designed with quality assurance standards among external auditors. Based on their findings, dAppER is effective in managing quality assurance systems. 12) Applications related to blockchain technology to enhance lifelong learning such as skill development, knowledge, and efficiency. It offers an ecosystem that puts learners at the center of the learning process and relevant information. It allows learners to draft a practical plan for their educational path conveyed in a desirable professional trajectory by offering them dominance and ownership during the learning process (Samah et al., 2019).

Blockchain technology supports preventing fake certificates and simplifying certificate verification with fewer resources. Blockchain consists of 3 steps to consider digital certification and store data on the blockchain: certification

meets specified; These certification bodies are then mandatory to issue certificates to educators and learners. And finally, the certificate is reviewed by educators and learners (Karale & Khanuja, 2019)

The application of blockchain in education has several aspects: 1) Online learning is composed of recording students in learning progress, certifying learning outcomes, and sharing content and other decentralized resources. 2) Privacy and consent of student data enable educational institutions to grant access to information for any legal purpose after obtaining consent to the students' parental access rights through smart contracts. 3) Learning outcomes and meta-diploma use blockchain for learning outcomes based on the Graduate Demand Index of professional accredited universities that can use the software as a tool in automated assessment. 4) Competitive skills 5) University grades 6) Education-Industry Cooperative System establishes a framework for participation between educational institutions and stakeholder companies. 7) Education Records, Reputation and Awards 8) Education Certificates 9) Assessment system of the students' competencies 10) Online Quiz Scheme Based on Double-layer, in traditional systems, the online scoring system may not be as transparent as it could be. As a solution to the problem of transparency, a web test was proposed based on the Double-Layer Consortium Blockchain. The proposed solution will provide open confirmation of student responses and record responses to either party that can be unalterable (Atienza-Mendez; & Gebresenbet Bayyou, 2019).

The new classification of fields of blockchain applications in education can be divided into issuing and storing certificates and diplomas, identification solutions, protecting intellectual property, new network of cooperation between students and their professors, creating academic portfolios, payment for education with cryptocurrencies, accreditation of educational institutions, and administration of the educational process (Fedorova & Skobleva, 2020)

The use of blockchain in educational environments includes 1) Student Records: Each record is grouped into a digitally signed block and is bound to the previous block forming the blockchain stored on each computer. If any user wants to edit some block, he can't do it because he will also have to modify others. So, the spoofing attack will be detected immediately. 2) Education Certificate Review and Sharing: Blockchain can change the market of student information systems, but it is complex. As reported by blockchain case studies by Open University the UK, University of Nicosia, MIT, and Maltese Educational Institutions, every educational blockchain application must use a distributed ledger-equivalent database to store transactions. Each of which has a timestamp and origin and destination information. Additionally, multiple agencies or individuals in different locations must be able to use blockchain. Therefore, they are interdependent during the transaction; and the set of rules for all participants requires trust between both parties and the user with respect to third parties. In addition, every educational blockchain application deals with skills and learning outcomes management, evaluation of the capabilities of professionals, collaborative learning, protection of learning objects, fees and credit transfers, digital tutorials, copyright management, improving student interaction in e-learning, assessment review and continuous learning support (Rojas et al., 2021)

Applying blockchain technology is to solve education problems in the blockchain-based degree verification system, student record keeping & performance tracking, and copyright management system. Blockchain systems can control the spread of copyrighted content on the Internet. The core function of the technology is to store secure data saved in the chain. As a result, data within the network cannot be changed manually as advanced encryption measures protect it. It will make academic material accessible but safe and immutable (Hashmani et al., 2020)

There are five main categories of application of blockchain technology in education, benefits of integrating blockchain technology in education, and challenges in applying blockchain technology in education as follows: 1) Verification and revocation of certificates/degrees and agencies involved in the use of blockchain technology in issuing digital certificates. Third parties can consult and verify it through the proof system that is untrustworthy and immutable, or even revoked when it is issued incorrectly. The first use case where the signed certificate is stored with encryption, anti-interference, and shareable is the Blockcerts system. 2) User-centric educational records management covering blockchain applications involves empowering students to access and control their educational data. 3) Assessment of students' professional abilities has focused on explaining that blockchain is used for employment advice by linking student professionalism to specific industries. 4) Blockchain-based educational institutions system is another application category that integrates research on blockchain applications for emergency credit transfers between universities. For example, EduCTX (Turkanovic et al., 2018) is a notice for a blockchain-based higher education credit platform based on blockchain technology, transfer system concept, and European credit accumulation. 5) Online learning environment: Blockchain technology has supported online and lifelong education. For example, the blockchain-based online quiz format uses blockchain technology to enable communication between students in a

highly secure and private collaborative learning environment. The game uses Edublock, a digital currency to quantify teaching hours as a transaction, and can be stored on the Blockchain, etc. (Tahiru, 2021)

Table 3. The application of blockchain in education

The application of blockchain	(Samah et al., 2019)	(Karale & Khanuja, 2019)	(Atienza-Mendez; & Gebresenbet Bayyou, 2019)	(Fedorova & Skobleva, 2020)	(Rojas et al., 2021)	(Hashmani et al., 2020)	(Tahiru, 2021)	Summary of Synthesis
Certificates management	✓	✓	✓	✓	✓	✓	✓	✓
Competencies and learning outcomes management	✓	✓				✓		
Securing collaborative learning environment	✓	✓		✓		✓		✓
Protecting learning objects	✓					✓		
Fees and credits transfer	✓			✓		✓		✓
Obtaining digital guardianship consent	✓	✓						
Competitions management	✓	✓						
Evaluating students' professional ability	✓	✓				✓	✓	✓
Copyrights management	✓			✓		✓		✓
Enhancing students' interactions in e-learning	✓					✓	✓	✓
Examination review	✓					✓		
Supporting lifelong learning	✓					✓		
User-centric educational record				✓	✓		✓	✓
Management and portfolio								
University grades		✓					✓	
digital tutorials		✓				✓		
Identification solutions		✓		✓				
Accreditation of educational institutions				✓				

The application of blockchain	(Samah et al., 2019)	(Karale & Khanuja, 2019)	(Atienza-Mendez; & Gebresenbet Bayyou, 2019)	(Fedorova & Skobleva, 2020)	(Rojas et al., 2021)	(Hashmani et al., 2020)	(Tahiru, 2021)	Summary of Synthesis
Administration of the educational process		✓		✓				

From Table 3, The application of blockchain in education, it can be concluded that the most applied blockchain in education is certificate management, followed by students' professional competence assessment, student interaction in the e-learning system, educational record management, academic portfolio creation, assessment management of learning outcomes, maintaining a collaborative learning environment, protection of learning objects, fees and credit transfers, copyright management, authentication using derived blockchain techniques, document security authorization, enhancing lifelong learning, educational record management, digital parental consent, competitive management, credit transfer, digital tutorials, identity solutions, issuing educational institution certificates, and educational management.

4. Conclusion

The missions of universities are now engaged in graduate production, research and development, academic service, and the preservation of arts and culture. The applications of blockchain technology in various fields are as follows:

1.Graduate production: the most popular blockchain application in education is certificate management. Next, it is applied in the assessment of students' professional competence, student interaction in the e-learning system, educational record management, academic portfolio creation, learning assessment management, and maintaining a collaborative learning environment.

2. Research and development: it can be applied in copyright management.

3. Academic Services: Blockchain can be applied to enhance lifelong learning and competition management.

4. The preservation of arts and culture: there is no direct application.

There are opportunities to apply blockchain technology in teaching and learning, student services, academic services, transactions with university stakeholders such as other educational institutions, enterprises, and relevant departments. In addition, educational administration for students and university personnel to enable various operations is convenient, fast, and reduces the process and cost incurred. The limitation is related to the trust in the transaction, exchange of information, and managing requirements for all participants.

References

Atienza-Mendez;, C., & Gebresenbet Bayyou, D. (2019). Blockchain Technology Applications in Education. *IJCAT-International Journal of Computing and Technology*, *6*(11), 68–74. www.IJCAT.org

Capece, G., Ghiron, N. L., & Pasquale, F. (2020). Blockchain technology: Redefining trust for digital certificates. *Sustainability (Switzerland)*, *12*(21), 1–12. https://doi.org/10.3390/su12218952

Daraghmi, E. Y., Daraghmi, Y. A., & Yuan, S. M. (2019). UniChain: A design of blockchain-based system for electronic academic records access and permissions management. *Applied Sciences (Switzerland)*, *9*(22). https://doi.org/10.3390/APP9224966

Digital Government Development Agency. (2019). blockchain for government services. Digital Government Development Agency (Public Organization) (DGA). 17th Floor, Bangkok Thai Tower 108, Rangnam Road, Thanon Phayathai, Ratchathewi, Bangkok, Thailand.

Fedorova, E. P., & 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

Hameed, B., Khan, M. M., Noman, A., Javed Ahmad, M., Ramzan Talib, M., Ashfaq, F., Usman, H., & Yousaf, M. (2019). A review of Blockchain based educational projects. *International Journal of Advanced Computer Science and Applications*, *10*(10), 491–499. https://doi.org/10.14569/ijacsa.2019.0101065

Hashmani, M. A., Junejo, A. Z., Alabdulatif, A. A., & Adil, S. H. (2020). Blockchain in Education - Track ability and Traceability. *2020 International Conference on Computational Intelligence, ICCI 2020*, *October*, 40–44. https://doi.org/10.1109/ICCI51257.2020.9247760

Hewa, T., Ylianttila, M., & Liyanage, M. (2021). Survey on blockchain based smart contracts: Applications, opportunities and challenges. *Journal of Network and Computer Applications*, *177*(February 2020), 102857. https://doi.org/10.1016/j.jnca.2020.102857

Karale, A. S., & Khanuja, H. (2019). Implementation of blockchain technology in education system. *International Journal of Recent Technology and Engineering*, *8*(2), 3823–3828. https://doi.org/10.35940/ijrte.B2462.078219

Lizcano, D., Lara, J. A., White, B., & Aljawarneh, S. (2020). Blockchain-based approach to create a model of trust in open and ubiquitous higher education. *Journal of Computing in Higher Education*, *32*(1), 109–134. https://doi.org/10.1007/s12528-019-09209-y

Murray, M. C. (2019). Tutorial: A descriptive introduction to the blockchain. *Communications of the Association for Information Systems*, *45*(1), 464–487. https://doi.org/10.17705/1CAIS.04525

Rojas, W., Gayoso Martínez, V., & Queiruga-Dios, A. (2021). Blockchain in education: New challenges. *Advances in Intelligent Systems and Computing*, *1267 AISC*, 380–389. https://doi.org/10.1007/978-3-030-57805-3_36

Samah, A., Marwah, A., Saira, G., & Ali, A. (2019). applied sciences Blockchain-Based Applications in Education : *Appl. Sci. 2019*, *9*, *2400*, 1–18.

Tahiru, F. (2021). AI in education: A systematic literature review. *Journal of Cases on Information Technology*, *23*(1), 1–20. https://doi.org/10.4018/JCIT.2021010101

Turkanović, M., Hölbl, M., Košič, K., Heričko, M., & Kamišalić, A. (2018). EduCTX: A blockchain-based higher education credit platform. *IEEE Access*, *6*, 5112–5127. https://doi.org/10.1109/ACCESS.2018.2789929

Villegas-Ch, W., Palacios-Pacheco, X., & Román-Cañizares, M. (2020). Integration of IoT and blockchain to in the processes of a university campus. *Sustainability (Switzerland)*, *12*(12), 1–21. https://doi.org/10.3390/su12124970