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Blockchain Technology in Education Management Information System: Concepts, Basic Terminologies and Emerging Potentials

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Abstract

Blockchain technology has moved beyond its origins in digital currencies to become a transformative tool across diverse sectors, including education. It offers unique opportunities for managing, securing, and sharing information. Within the educational setting, these attributes present innovative pathways for addressing long-standing challenges related to record keeping, credential verification, data integrity, and trust in institutional process. The system operates in ways that once a transaction has been effected and registered by the block, it becomes very difficult to change or temper with. Exploring the Blockchain Technology innovation in the area of education management information system would enhance better performance of the system. The paper argued that the Blockchain Technology (BT) being decentralised, was designed to prevent monopoly of decision making. It uses a peer to peer (P2P) network where everyone is allowed to partake. It was argued that if anyone creates a new block, every participant in the block should agree with the transaction within the block chain to be considered valid. If any transaction goes off contemplation, the entire block is invalidated, thus rejecting the transaction. The terminology explained includes the peer to peer, cryptography, proof of work, consensus algorithm, punishment and rewards as used in Blockchain. The emerging potentials of the Blockchain technology in education management information system were discussed while suggestions such as a close study of existing university use cases should be done with a view to importing valuable lessons into the global education management information system.

Keywords: Blockchain Technology, Education Management information system, Credential Verification, Data Integrity, Decentralization.

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INTRODUCTION

The global education system is undergoing a transformation tinting toward the exploration of technology to its advantage. An emerging technology which possesses certain potentials for educational management springing out from the Information and Communication Technology is the Blockchain Technology (BT), which could make education management information system more secured. BT has moved beyond its origins in digital finance to become a transformative tool across diverse sectors, including education. Characterized by decentralization, transparency, and immutability, BT offers unique opportunities for managing, securing, and sharing information. Within the educational domain, these attributes present innovative pathways for addressing long-standing challenges related to record keeping, credential verification, data integrity, and trust in institutional process.

The conceptual foundations of blockchain distributed ledgers, consensus mechanisms and cryptographic security- provide a framework for rethinking how education management information is stored and exchanged. At the same time, a growing body of scholarship highlights the emerging potentials of BT in enhancing efficiency, reducing fraud, and empowering learners with greater control over their academic records. This dual focus on foundational understanding and forward-looking applications underscores the importance of

exploring Blockchain not only as a technical innovation but also as a strategic enabler for a more transparent system.

In Nigeria, the exploration of the BT is being popularized by the Federal Ministry of Communication and Digital Economy (FM&DE) which recognized its importance in accelerating national development. According to Section 4:2 sub-section 7 of the National Blockchain Policy for Nigeria; The Government encourages the adoption of Blockchain Technology in various sectors such as healthcare, finance, education and logistics. It is expected that Blockchain Technology will drive innovation and economic growth in the country (FM&DE: 2023:20). Through technological adoption in education, it is believed that nations, institutions and individuals can benefit from easier and more productive operation. Hence, the National Blockchain Policy for Nigeria emphasized the Triple Helix Model (THM) which encourages collaboration between the University (academia), Industry (Business), and the government. The catalyst effect of such synergy is for overall national development.

The Blockchain Technology was popularised via its adoption in Cryptocurrencies Digital Assets which has been dangled as a Decentralized Finance (DeFi). Proponents believe Blockchain Technology would become more popular in the Web3 (next generation of the internet), Non-fungible Tokens (NFT) and Decentralized Autonomous Organization (DAO) etc. There is a consensus among stakeholders that its adoption in education management information could enhance transparency in academic records (Adeboye, 2019, Koshiry , 2023). Educational management information system (EMIS) has been described as a database aimed at ensuring accurate, appropriate and timely education data and information available to make necessary educational decisions (Ogunsola 2022). Education Management Information System functions in data collection, storage and retrieval in education institutions at all levels for operational improvement. This paper therefore would attempt to conceptualize the term blockchain Technology, discuss some common terminologies associated with the technology and would explore the emerging potentials of the Blockchain Technology in Education management information system.

Concept of the Blockchain Technology

A Blockchain consists of different chains of blocks interlocked in chain-like structure. It was originally intended as a Cryptocurrency but its popularity increased as the technology addressed other classical problems for the centralized system (Alsaadi & Bamasoud, 2023). In 2009 a Cryptocurrency in the name of Bitcoin was built using the blockchain under the pseudonym -Satochi Nakamoto. A blockchain is a distributed ledger open to as many persons interested in participating in the block. Its properties should guarantee security of data, accountability and stakeholders' participation. Johnson et al (2023) opined that the blockchain-distributive element in contrast to the already existing accounting digital tool updates stakeholders on each transaction as they happen. Registration in a blockchain is very difficult to change or temper with. Ruhlow (2021) defined blockchain technology as a particular type of digital database that is used to store a large amount of information in blocks. Koshiry et al (2023) defined the blockchain as a distributed digital ledger that records transactions in a secure, transparent, and tamper-proof manner.

Blockchain Technology (BT) could assist in educational management in keeping valuable data secured, reliable and temper-proof. The challenges of Information Communication Technology in education includes poor backup architecture occasioned by databases prone to cyber-attacks, cyber security threat and data irretrievability. It is expected that Blockchain Technology (BT) would minimize observed shortcomings. Fig i explains the

conceptual outlook of the framework and design of the Blockchain technology that enhances security of data and effective operation in education management information system. Transactions made in a blockchain are registered, secured and temper-proof which prevents it from manipulations.

Fig i: Conceptual framework of Blockchain Technology in educational planning. **Source:** Authors' Design

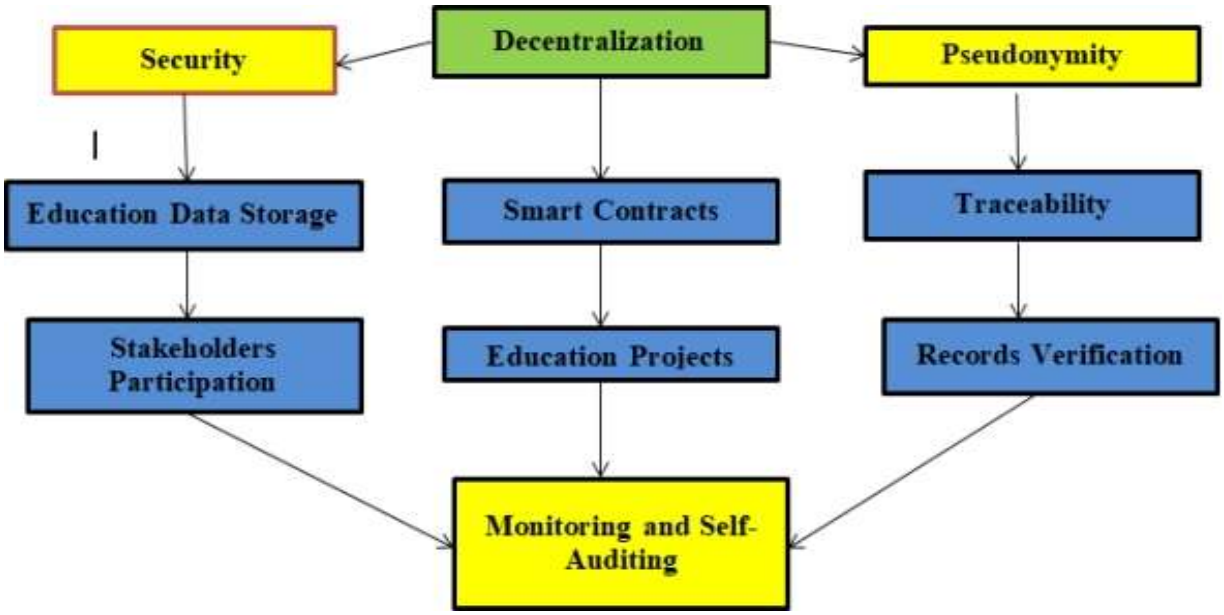

Fig i shows that Blockchain Technology could enhance education management information system. Decentralization as seen in fig i explains the unique nature of the Blockchain system.

Bureaucracy often times acts as gatekeepers to education progress because bureaucratic decision making is slow. According to Imakpokpomwan (2015), some major decisions affecting education are handled within political circles thereby allowing politics to override professional considerations. The centralized nature of government and the attendant consequence of red-tapism in influencing policy making and implementation could create room for data manipulation.

The Blockchain Technology (BT) is decentralized and designed to prevent monopoly of decision making. Decentralization within the blockchain system promotes education data integrity, smart contracts, education projects execution as all stakeholders have a stake, a voting right and real-time monitoring of education valuables. The Transactions in a blockchain is Pseudonymous which is in contrast with the term "anonymous". This allows for traceability without revealing the personal details of the personalities involved. Monitoring & Self-Auditing as seen in fig i demonstrates how the Blockchain Technology enables a self-auditing protocol. This is possible because it is an immutable ledger of records with a consensus mechanism that validates transactions in a transparent manner. The education system operating within the Blockchain incorporation would create a real-time monitoring of educational activities, improved accuracy with a well-managed risk and automated compliance. The self-auditing capability of the blockchain enhances transparency, accountability and credibility.

Blockchain Technology and its Operational Efficiency in Education

A Block contains three (3) important properties and they are namely: Data, Hash and Previous Hash. The Hash can take the form of a finger print, an address in a complex mix-up of letters, numbers and characters (e.g. e2gcbtFr2444Db3). Once a hash is created for the first time, it is called a genesis block with its unique identification. However, if a change is made, it causes something to change within the block making it markedly different from the genesis block, providing the awareness of a change to all participates in the network in the blocks or node.

Fig ii. Chain-like description of a Blockchain network. Source: Author's design

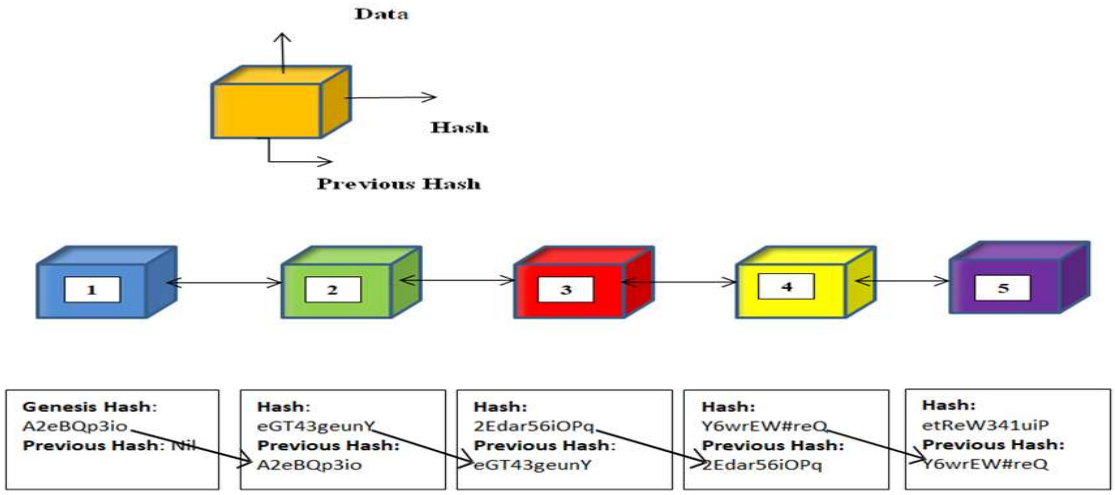

Fig ii gives a description of this concept explaining the phenomenon surrounding blockchain operation. As stated earlier, the blocks forms a chain-like structure, as the participant expands the blocks continue to build and link into one another with every block carrying its own unique information open to everyone in the nodes. Every record is immutable and secured in a blockchain system, thus, the information stored within it is temper-proof and can survive any form of attack from hackers. According to Alsaadi & Basamoud (2023), Cryptocurrency hash function is an integral part of the blockchain technology innovation. It is the main characteristics that give security capabilities to the processed transactions and making it immutable.

As shown in Fig ii, each of the blocks is interconnected with a unique identifier on the previous block known as a "hash" except for block number 1 known as the "Genesis Block". If block number 4 is tempered with, block number 3, 2, 1 will be invalidated while block number 5 will signal that "something is not right". There is a property that enables security of information registered on all blocks; it is called the Proof-of-Work (PoW). The Proof- Of-Work (PoW) is a consensus mechanism that slows down the creation of new blocks. It makes it difficult for the creation of new blocks and if for any reason a new block is created, same energy will be required to re-create or alter previously created blocks. Another way this works in making the blockchain temper-proof is that it is distributed and has no centralized control or authority base. It uses a peer to peer (P2P) network and everyone is allowed to partake. If a new person joins, he or she gets a full copy of the entire blockchain. If anyone creates a new block, the block is sent to everyone in the network. Every participants agrees (i.e. have a consensus) on what nodes and transaction within the block chain is considered valid and if any transaction goes off contemplation, the entire block invalidates or rejects the transaction. Alteration can only take place if the Proof-Of-Work is done for all the nodes or blocks within

the blockchain and every participants agree to it. This requires a dint of hard work making it near impracticable to achieve.

Data management in the blockchain works like registration approved in the book industry. For instance, a particular published journal or book has its unique International Standard Serial Number (ISSN) or International Standard Book Number (ISBN) respectively kept by the publishing company. Whenever the need to verify the authenticity emanates, one would look up to the relevant authority for confirmation. One common trait with the issuing body or the custodian of the assets mentioned is that they are centralized, that is having a central authority that issue and validates the information. The centralized nature could sometimes be manipulated and to prevent the forgoing, a decentralized platform like the Blockchain Technology (BT) will bring about the solution in the operations of the system. It is believed that decentralization reduces the risk of falsifying records, manipulation and corruption in the systems. Blockchain Technology (BT) by its characteristic, is opposed to centralization which encourages all round participation in the system, thereby reducing falsification or manipulation of data.

Terminologies Associated with the Blockchain Technology

Blockchain, though an emerging technology, has terms that make the understanding of its working system comprehensible. Some of them are presented as follows;

- **Peer to Peer (2P2):** This implies networks of computer consisting of nodes equally open to everyone to be involved. It operates in a two-way secured fashion.
- **Cryptography:** This is the art of secure communication in an environment considered hostile. Cryptography is needed for security reasons because every participant in the network or nodes can communicate including bad actors (hackers). Blockchains trust comes naturally with the network community because it provides cryptographic proof over a set of transaction (Alsaadi & Basamoud, 2023).
- **Consensus algorithm:** This means "the rule". Every node in the network has a predefined protocol it follows to create newer blocks or transaction within the blockchain. Hence, for a new block to be created, it must first meet the required condition of the established protocol. There are four (4) basic types of consensus algorithm which are: (i) **Proof-Of-Work**: This is a consensus rule in which actors within the blockchain can create new blocks by expending significant amount of computational power. This process is quiet rigorous, hence guaranteeing a temper proof security within the network. (ii) **Proof-Of-Importance**: This is an algorithm or consensus rule that determines the likelihood of an account being chosen for validation of transaction and creating new blocks for quality transactions that strengthen the entire blockchain network. (iii) **Proof-Of-Activity**: This is a consensus algorithm that combines Proof of Work (PoW) and Proof of Stake (PoS). It leverages on the strength of Proof of Work (PoW) and Proof of Stake (PoS) to reduce energy consumption in the system. (iv) **Proof-Of-Stake**: This is a consensus algorithm in the blockchain that allows validators to create new blocks without expending more computational power.
- **Punishment and rewards:** This derived from the games theory; it ensures that it will be in people's best interest to always follow the rules established. This is prevalent in FinTech (Financial Technology) where participants are rewarded (giving tokens) for following the rules and otherwise punished (deducting tokens) for disobedience to the rule. Strehle (2020) identified two types of Blockchain; as-public and private blockchain networks.

➢ **Public - Open Blockchain**: The Public Blockchain allows for public participation, it has no third party, but borderless, neutral, and temper-proof and opens to everyone. It has a

binary protocol of "valid" and "not valid". In other words there's nothing like good, bad, legal or illegal. Public blockchain is immutable and has no single point of failure; records cannot be removed or prevented from being published as long as the consensus algorithm prevails.

- **Private - Closed Blockchain**: It is limited by authorized participants and it doesn't really bespeak of Blockchain in the real sense because the whole idea of a blockchain is to ensure decentralization, but the private closed blockchain demonstrates the contrary.

The potentials of Blockchain Technology in Education Management Information System

Education sector is data-driven; records are stored, managed and retrieved for planning and other managerial purposes. Educational Planners have often time been confronted with the issues of reliability of data, where available, when planning the education system. Agboola, & Imakpokpomwan, (2011), cautioned that availability of accurate data is the hallmark for projection and once data are unreliable, the projections based on them are bound to be faulty. Fraud in data can also render the education sector less predictive including rise in credibility issues. Blockchain Technology can assist in the following ways;

- **Validation of Data:** In the developing world where access to academic records are not yet automated, accessing credentials, academic records and the validation of transcripts are mostly done through a manual process in a traditional method which could be porous, prone to social misdemeanor and could create room for fraudulent activities (Abdulrauf et al., 2024). Falsified certificates are deliberately designed to mislead and may be product of credential racketeering (Adebayo, 2024). Another issue associated with traditional methods includes possession of unverified certificates which borders on lack of authentication (Nwachukwu, 2024). These leakages in EMIS could be eliminated by the application of the blockchain technology.
- **Records Manipulations**: Intellectual theft, population and students' enrolment data manipulation has become a threat to the education system. Once education data are compromised, the integrity of its outcome becomes questionable because inaccurate data leads to wrong conclusions. It is more expensive to handle forged certificates than take stringent measure to prevent such occurrence. Forged certificate can lead to loss of integrity and credibility in the certificate and loss of public confidence in the certificate awarding institutions (Ofori-Mensah et al 2023), hence the application of the blockchain system in EMIS becomes imperative.
- **Access to education data**: One fundamental challenge confronting the educational managers is accessing current but reliable educational data. The EMIS should possess the infrastructural properties that could store, integrate, collect, process, share or disseminate education data. A weak link could results in unfulfilled expectation, obsolete and unreliable data processes. For instance, manual procession of academic transcript leads to delay, unpredictability and dissatisfaction. EMIS must be strong and predictable to lead to a functional system. The accessibility of real-time data is the goal in contemporary society hence a need for a Blockchain Technology in EMIS.
- **Security and Privacy Issues:** Cyber security is a serious issue in modern world of Information sharing and management. The Education Management Information System could be exposed to the threat of data breach as hacker and data theft could cripple a system if education data is not adequately protected. Blockchain presence, with its characteristics or framework could create a backbone for education data protection. Aloamaka (2023) opined that such could impact on data privacy and security reducing the dangers of threats and data breach.
- **Stakeholders Isolation:** Data generating process should be participatory, that is allowing education stakeholders to participate in the data-generating process. If the inputs are

trusted the outputs becomes valid and reliable. Education data are in form of Number of school buildings, Facilities/equipment, Number of Teachers, Students-Teachers Ratio, Students' Enrolment, Students Achievement Score, School Size and Class Size. If a system could automatically update itself and stakeholders are fully on the known, it would give credence to the database. The Blockchain ensures that every education data entry is time-stamped, providing an accurate log of where, when and who entered an information. The system updates and assists in monitoring real-time progress and addressing issues speedily. Once an education data is entered or retrieved, the blockchain registers it through a consensus mechanism known as Proof of Activity (PoA), it is immediately available to all participants' or stakeholders' in the block. This ensures that everyone including educational planners/managers is working with same datasets. World class educational institutions such as Massachusetts Institute of Technology, Stanford University, University College, London, University of Nicosia and the University of Melbourne are already using Blockchain Technology to issue certificate (Koshiry, 2023).

CONCLUSION

The use case of Blockchain technology in Education cannot be over-emphasized. The Blockchain Technology (BT) is highly needed in our educational system and institutions for transparency, securing of vital information, certificate, strengthening educational services such as registration, payment methods and online accreditation. Enhancing credential credibility and sharing in real time is the potential Blockchain Technology holds out to the educational managers and planners to achieve a better educational system.

RECOMMENDATIONS

Some suggestions for improvement are here made for improvement in EMIS.

1. Even though blockchain technology operates as a decentralized network over centralized system as its backbone, Ocheja et al (2016), advocate that conversation and consensus should be consolidated on standardization. No doubt, that standards establish the rules, regulations and limits. Information would be exchanged between multiple parties; there is a need for standardization to avoid challenges that could weaken the interoperability.
2. Institutions awarding certificates should study closely the benefits inherent in the blockchain technology with a view to importing valuable lessons learnt into their EMIS.
3. Educational institutions should organize seminar, conferences and workshop to popularize adaptation of the Blockchain technology in universities.

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