

## **Blockchain in Education – A Survey**

**Tapas Kumar Ghosh**

*Department of Computer Science,  
Bankura Sammilani College, West Bengal, India*

### **Abstract**

*Blockchain technology is a promising technology in recent times. Since its inception it is a core technology behind the use of several cryptocurrencies. The key features of this technology are distributed storage, immutability, impossible to hacking etc. These features are now attracting several sectors of digital world to adopt it. Digitization of education is also trending in present days. So naturally it draws attention from industry and academia to apply this technology in present day education system also. Application of this technology in education is extremely new with a limited number of peer-reviewed published literatures in this area. Little information about applications and limitations of this technology along with some already developed systems are available in the literature. We have tried to summarize that information in this paper.*

**Keywords:** Blockchain Technology, Educational Technology, Smart Contract, Distributed Ledger

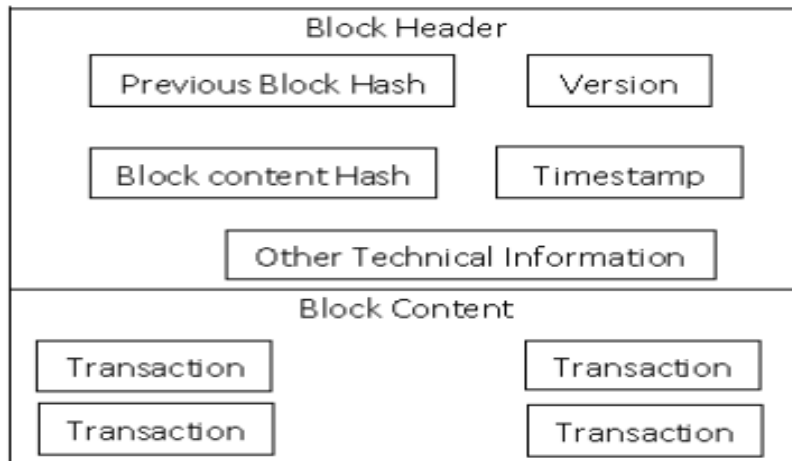
### **1. Introduction**

Education system in today's world is accelerating towards digital era. Combination of technology and education has become more popular in recent years. Applying technology in education system is a global phenomenon of present days and according to Global News Wire online learning through mobile phones is now the fastest growing market in the education sector [1]. Digitization of education has also become inevitable to mitigate the global crisis of Covid-19 pandemic. Several countries across the globe have forced to move their education system into digital platform during such crisis period. In this context security of technology enabled education system is also a great concern of present era. Different stakeholders in the field of education proposed different guidelines since its early adoption of technology. One solution that is gaining popularity in recent years is based on Blockchain technology. This tool can be effectively used to solve the shortcomings of present day education systems like poor certification, lack of recognition and data insecurity. This technology may make the learning process more reliable and authentic. Lifelong learning is also possible with help of this technology. The different key stakeholders of modern education systems are students, teachers, employers and government. Each of them interacts with the system in multiple different ways. Trustless and decentralised Blockchain technology in the form of immutable ledger of past activities to which different stakeholders can refer without any one of them to trust any other can perform a practical role in high stake spaces like education. A borderless digitized education system may be created with this technology.

The term Blockchain was first came into existence with the invention of a new cryptocurrency bitcoin. It was November 2008 when the world came to know about this currency from the renowned white paper "Bitcoin: A Peer-to-Peer Electronic Cash System" posted in the Internet by a researcher or a group of researcher under the pseudonym Satoshi Nakamoto [2]. In this paper he first gave the idea of creating and transacting the cryptocurrency bitcoin without intervention of a trusted third party. This new currency is fully distributed and maintained in the form of a chain of blocks which is called Blockchain. At present time this new technology has found its way into a number of diverse fields like finance, education, different supply chain management systems, IOT applications and so on. The key idea behind this technology is, it can create a distributed ledger of transactions which is immutable. After this brief introduction the rest of this paper is organised as follows. In Section 2 brief overview of Blockchain technology, smart contracts in it and applicability of Blockchain in education are discussed. In section 3 a literature review and some Blockchain based solutions in education system is discussed. Section 4 discusses about limitations of blockchain technology in education. Section 5 concludes the paper.

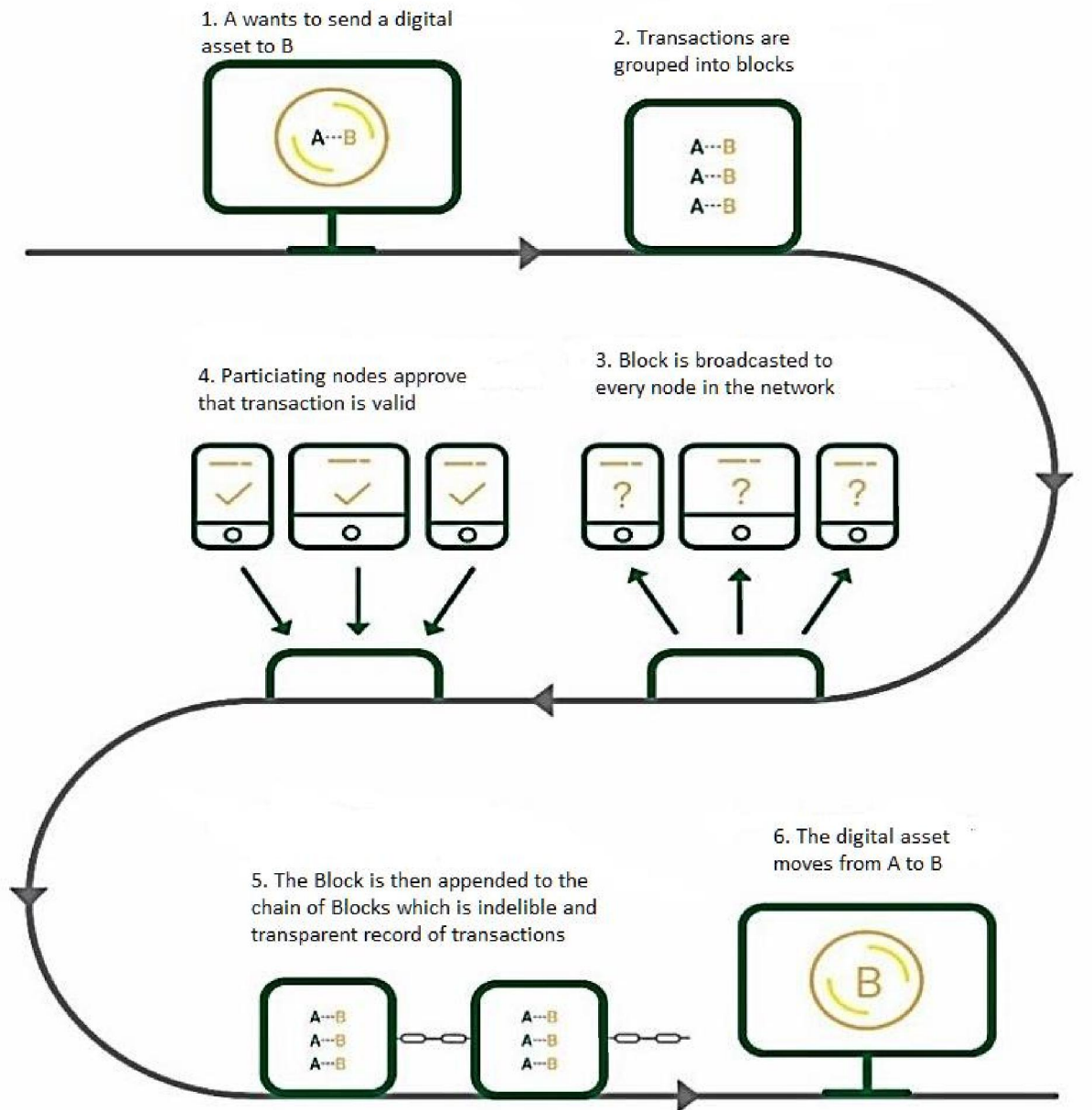
### **2.1 A Brief Overview of Blockchain Technology**

The Blockchain technology allows the nodes of a peer to peer network to keep a chain of digital records of transactions in a decentralized and distributed manner. Typically a block in a Blockchain looks like figure-1. Whenever a transaction occurs it is broadcasted to all nodes of the peer to peer network. After checking the transactions nodes group them into blocks. Identification of a block is done by its hash value computed using the content of the block. Each block also contains hash of its previous block in the Blockchain to make them cryptographically linked. To add a block to the Blockchain participating nodes have to run a consensus algorithm. This algorithm requires a node to solve a cryptographically strong mathematical puzzle which consumes some electric power and take some time (In the bitcoin network it is almost 10 minutes).



**Figure 1: A typical block format**

The nodes which will try to solve the puzzle are called mining nodes. The node which is able to solve the problem first will broadcast the solution in the network. The solution of the problem mainly depends on three factors such as consumption of power, the computer system used for mining, and the network infrastructure. In the bitcoin network application specific integrated circuits (ASIC chips) are the specially designed computer systems used by miners to solve the problem. After receiving the solution remaining nodes will check it and if it is correct they will add the block to the Blockchain otherwise the nodes will remove the block. Reaching consensus in this way is called consensus by proof of work. There are other ways of reaching consensus also like consensus by proof of stake, consensus by proof of capacity etc. In the proof of stake protocol validators are selected on the basis of their holdings in the related cryptocurrency. This algorithm was designed to avoid the computational cost of proof of work algorithm. Also in the proof of capacity consensus protocol mining rights are allowed to nodes depending on available space on their hard drive. After successful run of consensus algorithm, if the participating nodes validate the block, it can be added into the blockchain by every node in the network. All nodes in the network will share this chain of blocks commonly known as distributed ledger [3]. Once a block is added to the Blockchain it can never be deleted or modified. Only new blocks can be added at the end of the chain after reaching consensus by other participating nodes. Since each block contains hash of its previous block, the Blockchain becomes immutable, because tampering a block in the Blockchain changes its hash value, which in turn requires a change in all subsequent blocks. So consensus algorithm has to run for all subsequent blocks which are impossible. Figure-2 explains the working principle of a typical Blockchain network.



**Figure 2: How a Blockchain works [8]**

Usually three different types of Blockchain network namely Public, Private and Consortium Blockchain are available worldwide. A Public Blockchain is open to all. Anybody can download, run and make transactions in it. A Private Blockchain can be used by a limited number of parties to make transactions among themselves. Consortium Blockchain may be used as a hybrid model of public and private Blockchains. Members can join it through invitation only, but all invited members have equal voting rights with decision taken by consensus. A public Blockchain is more secure than the others. Table-1 summarizes the different parameters of the three types of Blockchain network. Commonly used different popular Blockchain platforms are Bitcoin, Ethereum, Hyperledger fabric, NXT etc.

**Table 1: Comparison among different types of Blockchain**

Property	Public Blockchain	Consortium Blockchain	Private Blockchain
Consensus Algorithm	Run by all miners	Run by selected set of nodes	Run by one organization
Access permission	Allowed to all	May be public or restricted	May be public or restricted
Immutability	Impossible to tamper	Possible to tamper	Possible to tamper
Network Speed	May be slow	High	High

## 2.2 Smart Contract in Blockchain

A common application, frequently used in Blockchain technology, is smart contract. This technique was developed on cryptographic security mechanism and is able to complete complex transactions without human activities. Implementation of automatic execution and verification of transactions through smart contract can simplify transaction process and able to improve transaction security. Comparing with the traditional paper-based contracts, a smart contract helps its users to codify their agreement without supervision of a central authority. Using smart contract, education system platform can complete course purchase, settlement between two parties and acceptance without taking any labour charge [4]. For example, if a student wants to receive an approval of the concerned authority, for a document, smart contract may guarantee the document is approved by the genuine authority within a specified time frame and in a particular manner.

Without a smart contract, the student has to approach physically to the concerned authority which may waste his time [5]. For another example of smart contract in education we may consider the following example. When a teacher wants to create a list of tasks to be done by students for completion of a course smart contract can help in this case. Anytime whenever a student completes a task smart contract can automatically verify it and after completion of all tasks student may be awarded credits for the course. A smart contract is also helpful in creating and conducting online examinations. The smart contract also guarantees about the genuineness of the document preventing fraudulent approval. In [6] authors have claimed that since smart contracts are stored and get executed in a Blockchain, they are also tamper proof. Solidity is a popular platform for writing smart contract on a Blockchain.

## 2.3 Applicability of Blockchain in Education

Adoption of Blockchain technology in education has a high impact on the way degrees and diplomas are achieved for developing the workforce of 21<sup>st</sup> century. Blockchain can be used to solve various problems of present day education system. One obvious problem is to check authenticity of someone's certificates of degrees and diplomas reflecting his/her skill and achievement. In a paper based old system of verification this task is time consuming and cumbersome. Even in a centralised digital system several problems may arise like verification from an employer side, or retrieving a copy of someone's own credential. Education providers generally store these credentials in their own servers which is not publicly accessible. Therefore to solve this problem a system is needed for instantly checking the authenticity or retrieving copies of these credentials. Blockchain technology may help in this regard. Education providers may keep the certificates or degree and diplomas in a Blockchain signing digitally with their own private key. An employer can check the blocks with the education provider's public key. Also a student can retrieve his/her own credential through his/her self sovereign identity. Digital self-sovereignty is a concept which helps an individual to get his/her own credential for the purpose of viewing, sharing or verifying independent of the education provider. This independence can be gained by a combination of three things as-

- Credentials should be issued in a format based on open standard.
- Issued credentials should contain public key of the recipient.

- Credentials should be available through an individual's mobile wallet that gives recipient's control on their own private keys and continue to operate and sustain forever independent of any particular education provider.

Thus in brief self-sovereignty means once the credentials of an individual is stored on a Blockchain the individual can become the custodian of his/her own credential.

### **3.1 Literature Review**

A virtual model of Blockchain based solution for utilisation of educational resources was proposed in [7]. In this paper the authors explored the proposed system's architecture and claimed that the system can help peoples from educational community to manage their resources in such a way so that unauthorized access and tampering of educational resources can be avoided. An exploratory study was also provided in [8] to investigate different facets of Blockchain technology in education. The authors claimed in their study that all stakeholders could be fully benefited through only open implementation of this technology in education. They have also stressed that PPP model is necessary to fully exploit Blockchain in education. In [9] the authors proposed a Blockchain based decentralised system for reputation and educational records management. Here reputation means how much the society trusts you. As high as your reputation you are more trustworthy considered by others. The reputation of a system or an individual can be judged from his or her previous interactions or transactions with the society. Falsification of personal reputation is increasing in present times. For example many service providers in E-Commerce may register a huge number of fake customers to get a high reputation. The authors have shown that Blockchain technology can solve this problem efficiently. [10] in their paper proposed an educational learning platform designed on a Blockchain based system which they claimed, may make the educational system more transparent and versatile. They also guarantee that their system provides strong privacy to teachers as well as students data. Also they claimed that the developed system can work in a multi user mode which allows students or a group of students to compete against each other. [11] In their work discussed several applications of Blockchain technology in education. The authors provided a systematic literature review on advantages and hurdles of applying Blockchain technology in education. Their study also identified some future areas in educational field where Blockchain technology may be successfully applied. In another work made by [12] the authors systematically analyzed 28 publications, from which they have discussed the current state of Blockchain application in education. From their review they also found that a continuous progress is happening in the field of education through use of Blockchain. A detailed discussion of different applications of Blockchain technology and its impact on lifelong learning is available in [13].

A learner centric model of learning process which emphasized on how to augment tutoring, smart badges and e-portfolio with Blockchain technology is discussed in this work. Several challenges and opportunities of applying Blockchain technology in higher education in India is discussed in [14]. According to the authors India stood at sixth position for approved patents of Blockchain technology but the education sector in India is not using this technology with high extent. Compared with other countries, India is lagging behind in application of Blockchain technology in education. According to them there is a lack of sophisticated human resources in this field in India due to lack of awareness about this new technology. Several potential issues of applying Blockchain technology in education are discussed in [15] also. According to the authors immutability feature of Blockchain technology will not allow any modification in the instructional records which may be necessary in future with justified reason. They also claimed that evaluation of class presentation and articles through an automated system is merely impossible.

Several potential applications of Blockchain technology in education is also discussed in [16]. The authors highlighted that Blockchain technology can play a crucial role in protecting the intellectual properties. In case of intellectual properties proving ownership is always challenging. Blockchain technology can solve this problem efficiently by checking the records stored in it. According to the authors smart contract based learning activities are able to provide transparency, which in turn strongly protect those teachers who will do a good job. Both learners and teachers behaviours can be recorded and also monitored through smart contracts. According to [17] after the current era of Net neutrality and Big Data Blockchain will become a technology enabled socioeconomic mega trend. The author claims that Blockchain can be adopted in every sphere of education like school funding, school payroll, financial procurement, cross border learning, certification, human resource management etc.

### **3.2 Existing Blockchain based solutions in education system**

Different institutes and organizations from the different corners of globe has started to provide Blockchain verifiable qualifications (BVQ) of which some remarkable ones are MIT Media Lab, University of Nicosia, LinkChains project, Learning Machines, Fraunhofer Institute's FIT4Edu, Sofocle Technology etc. Blockcerts is an open standard which creates, issues, helps in viewing and verifying Blockchain based credentials. Initially it was designed by MIT Media Lab and by Learning Machine which is now Hyland Credentials. The University of

Nicosia was the first university to offer an open source platform for issuing and verifying digital certificates based on Blockchain technology. They started issuing credentials through the use of bitcoin Blockchain as an anchor. Federation of State Medical Board (FSMB) of the United States have become the first professional membership organization which issues official document of medical education credentials through Learning Machine’s Blockchain based issuing system. In this system credentials of a group of students are batched together and the entire batch stored in the Blockchain at once. Merkle tree data structure is used here to allow members of a batch to be verified with their credentials which the student holds. Learning Machine supplies this facility for different institutes like MIT, FSMB etc [18]. UK’s Open University Blockchain team has developed a mobile app based system [19]using Blockchain technology for which they claimed that instant verification of test results without tampering is possible. FIT4Edu is also educational credential providing system developed on Ethereum platform.

**Table 2: Features of existing systems of Blockchain in education**

Application	Blockchain Used	Record Format	Actual Data Stored	Verification	Access to records
Blockcerts	Bitcoin	Certificates	Hash of Certificates	Open	Off-blockchain authorization
University of Nicosia	Bitcoin	Certificates on MOOC	Grouped Hash of Certificates	Open	Off-blockchain authorization
FIT4Edu	Ethereum	Certificates	Hash of Certificates	Open	Off-blockchain authorization
Certyza	Hyperledger Fabric	Certificates	Hash of Certificates	Open	Off-blockchain authorization

#### 4 Limitations of Blockchain Technology

Researchers from different parts of the globe have reported different issues that were faced in the implementation of Blockchain based education systems. The reported main areas are: Different problems between the European Union’s General Data Protection Regulation (GDPR) and Blockchain technology are discussed in [20]. The GDPR emphasized on individual’s privacy and autonomy should be preserved, whereas Blockchain technology believes in a decentralised and de trusted system. Therefore, any Blockchain application of education system in Europe should carefully consider GDPR implications.

The long time (in case of bitcoin 10 minutes) necessary for validation of each transaction is another limitation of Blockchain technology. Tradeoffs between size of block and security is also challenging as reported by [21]. Scalability is a serious issue in Blockchain technology. In simple words, the more the nodes or people join the Blockchain network, the more there is the probability of slow down of the network. Also proof of work based consensus algorithms results consumption of huge electric power. In the bitcoin network it is compensated with gifting some bitcoin to the miner. But in education system an alternative way is needed for such compensation.

Adoption of Blockchain technology in education may produce high data redundancy since each node has to maintain a copy of the entire Blockchain. This is especially problematic if educational resources like study materials, lecture notes, video clippings etc are needed to be stored in Blockchain. The alleged 51% attack related to security issues was also reported by many researchers including [22]. This attack may get successful only if 51% or more nodes in the network become dishonest and modify the Blockchain in their favour. Full adoption of Blockchain technology in education system requires solution for abovementioned limitations.

#### 5 Conclusion

The aim of this paper is to survey about applicability of Blockchain technology in protecting the educational resources that are circulated within an institute or multiple institutes on day to day basis. Though this technology is in its infancy stage for application in education, it is understood that in near future this disruptive technology will become a strong backbone of the present day education system. The key idea behind this technology is to move the education system from authoritarian centralised system to a distributed system that assures no alteration of information and maintain privacy. This technology has all potential to become a standard format for issuing academic credential which in turn is able to eliminate the conventional role of academic institute registrars as the distribution point of such records. On the other side students may become custodian of their own credentials and at the same time they would enjoy flexibility to access with protective security of their own credentials.

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