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COMPREHENSIVE REVIEW OF THE APPLICATION OF BLOCKCHAIN IN SMART EDUCATION: IDENTIFYING GAPS AND RESEARCH DIRECTIONS

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ABSTRACT
The rise of information technology has significantly impacted various sectors, including education, leading universities to embrace smart education for creating comprehensive learning ecosystems. However, the widespread adoption of smart education has also introduced challenges like information security and academic forgery. As a distributed ledger technology, blockchain offers technical advantages such as decentralization, anonymity, traceability, and tamper-resistance, making it a promising solution for addressing issues in university smart education. Despite being in its early stages, research on applying blockchain to smart education is gaining momentum. This paper aims to explore the research background and problem statement in this area, discussing potential blockchain applications, their advantages, and future challenges. By reviewing existing literature and problem statements, we emphasize the importance of integrating blockchain technology into the smart education environment of universities and provide insights for its extensive implementation. In summary, as technology matures and practical experience accumulates, blockchain holds immense potential for enhancing smart education in colleges and universities, providing students with a secure, reliable, and efficient learning environment.

Keywords:
Smart education; Blockchain technology; Higher education; Blockchain Application; Blockchain Challenge; Data Integrity

INTRODUCTION

As an emerging concept in the field of education, smart education at universities aims to use advanced information technology and communication technology to improve the quality of education, personalized learning and teaching management efficiency (Bhatia & Bhasin, 2023). However, the implementation of smart education at universities also faces a series of challenges such as data security and privacy protection, the objectivity of student learning evaluation, and the sharing and interoperability of educational resources. To meet these challenges and promote the development of smart education at universities, blockchain technology is widely considered to have the potential ability to solve existing problems of smart education (Sattar et al., 2023).

Although blockchain has also achieved some successful applications in other fields, its application in the field of smart education at universities is still in the exploration and initial stage (S. Liu & Li, 2023; Zhao et al., 2023). Therefore, this paper aims to explore the advantages and challenges of potential application of blockchain technology in smart education at universities, and propose relevant implementation strategies and suggestions.

RESEARCH BACKGROUND

The development background of smart education at universities can be traced to the rapid development of information technology and the popularization of the Internet. The emergence of the Internet has greatly changed the way people obtain and disseminate information, bringing many new opportunities and challenges to education (Majid et al., 2022). Educational institutions are actively exploring how to

use information technology to improve teaching quality, enhance student learning outcomes, and build a more flexible and intelligent teaching environment (Cui et al., 2023).

Smart education at universities is an important part of digital transformation in the field of education driven by information technology (Zhao et al., 2023). It utilizes advanced information and communication technologies to provide students with innovative solutions for personalized learning and teaching management. With the continuous pursuit of education quality and student development by society, smart education has gradually become the focus of attention for educational institutions (Tahora et al., 2023a).

In smart education, the utilization of advanced technological means enables educational institutions to enhance teaching efficiency and elevate the quality of education. By effectively leveraging shared campus resources, smart education optimizes resource allocation, thereby improving teaching efficiency. Additionally, by harnessing collected data and employing advanced analytics, smart campuses implement personalized learning, leading to more effective learning experiences (Sneesl et al., 2022).

PROBLEM STATEMENT

With the rapid development and wide application of smart education at universities, we cannot ignore the personal information security issues brought about by it. Smart education involves a large amount of personal data, covering students' personal information, academic performance, examination records, etc. as well as sensitive data such as personal information on teaching work, teaching materials, academic papers, and teacher-student evaluations (Dziatkovskii, 2023). The protection and security of these data are of great significance to safeguarding personal rights and promoting security of personal intellectual property rights (Saputra, Ochtaffia, & Apriani, 2023; Supriadi et al., 2023). However, there are often potential safety hazards and risks in the implementation of smart education during the collection, processing, transmission and use of personal data, (Kamruzzaman et al., 2023). Possible problems include data leakage, overflow, omission, digging, and even data forgery.

In addition, in the smart education environment, the problem of data forgery and tampering also needs to be highly scrutinized, and corresponding preventive measures should be taken (Huynh-The et al., 2023). Schools and relevant institutions should strengthen the verification and monitoring of data integrity and authenticity to ensure the accuracy and credibility of personal information and academic records (Arabi et al., n.d.,2022).

Therefore, it is very important to protect security of personal information and prevent data falsification in the implementation of smart education at universities. Only through comprehensive security measures and effective management mechanisms can we ensure proper protection of personal data and maintain the balance between personal rights and social stability (Patan et al., 2023a). This requires cooperation and increased attention by schools, educational institutions, governments and stakeholders. Advanced technology should be adopted to ensure the security of personal information in smart education systems.

Adding blockchain technology can effectively prevent personal information security issues and data forgery issues in smart education systems of universities, and provide more reliable data protection and security. By storing personal data in blockchains, the immutability and integrity of data can be ensured. The data in the blockchain cannot be tampered with or deleted, and any modification to the data will leave traceable signs. This way, students' personal information and data will be more reliably protected, reducing the risk of data tampering (Pu & Lam, 2023).

In smart education, important data such as students' personal files and academic performance can be stored and managed through blockchain technology to ensure their authenticity and integrity (Nyamasvisva& Arabi, 2022). Universities need to develop a blockchain-based technical framework for smart education, and develop applications on this basis. These applications can be used to solve current problems in smart education systems (Munasinghe et al., 2023).

OVERVIEW OF BLOCKCHAIN TECHNOLOGY

Definition of Blockchain

Blockchain is a decentralized, distributed digital ledger technology that records and verifies transactions across multiple computers or nodes. It is designed to provide a secure, transparent way to store and manage data without the need for a central authority (Oh et al., 2023).

In a blockchain, each transaction or data entry is bundled into a block and linked to the previous block by a cryptographic hash, forming a blockchain. The structure of the blockchain is depicted in Figure 1, illustrating how each block is connected to the preceding one through a hash pointer, creating an immutable distributed ledger. This chain-like structure ensures the continuity and security of data, where any alteration to one block would impact all subsequent blocks. The visual representation in Figure 1 vividly showcases the interlinking of blocks, establishing an immutable ledger, offering high transparency, traceability, and security, making blockchain a reliable solution for information storage and transactions (Elvas et al., 2023).

LITERATURE REVIEW

The resisting force is defined by the once the laboratory test was completed, the software analysis using the SLOPE/W was done to determine the FOS of the slope during failure using the Ordinary and Spencer analysis method. With the value of FOS during failure as a benchmark, two types of slope stabilisation work, such as the Changing Geometry method and Soil Nailing, were proposed to increase the stability and safety of the slope. A Changing Geometry method is converting the slope from steeper to gentler by trimming the slope or reducing the extra load applied on the slope, while Soil Nailing is constructed to withstand or resist against downward forces or pushing forces of soil masses. According to Shiferaw (2021), the method of Changing Geometry consider as one of the type chosen for the slope stabilaization work. Then again, the FOS will be computed using SLOPE/W to compare on stability increase of the slope due to the proposed stabilization work.

METHODOLOGY

ling. The software analysis was initially conducted on a trial and error basis, with around 15 trials for each section to determine the most approximate parameter and properties to be used for accurate analysis results.

Blockchain is constantly updated and synchronized between all participants in the network, ensuring the integrity and immutability of data (Pantan et al., 2023). Blockchain technology enables trust, transparency, and accountability by creating a decentralized and tamper-proof system that can be used for

a variety of applications represented by financial transactions, such as supply chain management, voting systems, and smart contracts (Y. Liu et al., 2023).

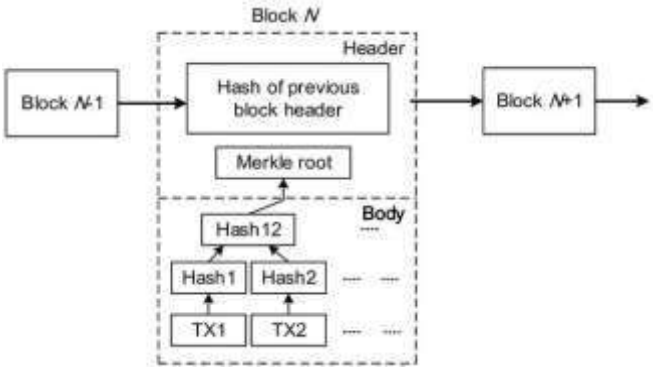

Figure 1: The Structure of Blockchain

Types of Blockchain

When studying the application of blockchain in smart education, it is crucial to choose the appropriate type of blockchain, which depends on the specific use cases, performance requirements, and security considerations required by the system. Common types of blockchains include public chain, private chain, and consortium chain. When selecting the appropriate type of blockchain, the education system needs to consider factors such as data privacy, security, performance requirements, and management controls. Generally speaking, smart education may choose consortium chains or private chains because they can better balance data privacy and management control, while providing sufficient transparency and security. However, this choice should be evaluated based on specific educational scenarios, It is important to find the most suitable type of blockchain. Figure 2 shows the relationships between various blockchains.

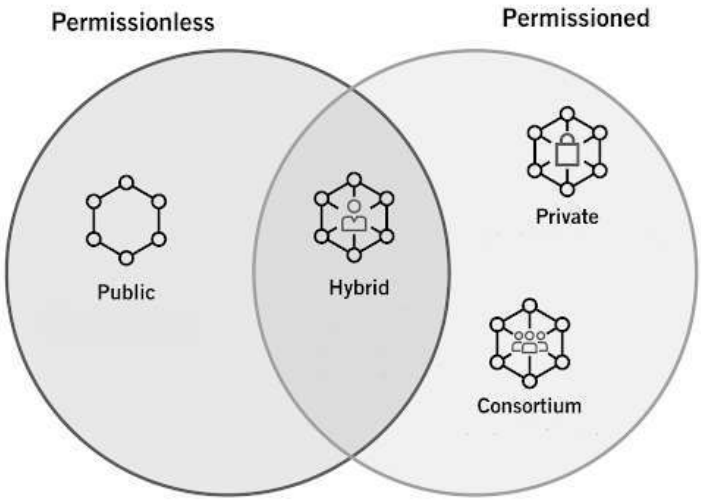

Figure 2: Four Types of Blockchain

The public chain refers to the blockchain that anyone at any node in the world, in any geographic location, can enter the system to read data, send transactions, compete for bookkeeping, etc. to participate in consensus. No organization or individual can tamper with the data in it; so, the public chain is completely decentralized (Loporchio et al., 2023).

The data of the consortium chain only allows different institutions in the system to read, write and trade. The PKI-based identity management system transactions or proposals are initiated through digital certificates, and consensus is reached through the verification of the common signature of the participants.

The private chain is different from the complete decentralization of the public chain. The access authority of the private chain is controlled by an organization, and the participation qualifications of each node are authorized and controlled by the organization. Since the participating nodes are limited and controllable, the private chain often has a fast processing speed, can support more than 1,000 data writes per second, and reduces the transaction cost of each internal node (Tan & Rodriguez Müller, 2023).

When the respective advantages of the public chain and the private chain are combined, a hybrid chain will appear. The development of hybrid chains is difficult, but has broad prospects. In the future market, there will definitely be giant companies developing underlying technologies and protocols. These giant companies will set up public chains, private chains or alliance chains for different purposes, based on different requirements for performance, security and application scenarios, grafting applications from different industries (Miriam et al., 2023)

THE APPLICATION AND ADVANTAGES OF BLOCKCHAIN IN SMART EDUCATION

Blockchain in Smart Education for Keep Student Records

One common application of blockchain in education is record keeping. There are essentially infinite student records, and establishing academic qualifications can be time-consuming, requiring extensive paper documentation and case-by-case checking.

When it comes to things like transfers across schools or states, blockchain can eliminate much of the overhead associated with this process and streamline verification procedures, saving educators and administrators time. A college enrolling a transfer student might use blockchain to authenticate their record and the courses they studied with a few simple clicks. The same idea applies to sharing records with an employer (Pradeep et al., 2023).

Blockchain in Smart Education for Digital Student Diploma

In the last few years, digital diplomas have become the foremost examples of how blockchain can be used in education. Using blockchain technology, the app provides a verifiable, tamper-proof diploma that can be easily shared with potential employers and other schools. Because of the inherent permanence, convenience, and security associated with blockchain, using this technology to store and share academic credentials, particularly diplomas, benefits students, institutions, and employers (Nargis et al., 2023). Table 1 shows the various advantages of blockchain-based digital degree certificates compared to traditional degree certificates.

Table 1: Advantages of Blockchain Digital Diplomas

Advantage	Blockchain digital diplomas	Traditional diplomas
Ownership Control	Students have ownership and control over their credentials	Schools have control over students' credentials
Verifiability	Employers and third parties can easily verify credentials	Requires additional steps and costs for verification
Streamlined Verification Process	Institutions benefit from a more efficient and cost-effective verification process	Time-consuming and costly verification processes
Fraud Prevention	Increases the authenticity and trustworthiness of credentials	Higher risk of forgery and fraud
Data Security and Privacy	Strong encryption and privacy protection features	Risk of data breaches and privacy concerns
Reliability and Integrity	Blockchain credentials are tamper-proof and verifiable	Traditional electronic credentials can be easily lost or tampered with

Benefits for students : Storing diplomas on a blockchain allows students to own and manage their academic achievements, providing them with the ability to share them when and where they choose. Historically, universities have owned and controlled student records, leaving students to rely on institutions to access and share their academic history and achievements(Christa & Mittal, 2023).

This model has obvious flaws. Physical records can be lost or destroyed, students may be required to pay fees to access them, and graduates of defunct institutions may struggle to find an authority to verify their academic achievement(Wang et al., 2023). The 130 sites spread across 38 states of the for-profit ITT Technical Institute abruptly closed their doors in 2016, leaving students and alumni without access to their data until the Department of Education intervened.

Blockchain enables students to take control of their academic identities by giving them ownership of their personal information. For graduates looking for work, for instance, this makes verifying the integrity of the credentials listed on their resumes much easier and offers them greater control over what an employer can access.

Benefits for institutions : Using blockchain to issue diplomas streamlines the verification process for higher education institutions, saving them time and money (Wang et al., 2023). According to recent research by the University of Rome, the process of authenticating credentials costs the institution over 19,000 euros yearly, or more than $20,000, which equates to almost 36 weeks of work. Blockchain-issued diplomas also make it considerably simpler for graduate schools to validate a student's academic record because they are essentially tamper-proof.

Using blockchain for digital diplomas offers employers several benefits. It simplifies the hiring process, as they only need a link to a secure digital version of a candidate's diploma, instead of requesting and verifying paper copies. The blockchain's robust security measures make it challenging for applicants to falsify their academic credentials, providing employers with increased assurance about the knowledge and skills of potential hires. Overall, blockchain implementation streamlines verification procedures and enhances the trustworthiness of academic records, leading to more efficient and informed hiring decisions (Sawant, 2023).

Blockchain in Smart Education for University Curricula

Blockchain technology has an impact on education that goes beyond record keeping. The management of university curricula has the ability to change as a result of this technology. For starters, blockchain enables the safe storage of electronic course materials and syllabuses. Institutions do use hard drives for this, but there is a chance that they could be corrupted or ruined. Another choice is cloud storage; however, it can be too expensive for some organisations (Pradeep et al., 2023). Figure 3 shows an online education security system based on blockchain technology.

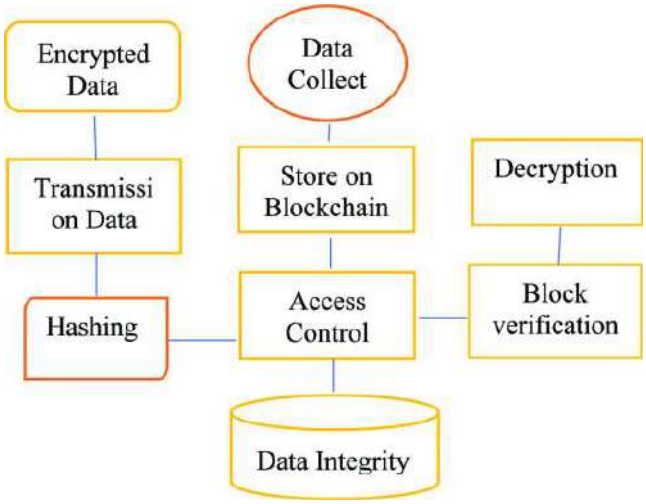

Figure 3: Blockchain-based online education secure system (Sawant, 2023)

Smart contracts on the blockchain may potentially facilitate the work of teachers. For instance, a teacher may create tasks for pupils as part of lessons and courses that are programmed into a blockchain. The blockchain's smart contract would automatically check that each job was completed before giving the student the next one, and so on, until all tasks were completed (Roshanzade, 2023).

The same smart contract technology might be used by teachers to help with grading. Students could take tests and examinations using computers or tablets, complete with questions, answers, and scoring criteria, into a blockchain. The student's score then becomes a part of their permanent academic record, maintained safely on the blockchain. The blockchain takes care of grading, freeing up professors' time to work on other academic projects (Roshanzade, 2023).

CHALLENGES TO USING BLOCKCHAIN IN SMART EDUCATION

Despite the potential benefits of blockchain, adoption is still relatively limited in the field. Nearly 50% of higher education respondents in the Gartner survey cited a lack of interest in using blockchain (Saputra, Ochtaffia, Apriani, et al., 2023). Much of this reluctance may stem from the challenges associated with implementing the technology, including issues of security, scalability, adoption rate, and cost.

Security: Blockchain is not impervious to threats, despite the fact that security is one of its distinguishing characteristics. Institutions must be careful about what data they save and how they choose to preserve it due to the sensitivity of the information stored on the blockchain - students' academic records and transcripts. Compliance with local, state, and federal data protection rules can be difficult.

Universities might need to use private or permission blockchains, encrypt data on the blockchains, or incorporate other tighter privacy protections (Patan et al., 2023b).

Scalability: Scalability can be a problem for blockchain applications in educational institutions due to the abundance of data they have about their students and alumni. The number of blocks needed grows as the amount of data included does, which slows down the speed of transactions taking place on the blockchain because each transaction needs peer-to-peer verification. This can be a major barrier when widely implemented. Positively, compared to permissionless blockchain, permissioned blockchain has a higher pace of transactions per second (Tahora et al., 2023b).

Adoption rate: Graduates only profit from ownership of their credentials if the schools or businesses they are applying to recognise the legitimacy of their credentials. Like other technologies before it, blockchain only functions when enough organisations and employers start to rely on it. But with a network of employment sites like Upwork and ZipRecruiter encouraging their use, as well as hundreds of colleges currently issuing and recognising blockchain credentials, they might soon become the norm rather than the exception (Awerika et al., 2023).

Cost: The cost of adopting and deploying any new technology might be high, even when it may result in savings in other areas. Computing power and updating current infrastructure can cost a lot of money. Additionally, many institutions might not have the knowledge and expertise required to manage student data on a blockchain platform, so they could have to spend money and time training school officials on how to use the technology (Mozumder et al., 2023).

RESEARCH GAPS

Research gaps refer to problems or gaps that have not been fully explored or solved in the field of applying blockchain technology in smart education at universities (Hu et al., 2023). While there have been some studies exploring the use of blockchain in education, the field is still in its infancy and there are still many issues that need to be further studied and resolved. Research gaps include the following:

Specific application scenarios of blockchain technology in smart education at universities: At present, there is still limited research on how to apply blockchain technology. Therefore, exploring and determining the specific application scenarios of blockchain technology in smart education at universities and how to integrate it with existing education systems is an important research gap.

Application of blockchain technology in smart contracts and automated processes: Smart contracts and automated processes can improve the efficiency and accuracy of educational processes. Exploring how to apply smart contracts in blockchain technology to automate educational processes such as tuition payment, course registration, and student evaluation, and evaluating its potential advantages and application value in university smart education is a direction worthy of in-depth study (Sharkey-Toppen et al., 2023).

CONCLUSION

Blockchain technology has great potential in smart education. It improves the transparency, traceability and security of student learning data, and provides students with personalized learning and certification mechanisms. Existing studies have focused on exploring the applications of degree authentication, learning achievement recording and learning resource management, and demonstrated the advantages of blockchain in solving problems such as academic fraud, learning achievement verification and unequal distribution of learning resources.

However, there are still some challenges and obstacles in achieving the widespread application of blockchain in smart education, including issues such as cost-effectiveness, compliance, security, adoption, scalability and standardization. To overcome these challenges, cooperation and attention from all parties, including schools, educational institutions, governments, and stakeholders, are needed. At the

same time, further research and exploration are needed on the best practices and solutions of blockchain technology in smart education at universities in order to further develop the smart education systems and improve the quality of students' learning environment.

Future research can focus on the following directions. First, there is a need to improve the scalability and performance of blockchain technology to meet the processing needs of large-scale education data. Secondly, in-depth research can be conducted on the combination of blockchain technology and education policy, and further explorations can be made on how to establish educational standards and policy frameworks adapted to blockchain technology. In addition, it is necessary to further study the acceptance of blockchain technology by users and develop corresponding training and support programs to promote the wide application of blockchain in the field of education.

In short, blockchain technology provides feasible solutions for smart education at universities, ensuring personal information security and data authenticity, and promoting the sharing and interoperability of educational resources. With the further maturity of technology and the accumulation of practical experience, blockchain has broad application prospects in smart education at universities, providing students with a safer, more reliable, and more efficient learning environment.

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