ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 6, June 2024

Sustainable Development in Nigeria Education: The Role of Blockchain Technology

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ABSTRACT: Our education system is getting diversified, challenged, and blended for the overwhelming advancement of disruptive technology. As part of the fourth industrial revolution (4IR), blockchain technology has been applied in many areas such as banks, finance, judiciary, and commerce. Disruptive technology is changing our experiences in terms of education and other lifestyle. Delivering lectures, interacting between students and lecturers, evaluating learning outcomes, and verifying educational credentials might be smoother, easier, faster, and cheaper than before. This will be of great value in the educational sector due to its ability of data storage, which is securely encrypted on a blockchain network and will significantly reduce risks with information sharing. Blockchain technology in the educational sector will eliminate many challenges such as unsecured system, manual filing of documents which takes up time and often cause duplication of information, inaccurate sharing of information, vulnerability to identity mis-management and theft. It will also make data highly available in real time than a centralized database and cuts down cost of building infrastructures for data hosting. This paper fills literature gap by presenting a comprehensive review on blockchain technology and the various ways through which it will help in providing sustainability in the educational sector in Nigeria.

KEYWORDS: Disruptive Technology, Blockchain, 4IR, Network etc.

I. INTRODUCTION

In recent years, Blockchain technology has been growing tremendously along with the advancements in Information and Communication Technology. With the increasing utilization of the Internet access in the modern digital life, ensuring security and privacy, especially, for the financial and e-commerce applications have become critical. The enormous growth of cryptocurrencies leverages the rapid development of Blockchain technology. Blockchains are immutable and distributed digital ledger systems without a central authority, storing the cryptographically signed transactions in the form of blocks [24]. In the Blockchain network, the ledgers are public to the community of users in essence; each block has the cryptographically linked connection with its previous block after validation. The block chains are constantly growing, according to the transactions and, thereby, being appended the new blocks. Each block contains a hash value regarding the content of the previous block in the Blockchain network. The Blockchain technology has successfully enabled e-commerce systems such as Ethereum, Bitcoin, Litecoin, and Ripple etc. The Blockchain technology has been broadly used for a variety of applications. Three different types of Blockchains are available based on the availability of the data, managed data, and actions, including public-permission-less Blockchain, the public permissioned Blockchain, and private blockchain. Blockchain technology has widely used in different emerging fields such as the Internet of Things (IoT), education, finance and auditing etc. [28]. According to (accountingtoday.com), the global market investments in terms of estimated capital market spending in blockchain technology during last five year are given by the following chart.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 6, June 2024

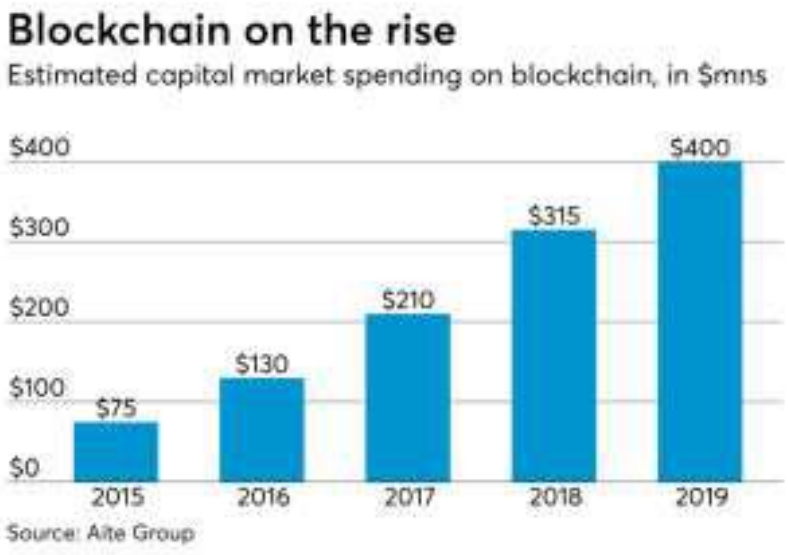

Figure 1- Estimated capital market spending on Blockchain technology [32]

The Blockchain is an encrypted, distributed database that records data, or in other words it is a digital ledger of any transactions, contracts, that needs to be independently recorded. One of the key features of Blockchain is that this digital ledger is accessible across several hundreds and thousands of computers and is not bound to be kept in a single place. Blockchain has already started disrupting the financial services sector, and it is this technology which underpins the digital currency bitcoin transaction. With Blockchain technology in financial sector, the participants can interact directly and can make transactions across the internet without the interference of a third party. Such transactions through Blockchain will not share any personal information regarding the participants and it creates a transaction record by encrypting the identifying information. The most exciting feature of Blockchain is that it greatly reduces the possibilities of a data breach. In contrast with the traditional processes, in Blockchain there are multiple shared copies of the same database which makes it challenging to wage a data breach attack or cyber-attack. [28]. With all the fraud resistant features, the blockchain technology holds the potential to revolutionize various business sectors and make processes smarter, secure, transparent, and more efficient compared to the traditional business processes.

II. BACKGROUND

In 2008, a person going by the name Satoshi Nakamoto proposed using blockchain technology for virtual currency. Nakamoto developed bitcoin, a digital money based on the blockchain. This network stores and disseminates data using distributed ledger technology and operates on a peer-to-peer model [18]. Numerous alternative cryptocurrencies appeared on the market after Satoshi Nakamoto used blockchain technology to create bitcoin. Essentially, blockchain is a shared ledger that records and verifies financial dealings between parties. To put it simply, blockchain is a distributed database that records digital transactions. The blockchain is a distributed ledger in which each user's transaction history is recorded in chronological order and could be altered by a consensus of all users [20]. Private Blockchains are exclusively utilized internally at a corporation or organization, while public blockchains are available to the general public. There are several different blockchains, but the one at the heart of Bitcoin's cryptocurrency is the most well-known. Various applications exist for DLT's tamper-proof transactions and its ability to maintain a clear and unambiguous register of information exchange [4].To address the need for decentralization and confidentiality of cycles common to ordinary people and organizations, the blockchain is a large and global encoded dataset that puts an end to the distribution or monopolization of data by the parts that interacted with that data. [7]. At first, blockchain technology was mainly used for digital currency transactions, but now there is a growing body of research on the potential benefits of blockchain in other industries, including medicine, education, urban planning, finance, insurance, and many more. The blockchain provides an impregnable and unhackable network for computer-based applications; therefore the trend has turned towards the secure and verified system [23].

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Now, in terms of the education industry, the rapid development of distributed information and blockchain technology has prompted us to reassess and re-examine several fundamental components of existing education, literacy, and training frameworks. With the introduction of this new system of improvements, previously held beliefs about things like trust, value, security, and character are being called into question. Because of the fast development of distributed computation and blockchain technologies, many of our long-standing educational institutions are being rethought and redesigned. When blockchain technology is introduced to the classroom, it raises new questions about the nature of ideas like trust, privacy, and identification, as well as a whole new set of technologies [23]. The primary focus of blockchain research in the education sector is on the ways in which the technology might facilitate the safe, reliable, and auditable dissemination of knowledge. The ledger then serves as a central repository for all of the related educational institutions to access and use in the course of their respective teaching, learning, and accrediting processes [5]. Researchers have discovered that Blockchain technology creates a setting where students may act as their own registrars and where third parties are not required to record or modify their grades. Education providers may also use blockchain technology, a decentralized data exchange, to issue, validate, and share certificates, which will assist to reduce the prevalence of certificate fraud [1]

Research Objectives:

1. To understand Blockchain technology and it's working principles.
2. To know the various probable applications of Blockchain technology in education.
3. To identify the benefits that Blockchain technology brings to education.

III. METHODOLOGY

In order to address the research objectives posed by the study, a thorough content analysis of the available literature has been conducted as a secondary data source. The purpose of content analysis is to identify recurring ideas, topics, and terminology within a body of qualitative data (typically text). Researchers may use content analysis to determine the frequency with which certain words, ideas, or concepts appear in a text, as well as their significance and interrelationships. Investigators may check articles for signs of prejudice or partiality by analyzing the words and phrases used. This allows them to draw conclusions about the book's meaning, the author, the intended readers, and the historical and cultural context in which the piece was written [10]. Content analysis may be broken down into two broad categories: conceptual analysis and relationship analysis. Using this method, we may ascertain whether or not a text contains any ideas and how often they appear. By digging further into the interconnections between ideas in a text, relational analysis expands on the conceptual analysis. Results, conclusions, interpretations, and meanings may vary depending on the method used to analyses the data. Conceptual analysis was performed with content analysis in this study [13].
Books, journal articles, essays, talks, newspaper headlines, lectures, media, historical records, and online forums are all mined for information for this study. The study used a process called content analysis, in which the text was dissected from several perspectives to reach its goal. The primary method used for this was a literature of previous research.

IV.LITERATURE REVIEW

A.Blockchain Technology

Blockchain technology is also known as distributed ledger technology. It allows participants to secure the settlement of transactions, achieve the transaction, and transfer of assets at a low-cost [20]. A sample flow of cryptocurrency blockchain transaction can be seen as follows. User A initiates a transaction to User B via a peer-to-peer blockchain network. A cryptographic proof of identity (a pair of public key and private) is used to the network to identify user A and user B uniquely. The transaction will then be broadcasted to the memory pool of the blockchain network waiting for transaction verification & validation. The new block is generated by obtaining a certain number of approved nodes; this is called reaching consensus. After reaching consensus, new "block" on the entire blockchain network is formed, and each node updates its respective copy of the blockchain ledger. This block contains all the transactions that occurred during this time. It is "linked" to the original block in the network through the digital signature [31]. The consensus stage is achieved through the use of a consensus algorithm. This process is called mining. Namely, Peer-to-Peer network reaches consensus on the current state of the distributed ledger [12]. Each node can vote through its CPU power to accept valid blocks by taking extensions or reject invalid blocks by denying expansions. Any required rules and incentives can be implemented through this consensus mechanism [17]. Each transaction in a block is tagged by a specific timestamp. The two blocks are also linked by a timestamp. Therefore, the data on the blockchain has a property of time, and the length of the chain is continuously growing. It means that blockchain is a distributed variant that implements the timestamp service [8].

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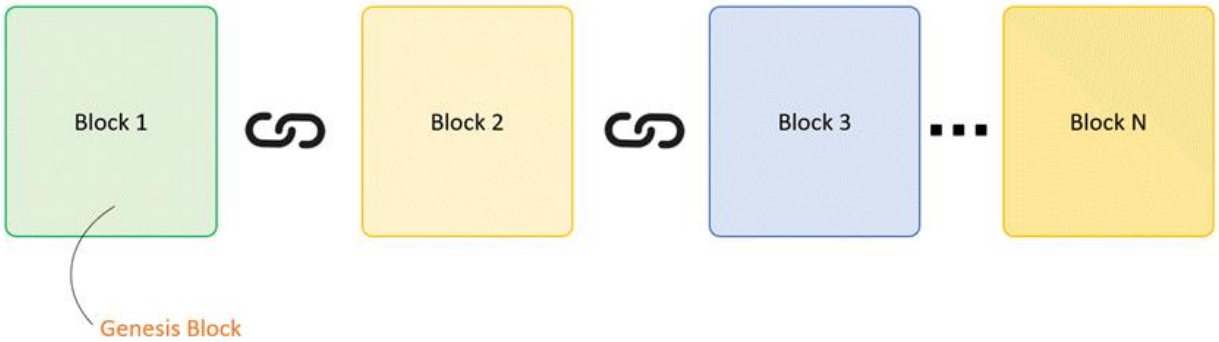
Blockchain uses specialized hardware to construct sizeable cryptographic data chain, and SHA-256 hash function is used to prevent the tampering of data of third-party users [29]. Any attempt to change even just a bit of information will break the existing chains. In short, blockchain is a decentralized and trustworthy digital public ledger. It uses distributed techniques and consensus algorithms that were maintained by all participants.

Blockchain is not only a new type of internet infrastructure based on distributed applications but also a new type of supply chain network. Essentially, blockchain is a distributed network of computers (nodes) used to maintain the source of information sharing. Each node maintains the security and accuracy of the information by keeping a complete set of ledgers of past transactions. When a new block is being created by a miner, who is the first one to validate all the transactions in the block and solve the mathematical problem by generating a digital signature for the block which meets a pre-defined rule using the hash function. The newly created block will be broadcasting to the whole blockchain network, allowing all nodes to maintain the same complete ledger [29]. Consensus mechanism is achieved through three major verification mechanisms. Bitcoin uses a verification mechanism called Proof of Work [18]. The miners are nodes working in a blockchain peer-to-peer network. Their task is to validate all transactions included in one block and solve the mathematical problem of the digital signature using a hash function. The miners compete with each other, and once someone solves the problem, the solution will be shared with other mining nodes. The winning miner receives additional bitcoins as rewards. Other miners accept the Proof of Work, and the new block will be added to the blockchain network [6]. Ethereum has four development stages, including Frontier, Homestead, Metropolis, and Serenity. The first three stages use the verification mechanism of Proof of Work, and the fourth stage uses Proof of Stake. The Proof of Stake requires the certifier to show the ownership of a certain amount of cryptocurrency [23]. “Proof of Zero Knowledge” is the consensus mechanism used in Zcash which can provide better privacy to its users. Compared with other verification mechanisms, Proof of Zero Knowledge has improved both regarding functionality and efficiency [29]

B.Architecture of a Blockchain

Blockchain can be defined as a chain of blocks that contains information. The data, which is stored inside a block, depends on the type of blockchain. The real purpose of blockchain is to address the problems of double records without need of a central server.



C.Block

A block comprises components such as Data, Hash and Hash of the previous block. The first block in the chain is called the Genesis block while each new block in the chain is linked to the previous block by some elements called the hash [29].

D.Hash

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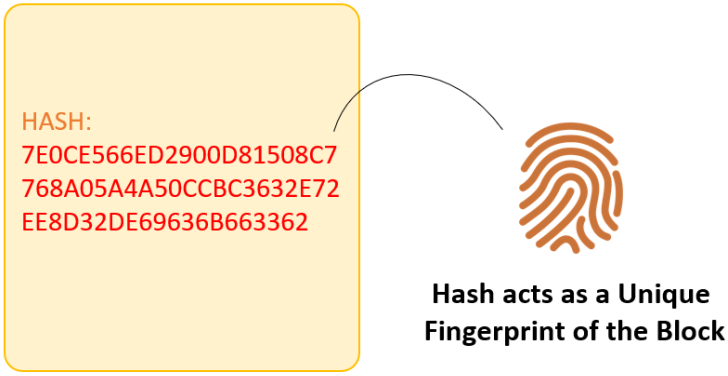
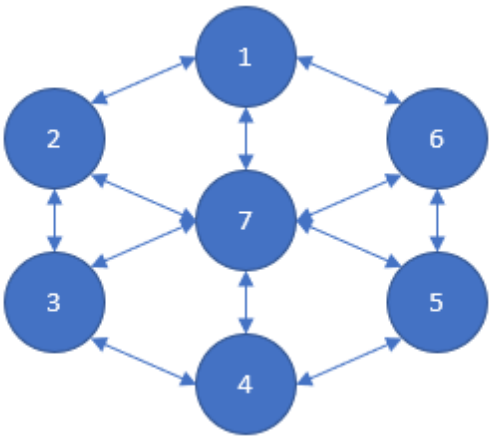


A hash is a 256-bit cryptographically unique value calculated on the contents of the block. A hash can also be found in a block as started earlier. It can be understood as a fingerprint, which is unique to each block. Therefore, once a block is created, a hash is generated and any change inside the block will cause the hash to change and therefore it does not remain the same block [25].

E.Nodes

Nodes can be any type of electronic device that maintains copies of the blockchain and keeps the network functioning. The nodes check transactions and group them into blocks. Without nodes, a blockchain's data would not be accessible. They store, spread and preserve the blockchain data, so theoretically a blockchain exists **on** nodes [22].



F.Miners

Miners create new blocks on the chain and the process is called mining. To add a block, it is necessary to undermine it. Special software is developed and used by the miners to find a nonce that generates an accepted hash which requires solving a unique mathematical problem of great difficulty that consumes some very considerable computing resources. This makes mining a block difficult especially on large chains. When the right nonce has been found they term it the "golden nonce" and their block is added to the chain. Therefore, making a change to any block requires re-mining not just the block to be changed but all of the blocks that come after it. That is why it is extremely difficult to manipulate blockchain technology since it requires enormous amount of time and computing power [23].

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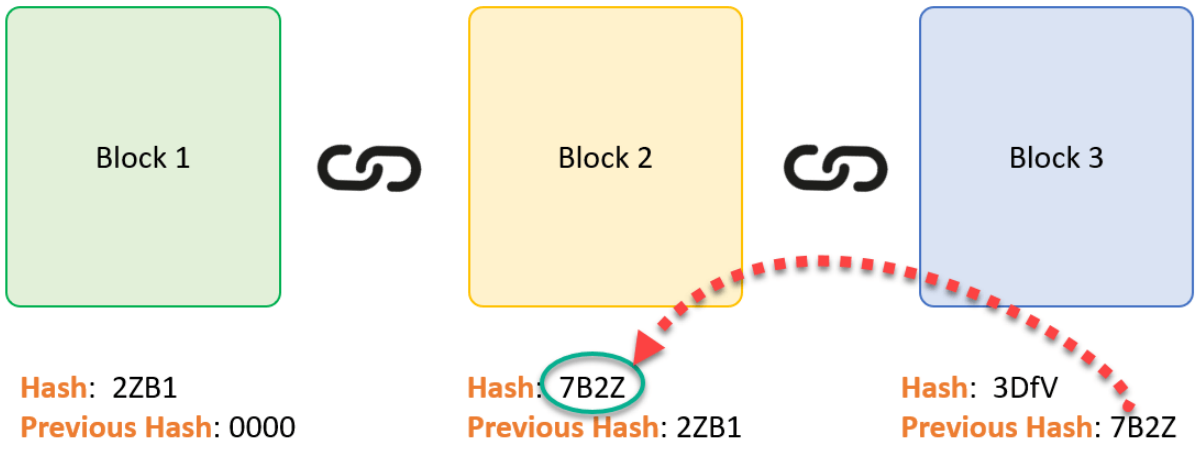
G.The Working Principles of Blockchain

First Step: A person requests a transaction. The transaction can vary from cryptocurrency, records, contracts, etc.
Second Step: The requested transaction is broadcasted to a distributed network with the help of the nodes.
Third Step: The network of nodes validates the transaction and the user's status with the help of known algorithms.
Fourth Step: At the point the transaction is completed the new block is then added to the existing blockchain.
NB: Once the block is added it is permanent and unalterable.

H.Blockchain Immutability

Consider the following example, assuming we have a chain of 3 blocks. The 1st block has no predecessor; hence it does not contain the Hash of the previous block. Block 2 on the other hand contains a Hash of block 1 likewise block 3 contains the Hash of block2



Assuming an attacker successfully changes the data present in Block 2. The Hash of the Block also changes, but Block 3 still contains the old Hash of the Block 2. This makes Block 3 and all succeeding blocks invalid, as they do not have correct hash of the previous block [23]

V. BENEFITS OF USING BLOCKCHAIN TECHNOLOGY

The major benefits of blockchain technology are numerous and not limited to the ones being discussed shortly
Transparency and Immutability: Every party in the network is a point of authority and any added data or transactions is seen and verified by all, providing maximum transparency. The immutability of data makes it even trustworthy as well. Once data is created on a block and transaction completed, it can't be deleted or altered.
Process integrity and disintermediation: There is high regard for integrity such that the parties in any transaction will be aware that everything agreed on will hold exactly as they said. The trustworthiness between the party eliminates the need for intermediation by a third party.
Lower costs and faster transaction: Blockchain is very great at cutting down overall transaction costs and time by discharging the need for a third-party intermediary in exchanging assets. For example, in the sale of real estate and intellectual property, the transaction is peer-to-peer, seamless faster within seconds and trusted.

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Access to high-Quality Data for everyone: Every participant in the network will get in real time the complete data, updated information of the transaction they need which is accurate, timely and consistent.
Security: Attacking a traditional database is the bringing down of a specific target. With the help of Distributed Ledger Technology, each party holds a copy of the original chain, so the system remains operative, even the large number of other nodes fall

A.Educational applications using blockchain technology

Present blockchain applications in education
Nowadays, some universities and institutes have applied blockchain technology into education, and most of them use it to support academic degree management and summative evaluation for learning outcomes [23]. Blockchain technology can formulate the whole transcript. In the formal learning context, this includes learning contents and outcomes as well as students' achievements and academic certificates. Subsequently, in the informal learning context, information about research experience, skills, online learning experience as well as individual interests are included. These data can be safely stored and accessed on a blockchain network in appropriate ways. The University of Nicosia is the first school which uses blockchain technology to manage students' certificates received from MOOC platforms [23]. Sony Global Education also used the blockchain technology to create a global assessment platform to provide services for storing and managing degree information [11]. Additionally, Massachusetts Institute of Technology (MIT) and the Learning Machine Company cooperated to design a digital badge for online learning based on blockchain technology. Students who have attended the projects of MIT Media Lab and passed the assessment will receive a certification which will be stored on a blockchain network [28]. Holberton School is the first institute applying blockchain technology to store degrees and has claimed that they would share this information from 2017. The blockchain ledger can match all kinds of educational information with the user's unique ID. It includes learning behavior in class, micro academic project experience, and macro educational background, etc. Moreover, blockchain technology contributes to reducing degree fraud. In the past, there were numerous cases of degree fraud. However, it can be avoided by employing blockchain in granting and managing student's degree now. The data matched with users' ID and stored in blockchain are checked, validated, and maintained by the miners from all over the world. Blockchain distributed ledger is immutable and trustworthy. Thus, the reliability and authority are both ensured, which will significantly reduce degree fraud.
Also, blockchain can be used as a "capacity-currency transformation bank." Specifically, blockchain learning ledger records detailed information about the users' learning experience and follows the development of their knowledge and skills. All of them can be transformed into a sort of digital currency and stored on a blockchain network according to a series of comprehensive standards. Students will gain rewards through their efforts on studies, which is called "learning is earning" [23]. Some schools have also started the application with this concept, for example, Sharples and Domingue [23] claimed a kind of Education Reputation Currency named Kudos. It can be used to measure learning outcomes and stored in a virtual wallet.

VI. BLOCKCHAIN IN EDUCATION

During the epidemic, educational institutions jumped on the digitizing bandwagon. As a result of the revolutionary nature of blockchain technology, this industry may see a dramatic shift. To begin, blockchain has the potential to drastically improve the ways in which academic collaboration and record keeping are handled. Since blockchain is a distributed ledger, it has the potential to greatly improve the sector by increasing openness and responsibility in technology. As the globe becomes more technologically sophisticated, the educational system stands to be shaken up. The education technology sector has benefited us for twenty years. It is safe to say that this trend has hastened the process of bringing schools up to date. Now is the moment for blockchain technology to greatly quicken the process. The distributed database of the blockchain, AI, and machine learning are gradually displacing textbooks (Maryville, 2021). Below, we highlight the applications and consequences of blockchain technology in the academic sector [5].

A. Intelligent Agreements for Courses and Assignments

Agreements are often implemented on blockchains. This may help instructors create blockchain-based courses and lessons. After the requirements have been met, the class will be taught automatically and at the student's own speed. Students and instructors might sign a contract detailing assignment restrictions, due date, and grading deadline.

B. Certifications, Report Cards, and Documentation

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The immutable ledger technology of blockchain produces a chronological record of recent occurrences. This might be useful for presenting student transcripts, producing a thorough report card, monitoring attendance, and informing students and stakeholders about their progress. Using blockchain, students may submit homework without concern of losing them. Additionally, students may obtain their degrees and certificates online, as opposed to on fragile paper. Digital degrees & certificates are favoured since they are hassle-free, well-organized, and uncomplicated [5].

C. Streamlining the Payments of Fee

The procedure of paying student tuition is time-consuming and difficult. Students, parents, banks, organizations or government organizations for grants, lenders, and other university departments are involved. This process, however, can be expedited using blockchain technology, resulting in decreased administrative costs and maybe even cheaper tuition fees.

D. Universal Admittance and Lower Expense

To encourage and facilitate lifelong learning, blockchain technology may facilitate the distribution of freely available, open educational content like books, lectures, and films in the public domain. Blockchain technology allows for the safe and low-cost public sharing of such assets. Additionally, blockchain enables teachers to assess their students' work on the blockchain, making it possible for students in far-flung regions to participate in digital versions of courses and exams.

E. How blockchain can solve the challenges of education system

According to Wallace [5] and [27], below are some of the sectors of the education business where Blockchain might have an influence and how it can tackle the issues of the education system:

I. The purpose of higher education is dual in the field of research: first, to preserve information for future generations of students, and second, to increase current knowledge via research. Professors spend a great deal of time performing research work and publishing their results, expanding the boundaries of their disciplines and uncovering new areas of study that will lead us into the future. Moreover, the reach and effect of such articles may have an influence on academics' potential to seek large funding to cover future research. There is a strong incentive for authors to monitor the distribution of their works and take measures to discourage blatant theft.

II. Researchers would be free to publish anything they choose, so long as they publish in a fashion that allows them to measure the reuse of their work (such as how frequently it is referenced or used as teaching materials), which is crucial since it may lead to recognition and further funding.

III. While still in its infancy, blockchain in E - learning has been heralded as "the ideal technology" for retooling an antiquated system.

IV. With the spotlight shining brighter than ever before, Blockchain's distributed ledger keeps technology of transactions in near real-time and cannot be altered once they have been recorded. This is a great way to maintain tabs on kids' academic standing, show a full report card, and verify transcripts. Students who use blockchain to turn in their work cannot complain that their submission was misplaced.

V. Smart contracts may also be used to emphasize responsibility. Teachers, administrators, and students at educational institutions will soon have access to smart contracts. To clarify the parameters of an assignment, the due date, and the grading schedule, for instance, students and professors might sign a digital agreement. It is possible that student loan debt may be settled via smart contracts.

VI. When applied to the problem of reducing the price of higher education, it has the potential to have a dramatic effect. Open educational materials are those that are in the digital realm and free to use and redistribute, and they might be made accessible to everyone via the use of blockchain technology, in addition to their potential utility in promoting lifelong learning. Blockchain technology makes it possible to safely and cheaply distribute these kinds of resources on a public network.

VII. Blockchain has the ability to change the education landscape because it can address these issues by providing new, less expensive means of teaching and by breaking the current link between schools and students.

F. Possible limitations in adapting blockchain in education sector

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Blockchain has a lot of promising applications, but it has not yet seen widespread adoption. More than half of the students polled by Gartner said they had no plans to use blockchain technology. The difficulties of putting into practice the technology might be to blame for much of the resistance [2]

Security: Even while blockchain's security is a major selling point, it is not bulletproof. Institutions need to be careful about what material they save and how they select to store it due to the sensitive nature of the information being kept on the blockchain (students' academic records and credentials). There may also be difficulties associated with meeting the requirements of federal and state privacy legislation. More stringent privacy safeguards may be required at universities, such as the use of private or private blockchain or the encryption of blockchain-stored data [2].
Scalability: Large amounts of student and alum data held by educational institutions might provide a scaling challenge for blockchain applications. More blocks are needed to accommodate more data, which slows down blockchain transactions since each one must be verified by the network's nodes. This may be a serious barrier to widespread implementation. A benefit of permissioned blockchains is that they can process more transactions per second than permission-less ones [2].
Adoption rate: Blockchain, like other technology before it, is only useful when enough universities and employers depend on it; students only gain from proprietorship of their diplomas if the schools or firms to whom they are applying recognize their validity. Many job boards, like Upwork and ZipRecruiter, are actively encouraging blockchain-based credentials, and hundreds of colleges are now issuing and accepting them.
Cost: Adopting and deploying any new technology may be fairly expensive, despite the fact that it might lead to benefits in other areas. Investing in more computer resources or upgrading a current infrastructure may be expensive. Institutions may also need to spend time and money training school administrators to utilize the technology [27]. This is because many organizations may lack the expertise and skills essential to handle student data on a public blockchain.

VII. LIMITATIONS OF BLOCKCHAIN TECHNOLOGY IN EDUCATION

Slower transactions and scalability challenge: since educational systems have large data collected on so many students, which leads to increase in block sizes. These leads to scalability challenge and slow speed blockchain transactions because as the number of blocks becomes larger, transactions on the blockchain requires more time given that each transaction requires peer-to-peer validation [15]. These slow transactions might be an impediment when blockchain-in-education solutions are explored and adopted on a wider scale Risk of error: since the data encrypted on a blockchain network is immutable and unalterable, any error make on any block cannot be overwritten and it requires the creation of a new block. A vision for the future: it is hard to predict whether blockchain will have a long time sustainable impact in education. It was gathered that unless large multinationals and/or governments start to use and value digital credentials in the near future that in 5 years academic digital credentials may become extinct.

VIII. CONCEPT OF SUSTAINABLE DEVELOPMENT

Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” .Most technologically inclined companies like IBM and Microsoft are investing in infrastructures to support blockchain, it would be a lot easier for companies and business to move in that direction. Blockchain as we know it can change the way business transactions take place. The visibility in its process, which help ensure efficient transactions, promoting food safety, efficient records, elimination of counterfeits and trust between ethical trading partners [28].

IX. CONCLUSION

Blockchain technology has been seen to be of great value in the educational sector due to its ability in data storage, which is securely encrypted on a blockchain network and provides information on real time basis. It has also seen to be useful in improving the education system in the way of record transparency of both students and staff and effective maintenance to avoid duplication, accurate verification to avoid errors or alteration while retrieving information, tracking of past records and aggregation of information for final use, thereby ensuring sustainability in educational sector. It can be seen that the application of blockchain in the field of higher education has a good development prospect. The application of blockchain technology in education is still in its infancy. In order to identify specific gaps in research that must be considered in future studies, it is required to conduct a study of current blockchain work in the domain of education. This

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
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study aimed to perform a thorough review of blockchain implications in the education industry. For this purpose, this paper conducted a literature review based on content analysis. Our literature review enabled us to assess the benefits and drawbacks of using blockchain technology in educational arena. Consequently, our research may assist future attempts to overcome the limitations of current solutions in the study of blockchain integration in education.

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