

A Review of Blockchain and its Impact in the Education Sector

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Abstract—Blockchain is the title of the mechanism that has been primarily used for cryptocurrency transactions. Blockchain is being used in a number of industries, including finance, education, and commerce, in this age of inventions and technological developments. This paper provides a general introduction of blockchain's features and operation and in addition the comparisons of various consensus techniques and cryptocurrencies. It also examines how blockchain can be used in the education industry, with examples of current applications. A few anticipated challenges are also addressed.

Index Terms— Blockchain, education, cryptocurrency, smart contract, consensus.

I. INTRODUCTION

Over the years, there has been potential expansion in the education sectors around the world. Only 12 percent of the world's population was literate in the 1820s, and after nearly two centuries, the number has reversed, with 12 percent of the world's population being illiterate. Every five years, the worldwide literacy rate has increased by 4% in the last 65 years. The education sector has transformed dramatically from conventional teaching and learning to online teaching and learning, resulting in a new concept of education. Many online education platforms exist in this generation, such as Khan Academy, Udemy, Unacademy, Byju's, and others. Massive Open Online Courses (MOOCs) are courses where learners get unrestricted access to online courses. For a lifelong learner, it is very difficult to get the degrees or certifications for the knowledge they gain. Schools, colleges, and other educational institutes can offer limited certifications [2][5]. Blockchain helps the learner to get online certification and even 'open badges' or 'digital badges' for his/her achievement. Every year, educational institutions must keep track of thousands of students' records. This procedure becomes frantic, and it is complicated to maintain these documents as hard copies because it would necessitate a lot of storage space and paper. The records could be misplaced or torn. Blockchain may be utilized as a lifelong e-portfolio to keep all our certificates and online degrees organized and accessible. By learning, we can also perform certain smart contracts and receive rewards or 'kudos' [1].

A. Cryptocurrency

Cryptocurrencies are the cash that are digital that are traded over a blockchain ledger, with the ownership of each coin kept in the database using cryptography to manage, safeguard, and verify transactions. For example, if we wish to send money to a person in another nation, we'll first transfer the funds to that person's bank account through a bank. The individual can then receive the funds from the appropriate bank, however this procedure

delays and there is no direct connection amongst the sender and the receiver. In addition, the bank, as the intermediary, receives a portion of the proceeds. It was proposed that a system be developed that would facilitate for quick transactions and money transfers without the need of a third party, and Bitcoin was created as a result. In spite of the fact that there are numerous cryptocurrencies available today, two of them serve as cryptocurrencies' paradigms. Bitcoin and Ethereum are the most popular cryptocurrencies and have a large market capitalization.

Satoshi Nakamoto created Bitcoin, the first cryptocurrency, in 2009. It was created for peer-to-peer digital transactions. As of 2017, Bitcoin's price had risen over 1700 percent to \$20000 due to trading. A digital wallet containing a public key and a private key is held by the bitcoin system. The user's transactions are accessible using a private key, which is only visible to the user. Others may apply the public key to access the user's bitcoin address and make transactions with them. Bitcoin uses Proof of Work (PoW) type of consensus algorithm to perform transactions [14].

After Bitcoin, the second most admired cryptocurrency is Ethereum with regard to market capitalization. Ethereum was founded in 2013 by Vitalik Buterin and went live in 2015. It was designed as a decentralized open source blockchain for smart contract execution and decentralized application development (dapps). Ethereum uses both a Proof of Work and a Proof of Stake consensus algorithm (PoS). Every transaction is verified and secured by a massive amount of computing power given by all of the machines on the network which are encrypted, making it nearly impossible for a third party to intervene.

B. Consensus Mechanisms

In blockchain, a consensus mechanism is a technique through which the miners of a particular blockchain reach an agreement on the data inside the network.

When a block needs to be added to a blockchain, the PoW algorithm presents it to the miners as a cryptographic puzzle. Miners compete against one another in order to solve the riddle. They alter the hash several times to ensure that it is unique from the rest of the blocks in the hash. They do it by sending processing power as energy. By consensus, all other miners on that blockchain validate the block, and the first one to solve the puzzle wins and distributes the solution. The miner who won would receive 'block rewards' which are monetary benefits.

To reduce significant resource consumption during the competition process, PoS provides a concept of coin age, which is unspent asset multiplied by its length from the last winning time to the present time. The hashing operation is also used in the consensus process in PoS. The validators of a PoS algorithm must present a 'stake' of their cryptocurrency. The greater the stake, the greater the miner's mining power. The stake winner would earn some benefits in exchange for validating a new block on the blockchain.

The Directed Acyclic Graph (DAG) is a conceptual representation made up of circles (or vertices) that represent activities and are often connected by lines (or edges) that point out to the direction of flow of data from one vertex to the next. One of the five Distributed Ledger Technologies is DAG (DLT). Blockchain, Hashgraph, Holochain, and Tempo are the other four DLTs (Radix). For validating a transaction on their ledger, each DLT takes a different approach. Any node can initiate transactions in the DAG method, but in order to validate them, the node must first check two or more previous transactions on the ledger. Their transaction will be confirmed if they do so. The more transactions a person validates, the more transactions he or she will be able to validate in the future. Hence, a longer chain is created and provides greater scalability [3].

C. Smart Contracts

A smart contract is a contract that is digital rather than paper-based. The contract's terms and conditions have already been programmed. Without the use of a third party to intervene, smart contracts boost trust between two parties. Smart contracts are the digital contracts or agreements that contains the terms of the deal that have been pre-programmed. It can be executed without the involvement of a third party according to Ethereum's blockchain technology. When a deal is struck, the blockchain creates a smart contract that lasts for a set amount of time. Smart contracts are written in code and operate on IF-THEN logic. If the contract is successful, the details are made public, and the code is removed so that no one may change it in the future. When preset circumstances are satisfied and validated, a network of computers is used to carry out the tasks. These activities could include transferring payments to the proper parties, registering a vehicle, providing alerts etc. The blockchain is upgraded once the transaction is accomplished. That is to say the transaction can't be changed, and the outcomes are only visible to people who have been granted permission to see them. A smart contract can have as many parameters as necessary to persuade participants that the activity will be completed appropriately. In order to figure out the conditions, contributors must agree on how transactions and associated data is represented on the blockchain, upon the "if/when...then..." rules that regulate those transactions, analyze any exceptions that may

exist, and design a structure for resolving conflicts. A developer can then code the smart contract, though businesses that implement blockchain are increasingly giving web interfaces, templates, and other online resources to make smart contract creation easier [8]. The contract is immediately executed when a condition is met. There is no paperwork to deal with, and no time lost fixing errors that can occur when filling out paperwork by hand, since smart contracts are digital and automated. Because there are no third party involved and encrypted transaction records are distributed among participants, there is no necessity to be concerned about information being altered with for personal advantage. Transaction records on the blockchain are encrypted, hacking them is exceedingly difficult. Furthermore, because every transaction on the distributed ledger is linked to the entries before and after it, to update a single record hackers would have to change the entire chain. Smart contracts do away with the necessity for intermediaries to perform transactions, also the temporal delays and expenses.

II. UNDERSTANDING BLOCKCHAIN

Blockchain is a decentralized, distributed, open ledger technology that is mostly utilized for cryptocurrency (digital money) transactions such as Bitcoin. It's a peer-to-peer system. As the name implies, 'blockchain' refers to a collection of data linked together as time-stamped, immutable records that are organized chronologically as 'blocks of data'. Each block contains data, the previous block's hash, and the hash of its own block. A block can be around 1 MB in size. In a blockchain, each block has its own hash, which is a unique 64-digit address. Blocks are linked to each other using hashes [18]. Over the last few years, blockchain technology has grown at a breakneck speed. From 2013 to 2016, venture capitalists invested a total of 550 million dollars in blockchain start-ups, according to Statista. The global blockchain technology market was anticipated to be valued around 2.3 billion dollars by 2021. According to McKinsey & Company, in spite the fact that this technology is still in its infancy, it may reach its full potential in the next three years. Blockchain is a brilliant idea and powerful technology that is potent to address mutability and social security concerns.

A. Working of Blockchain

There are four people in a bitcoin blockchain, for example. They each have a bitcoin. As a consequence, the blockchain's total number of coins will be four. Each user would have a duplicate of each other's bitcoin hashes, as well as their own hash. If someone tries to hack a bitcoin, the bitcoin's hash will be affected. The blockchain verifies if each member's number of shared hashes is the same or not. When it discovers that a coin's hash differs from other hashes, it will automatically reject the coin. As a result, blockchain is a secure platform that decreases the risk of being hacked. All of the blocks on a blockchain should be connected in some way. Every block, for example, should have the first 15 digits set to 0. As an outcome, the blocks in a blockchain become uniform. To do this, the strings of the blocks are modified repeatedly in order to obtain a desired similar hash, as even a single number or character in the block can affect the hash. However, we do not want the blocks' data to alter that is why we add a nonce, which is a random string of digits. Only nonce is allowed to change as a result of this, and the data is unaffected. Mining is the process of changing the nonce repeatedly to obtain a desired hash, and miners are the ones who do it. Miners send a set amount of processing power as electricity for mining. The higher the power, the faster the change in hashes.

B. Features of Blockchain

Blockchain has various distinguishing characteristics that set it apart from other networks [3]. The following are the details: -

1. Decentralization: No node in a blockchain network functions as a server, and there is no central authority. As a result, each node is given an equal chance and is able to act more quickly. In case of Bitcoin, blockchain is employed in a decentralized manner, meaning that no single person or group has power rather, all users have control collectively.
2. Immutability: It means that once a block is constructed and data is saved in it, no one else can edit it. Changes in the data will also modify the hash, which can be identified. Furthermore, blockchain is consisting of thousands of nodes that are all active at the same time. As a result, every modification in the chain would necessitate the replacement of a majority of the ledger, which is essentially impossible. It provides safety.
3. Time-stamped: Blockchain is mostly utilized for financial transactions and activities. It's a private network that can't be hacked by a third party. By some pre-defined formula, the currency base of blockchain is 21 million caps. A block is timestamped when it is created. This aids in determining when and where the transaction occurred, as well as locating data of previous transactions.

4. Consensus: This is a means for all members to verify and come to an agreement on a fresh block to be put to the blockchain. It can be accomplished in three ways. - Miners compete against one another to solve a digital, mathematical problem in order to create the new block. The person who solves it is rewarded with additional bitcoins, and the solution is accepted by others, and the block is added. This is referred to as “proof of work”. It is known as ‘Proof of stake’ when a particular number of cryptocurrencies are displayed for proof of being an active member of the blockchain. Another method of verification is known as ‘Proof of Zero Knowledge’, which uses Zcash (a cryptocurrency) to give improved privacy and efficiency.

5. Distributed: Every node in a blockchain receives the same amount of data. Transparency is prioritized. Consensus is used to add a block to the blockchain, that implies that all members must agree upon that. This guarantees that each blockchain node is involved. For financial transactions, distributed ledgers such as blockchain are quite beneficial. Because of their decentralized nature and the immutability of the ledgers, they give greater security.

III. BLOCKCHAIN IN EDUCATION

We discussed the many components of blockchain and how it works. Blockchain technology is already being used in a number of educational institutions. Learning and teaching are both possible with blockchain. After receiving a digital certification from the blockchain, a person who has completed a course can teach other members. With its unique characteristics, in the educational sector, blockchain is potent to discover a variety of applications. and to become an integral component of it in the next years.

A. Need of Blockchain in Education

Blockchain can be utilized to verify a student’s identity, preserve their privacy, measure records and credentials, and save them as a permanent public record. It has the prospective to go beyond the old, traditional learning model and provide a whole new way of teaching and learning, with open access and a platform for life-long learning. It can also add value to education by funding it and pupils are rewarded for their growth and achievement. Blockchain can be beneficial to education in the following ways:

1. Maintaining student records: Keeping records is one common use of blockchain in education. The quantity of student records is practically infinite, and establishing academic qualifications can be time-consuming, requiring extensive paper documentation and case-by-case verification. For situations 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. With a few simple clicks, an institution admitting a transfer student might validate their record and the courses they took using blockchain. The same principle applies to sharing records with an employer. A digital transcript can be extremely thorough, incorporating information such as attendance, courses taken, and even exam or paper outcomes. Those who access the transcript of a student, such as other institutions or possible employers, can see how they performed particular tests. This technology could be beneficial not just in higher education, but also in primary and secondary school.

2. Managing digital diplomas: A college diploma is most precious records a student may have. Digital diplomas have been the most prominent examples of how blockchain can be used in education in recent years. Maryville University became one of the first institutions to introduce blockchain transcripts and diplomas in 2019, giving students and alumni control over their academic credentials. Blockcerts Wallet, a smartphone software, now allows students to manage their digital credentials. The programme uses blockchain technology to create a tamper-proof, verifiable diploma that may easily be shared with prospective employers and other educational institutions. Using blockchain to store and transfer academic credentials, particularly degrees, benefits students, institutions, and employers due to the technology’s inherent permanence, convenience, and security.

Benefit for Students: Students may own and manage their academic achievements and share them whenever and wherever they want by storing diplomas on a blockchain. Historically, colleges have owned and controlled student records, forcing students to rely on them to access and share their academic information. There are numerous problems in this model. Physical documents can be lost or destroyed, students may be charged a price to access them, and graduates may have difficulty locating an authority to validate their academic achievements. Students may take control of their academic identities thanks to blockchain, which provides them ownership of their personal records. This makes it much easier for graduates who are job looking, for example, to prove the veracity of the qualifications on their resume and offers them control over what an employer can access.

Benefit for Educators: Smart contracts, a feature of blockchains, could make instructors’ jobs easier. When specific criteria are met, a smart contract consists of lines of code programmed into a blockchain that automatically execute. A teacher, for example, may programme lessons and courses into a blockchain, assigning

tasks to pupils, and the blockchain's smart contract would automatically verify each assignment's completion and then assign the next task to the student, until all tasks are completed. Teachers might utilize the same smart contract technology to help them grade their students. Educators might programme whole tests into a blockchain, including questions, answers, and scoring settings, and pupils could take the exams on computers or tablets. The blockchain then handles grading, freeing up professors' time for other academic pursuits, and the student's grade becomes a permanent part of their academic record, safely kept on the blockchain.

Benefit for Institutions: Higher education institutions save time and money by using blockchain to issue diplomas, which streamlines the verification process. Blockchain-issued diplomas make validating a student's academic record considerably easier for graduate institutions because they are virtually tamper-proof.

Benefit for Employers: Employers will find it easier to hire with blockchain-based digital diplomas. Employers merely require a link to a digital version of a potential hire's diploma, rather than requesting the issuing institution to validate a paper copy. Because storing information on a blockchain provides further security, it is more difficult for applicants to fake their academic credentials, ensuring that new hires have the essential knowledge and abilities to succeed in the workplace.

3. **Transforming university curricula:** The influence of blockchain in education is far more than just storing records. The technology has the ability to change how university curriculum are managed. For starters, blockchain allows for secure preservation of digital syllabi and coursework. Hard drives are used by institutions, however the risk of the drives being damaged or compromised is a problem. Another alternative is cloud storage; however, it may be too costly for some organizations. By strengthening the accreditation process, blockchain can also increase the quality of online education. Because of the convenience of online education, unaccredited or uncertified colleges may operate on a seemingly level playing field with reputable universities, putting online learners at danger. Accreditation records on the blockchain give openness and security. Blockchain can also be utilized as a decentralized platform for institutions to share information on online courses and programs, also for students to submit ratings of online offers, assisting other students in finding accredited programs to further their education.

4. **Lowering education costs:** Managing student tuition payments is a time-consuming procedure that involves a number of stakeholders, including students, parents, scholarship foundations, private lending businesses, federal and state organizations, and university financial departments' often-massive bureaucracies. Blockchain has the ability to streamline this process, decreasing administrative expenses and, as a result, potentially cutting tuition costs. In addition to its potential to support lifelong learning, blockchain technology might be used to enable universal access to open educational resources, such as books, podcasts, and films, which are available publicly and are free to use and redistribute. In a public network, blockchain allows these resources to be shared inexpensively and securely.

5. **Promoting research:** Higher education has two goals: to pass on knowledge to future generations of students and to expand present knowledge through new research. Professors devote a significant portion of their time conducting research and publishing their findings, pushing the frontiers of their fields and revealing study topics that will take us into the future. Importantly, the reach and impact of those papers can have an impact on academics' capacity to acquire major funding to support future research. Authors have a vested interest in keeping track of how their work is utilized and preventing flagrant piracy. Researchers would be able to publish without restrictions, but in a way that would allow them to track their research's reuse, such as how often a work is cited and used as teaching materials, allowing them to track its impact in the field, which is important because it can lead to accolades and future funding.

B. Some Applications of Blockchain in Education

Crowdsale is a digital platform for BitDegree. It is blockchain powered online education platform. BitDegree is the first blockchain powered platform that used tokens scholarships. They provide great online courses with a transparent blockchain based reward system and success rate tracking. LiveEdu is a website that is like the YouTube for online education. Blockchain helps in the complex database system of student record by providing tamper-proof system of records we want as confidential and secure. For example, Sony Global Education made a private IBM blockchain platform for holding student records. It includes degrees, diplomas, assessments for primary and higher education. They share this as a commercial for selected educational institutes. IBM Company with Linux foundation used blockchain technology, made an umbrella project called Hyperledger Fabric for open source blockchain projects. It had over 1,500 people working on various blockchain projects under Hyperledger. Mozilla Open Badges designed in 2012 for digitizing credentials, used blockchain technology to create Blockcerts. Blockcerts is an open standard for combining issuers, earners and displayers for model of Open Badges and integrate the security, accessibility and permanence. Open Badges were originally created as a

research project in MIT (Massachusetts Institute Technology) that gives blockchain based certificates. University of Nicosia use academic certificates using bitcoin blockchain since 2014. Ngee Ann Polytechnic at Singapore started issuing certificates using blockchain with the assistance of Attorees for job seekers and admission for students. It helps employees as less time is required for selecting employees digitally rather than doing manually.

C. Challenges of Blockchain in Education

Despite the potential benefits of blockchain, its adoption in the area is still restricted. Much of this apprehension may be due to the difficulties of deploying the technology, which include issues of security, scalability, adoption rate, and cost.

1. Security: Though one of blockchain's distinguishing characteristics is security, this does not imply that it is impenetrable. As the blockchain-based storage is so sensitive, students' educational records and academic credentials, institutions must be careful what data they store and how they preserve it. Universities may need to use private or permissioned blockchains, or encrypt data on the blockchain, to adopt greater privacy safeguards.
2. Scalability: Educational institutions have a lot of data about their students and graduates, which might make blockchain scalability a problem. Because each transaction requires peer-to-peer verification, the number of blocks required grows as the amount of data involved grows. This lowers the speed of transactions on the blockchain. This may be the case of a substantial impediment if implemented widely. Permissioned blockchains, on the contrary, have a higher transaction rate per second than permissionless blockchains.
3. Adoption Rate: Blockchain, like other technology before it, can only succeed if enough institutions and employers trust it; graduates will only benefit from ownership of their credentials if the schools or firms to whom they are applying accept their legitimacy.
4. Cost: Although it can save money in other areas, implementing and putting into practice new technology is expensive. The cost of computing power and the cost of modifying current infrastructure can quickly pile up. Furthermore, many institutions may lack the knowledge and skills required to manage student data on a blockchain platform, necessitating the expenditure of both money and time in training school administrators on how to use the technology.

IV. CONCLUSIONS

Blockchain is a true boon to innovation and technology. It can be used in different ways. It is a technology that is always changing that will find applications in a large number of fields. We went over how blockchain technology is secure as the blocks are linked together by hashes, eliminating the possibility of data being hacked; immutable because after data is saved in the blockchain network, it cannot be modified or altered; decentralized because there is no central authority and thus no chance for mediators to intervene; and distributed because data is evenly distributed to all participating nodes in a blockchain, eliminating the possibility of data being hacked.

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