

Review Paper

Blockchain in Educational Development: Potentialities and Issues— *Towards sophisticated Digital Education Systems*

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ABSTRACT

Blockchain has become an important digital technology component in the Information Technology field and applicable in diverse areas of society and community. Blockchain and its gradual development lead it to become an emerging technology and called as 'Blockchain Technology. Blockchain simply offers a system of recording information and which are not possible to change due to robust and secure systems. Blockchain is a kind of digital ledger transaction that spreads over the entire communications or networks. Due to the adopted mechanism in Blockchain it is difficult to change or hack or check within the systems and therefore this technology is rising gradually as it is using encrypted and distributed databases connected with transactions. Blockchain is a digital ledger system and that further depends on different independent record, and keep recoded data in a particular place. Blockchain is dedicated in tangible and intangible asset management and further concerned pieces of data stored in the same place. Normally, it is being started its uses in the financial segment regarding proper digital currency transactions but gradually it has become an important tool in diverse areas such as in tangible and intangible asset management. As far as the Education sector is concerned it is useful in both onsite and online education systems. However online and e-learning are more suited with Blockchain. Today in educational institutions many third parties are being used in proper educational delivery and Blockchain is being used in proper safeguarding in newer educational and training models. This Paper is about Blockchain with its concepts, features and applications in educational systems, management and the teaching-learning process. Work also suggested the issues and concerns of Blockchain in educational development and management.

Keywords: Blockchain, Online Education, Educational Technology, IT Management, Information Technology, Digital Education

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Blockchain is useful in different industries and institutions such as business and commerce, healthcare and medicine, government and administration, transportation, education, and training, and this trend is emerged in diverse fields due to its decentralized and secure nature^{[1],[5],[27]}. This is also rising for its decentralized storage systems, traceability as well as transparency. As far as Education is concerned it offer ample opportunities to different students community and helps in economic management and development including more potentialities for healthy record keeping, increasing efficiencies, and improved security and expanding more advanced educational development. Blockchain has is able in changing educational systems with the support of more enhanced educational support, and more accessibilities as far as educational development like students-teachers' relationships, and educational management. Here using Blockchain different distributed cryptographic techniques are being used with different algorithms viz. POF (proof of work). Blockchain is a kind of tamper-proof data storage and offer heavy scalability and effective systems for educational development^{[17],[18],[35]}. Blockchain is useful in training and educational certificate management and helps in reducing overall fraud and tempering of degrees. With Blockchain support, smart contracts can be designed using a solidity programming language. Apart from large educational intuitions or traditional education Blockchain is being used in corporate educational systems and executive education including training. Inan effective educational management Blockchain and allied technologies are worthy. One of the key challenges of the modern educational system is collecting lots of different types of data of the students regarding its collection, storage, and analysis and Blockchain can be useful in a different context. As far as individual learning is concerned it gives for learning outcomes, and managing students portfolios Blockchain is emerging and alarming. Efficient organization of the data across different departments is helpful in improving student retention and also in graduation rates. Integrating existing technology into the traditional and existing learning systems also be fruitful using Blockchain. The traditional educational systems can be significantly changed into secure, robust, and publicly accessible eco-systems. In the security of educational systems, educational institution management also Blockchain is effective along with other allied technologies and systems^{[8],[19],[28]}. The growing applications of Blockchain raised to this stage from different passed steps as depicted in Fig: 1.

OBJECTIVE OF THE CHAPTER

The current paper entitled 'Blockchain in Educational Development: Potentialities and Issues—*Towards sophisticated Digital Education Systems*' is a conceptual and theoretical one and focused on the following agenda—

- ☐ To learn about Blockchain Technology especially basic aims and objectives with some application areas.
- ☐ To learn about the basics of Digital Education and Education Technology with its nature and characteristics in contemporary scenarios.
- ☐ To gather about potential and emerging applications of Blockchain in the context of educational pedagogy and especially educational management.
- ☐ To find-out the issues and challenges of Blockchain application in Education, Training, and academic world in the context of Digital Education.

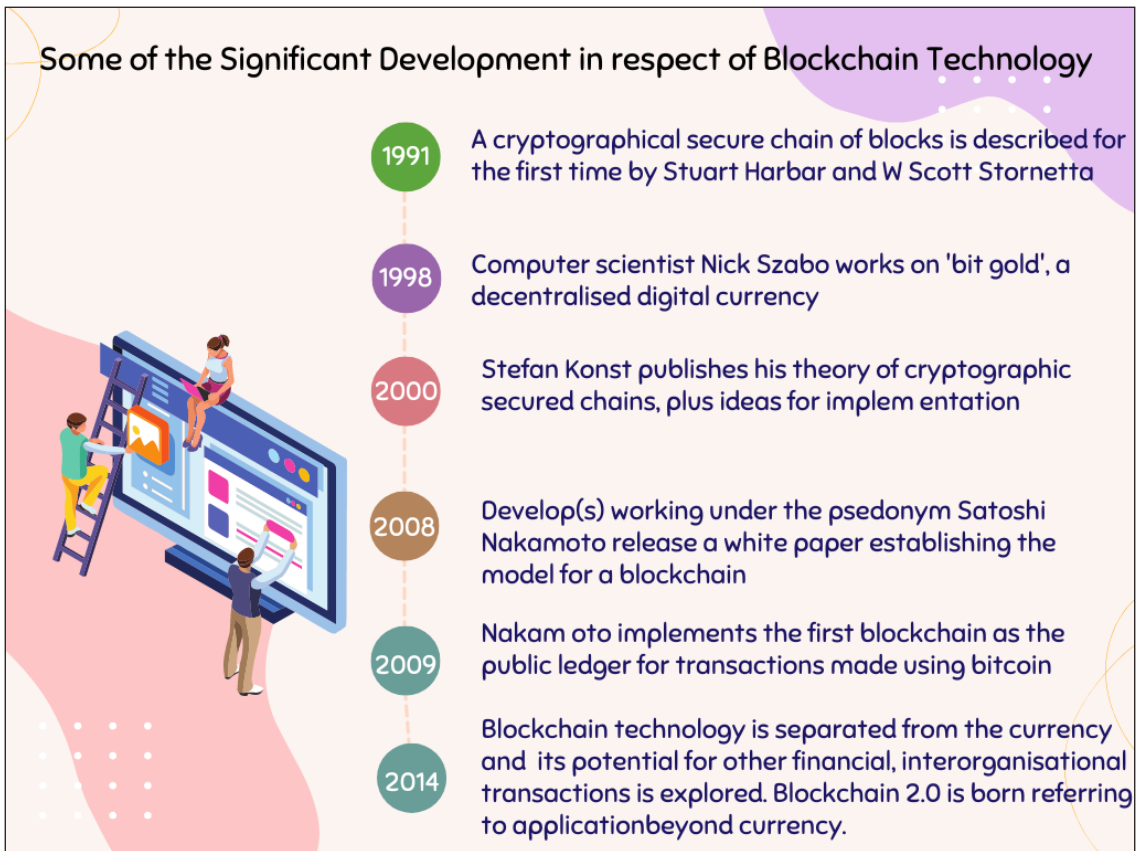


Fig. 1: Timeline of Blockchain Technology as an advanced too of IT (Paul *et al.* 2023)

METHODS ADOPTED

The current paper entitled ‘Blockchain in Educational Development: Potentialities and Issues—*Towards sophisticated Digital Education Systems*’ as conceptual therefore a review of literature played a leading role in its design and construction. As far as the review of literature is concerned it has used journal works, edited research based books, dissertations, and thesis. Websites of the companies and organizations dedicated to Blockchain related businesses have also been analyzed and is used in preparing this work.

BLOCKCHAIN: FUNDAMENTALS

Blockchain become a Technology now and *reached from the fundamental* ‘Blockchain’. Rather technology it is a database with a strong focus on digital trust. In the year 1982 David Cham coined the term Blockchain and thereafter Stuart Haber and W. Scott Stornetta both have written a book in the year 1992, and in their book, the ideas became introduced on Blockchain^{[15],[16],[41]}. However, it is important to note that Blockchain Systems later progressed and were implemented by Satoshi Nakamoto especially after deploying the first digital currency, i.e., Bitcoin. Blockchain Technology comes to this stage by different time-lines such as—

- ⊙ Enhanced cryptography,
- ⊙ Decentralized in currency,
- ⊙ Implantation of secured cryptographic systems,
- ⊙ Implementation of a public ledger system,
- ⊙ Development of blockchain 2.0.

In Blockchain data is basically stored in blocks and all the blocks are linked together in a form of a chain. In every block, they have a specific capacity and upon filling the blocks become closed and it is then linked to the previous block^{[7],[33]}. Further newly added information after the last block is compiled into a newly formed block and added to the chain once filled.

EDUCATION TECHNOLOGY & DIGITAL EDUCATION

Educational Technology is a field of practice and study which is required for the process of not only for studying and analyzing but also for designing, developing, and implementing educational pedagogy and instructions with proper study and learning materials. This technology is an interdisciplinary cluster and helps in improving the teaching and learning process perfectly. Educational technology further helps in today's teacher community regarding implementing new technologies and this may lead newer classroom environment^{[6],[7],[32]}. With adopting Education Technology trainers and faculties are able in offering and upgrade their skills and teaching abilities to improve learner-centeredness and further this technology also enables teachers to engage in more unique, innovative teaching-learning in sophisticated ways. With adopting Teachers are also able to expand their network and connection with other teachers and educators nationally and globally. Refer to the conceptual Fig. 2 depicted herewith on Blockchain in Education.

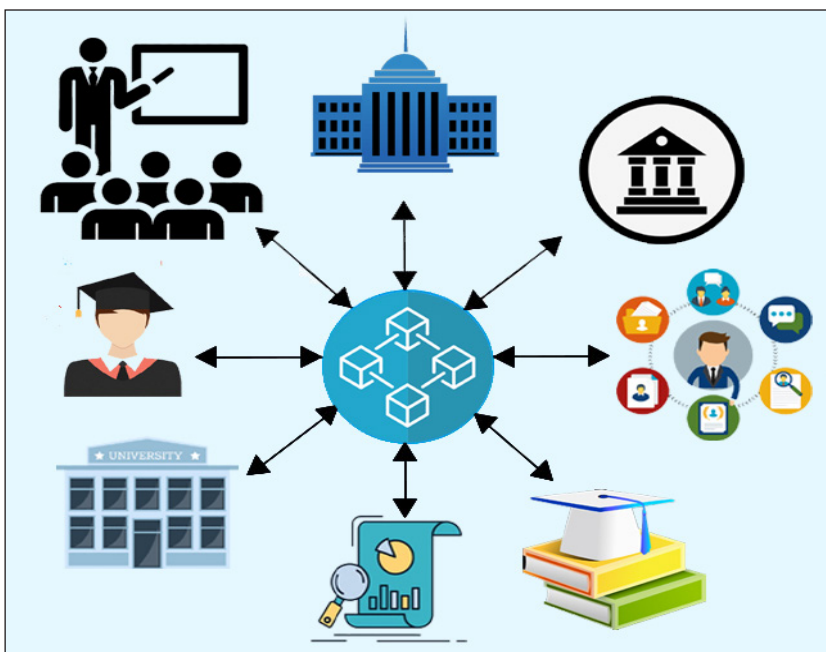


Fig. 2: Conceptual Representation of Blockchain in Education

Education Technology is responsible in generating different new educational models and as a whole, with Information Technology a new concept of theory and practice has been developed that is called Digital Education. Digital Education is now a broad concept and various Digital tools and technologies of Information Technology are being used such as Communication system, Database systems, Networking systems, Multimedia system, Software system, etc.^{[13],[14],[20]} for developing sophisticated Digital Education System development. Digital Learning is also a synonym of Digital Education and is practiced in modern Higher Educational Institutes, both traditional and e-learning. In developed nations and in many developing nations Digital Education is being also started in basic classes and examinations, operation, and administration. There are different forms of Digital Education and Adaptive learning are being used in Digital textbooks and learning, in content management, in object management and data analytics, in effective free educational content & resource management, in developing streaming content, as far as intelligent learning is concerned Digital Education is widely popular and also being used in *E-Learning* or Educational technology and treated as a branch of Digital Education according to some expert. Digital Education is enhancing not only traditional educational institutes but also other corporate houses and companies regarding On Job Training. This trend is gaining rapidly and running in association with many universities or educational institutes. Digital Education takes benefits of various allied technologies such as Big Data, Cloud Computing, IoT, etc. for various new age educational models viz. Continuing Learning, Skills development program. Digital Education is today become available as Minor/ Major/ Specialization and ultimately it is required for various purposes but not limited to the following—

- ❑ Enhanced and adaptive learning using advanced systems & technologies.
- ❑ In designing, and developing digital records and documentation with proper documentation combine with text and reference material such as encyclopedias.
- ❑ Learning as well as researching in online or blended mode.
- ❑ Searching and availability of the contents and objects using analytical tools.
- ❑ Enhanced and advanced Open and free educational resources.
- ❑ Enhanced and recorded content for the purpose of teaching and learning.

Therefore, Blockchain is also going to be more effective and important in healthy and intelligent Digital Education systems and promotion^{[22],[25],[42]}. As far as Education Technology is concerned Blockchain is applicable in onsite and online education, both.

BLOCKCHAIN IN EDUCATION AND DIGITAL EDUCATION

Blockchain technology basically supports all the registered members immediately, and they are able in sharing as well as offering complete and advanced transparent information. As far as tracking of the orders, payments, and accounts (including production) are concerned Blockchain is beneficial in a different respect. Using Blockchain transaction details is easily identified, and thus it is applicable in diverse areas such as business and commerce, health and medical systems, government and administration mostly, and among more emerging important is education and training, entertainment, banking, and trade, etc. Blockchain is a fraud resistant system and offers more transparent financial services than any kind of traditional business process. Satoshi Nakamoto was the person who were devised an immutable ledger of transactions that contains chains together blocks of data using digital cryptography to solve the double-spending problem associated with digital currencies. Blockchain Technology offers a flexible business

even without knowing the participants^{[9],[10],[25]}. Ultimately the development of the Blockchain rising due to its wider benefits and among these important are *Immutability*, which is dedicated in replacing or erasing recorded data and thus it prevents data tampering within the network. As far as *Transparency* is concerned Blockchain offers its best as it is decentralized and any of the registered and authorized members can verify recorded data and thus it can gain trust in the network. *Censorship*, is another important feature and it is free from censorship and does not require any kind of third party's involvement. Blockchain is dedicated and responsible for finding participants with validating transactions and also making sure regarding norms. Blockchain has many benefits but it is essential to adopt and follow proper laws and regulations, norms and guidelines, etc.^{[3],[4],[12]}.

BLOCKCHAIN AND EDUCATIONAL DEVELOPMENT: THE POTENTIALITIES

Blockchain has wider applications and potentiality in Educational Systems and allied areas and this can be seen in different other contexts. Bitcoin is an example of Blockchain application that can be used education sector indirectly. However, it is important to note that cryptocurrency is being used in this regard. With Blockchain students can be able in developing skills such as poetry or math genius even before their senior or higher school, and for these various Blockchain enabled tools are being used. Smart contract is another example where Blockchain is widely applicable with huge potentialities^{[16],[23]}. Using Blockchain entire exam system can be processed further with an intelligent way and educators and examination Departments can get the benefits further. As far as Online Education is concerned Blockchain is important mainly in improving the quality of online systems and also preventing fraudulent activity. Using the allied tool of Blockchain, i.e., cryptocurrency teachers and students can improve rewards in education systems. Using this technology teachers can offer rewards to their students based on the performance of the students and the task even homework. As far as record keeping is concerned it is important in enhancing more convenient education. The growing and possible blockchain application in Education is depicted in Fig: 3.

Data Management of the Learners and Academicians

As far as Blockchain is concerned it is worthy and impactful in different academic activities of the school, and higher educational institutions for different reasons. Blockchain is empowering the Education Technology sector and offering different available and possible opportunities for enhanced and advanced educational practices. Blockchain is able in securing data and for this, it does traceable and immutable affairs. Using Blockchain the changed and updated data is basically verified by the participants of the network, and this empowers entire educational systems for more transformation^{[26],[30]}. Different organizations have also been involved in the process of modernizing Blockchain in educational systems and it ultimately helps in different activities such as—

- ☐ Finding and addressing the gap in skill and knowledge.
- ☐ To find talents and their learning.
- ☐ Verifying and Managing Data and Information of the pupils.

Worldwide different organizations and institutions are being involved in applications of Blockchain in educational development, and among this important are Learning Economy Foundation, Colorado's C-Lab, Texas Blockchain Council, and so on. These companies are engaged in an open data exchange protocol and which allows students to share their academic records.

In Enhancing Efficiency and Security

Blockchain has wider potentialities in online education and e-learning for advanced and intelligent learning. It offers new opportunities to students and academic institutions. As far as efficiency and security is concerned Blockchain has an impactful role. In digital credentials, intellectual property management and verification of certificates and other testimonials Blockchain are worthy. For students record management also this technology including other allied technology has wider potentialities and saves time. Blockchain helps in time management, and institutions are able in getting data and other processes in earlier time. Blockchain is helpful in student record management in past and future students, both. Students here using Blockchain can save the data directly to the Blockchain systems^{[11],[31]}. Therefore in ensuring securing collaborations, this technology is important, and here authors are unable to remove or edit their own data. In educational world writing is considered as most important and there are concern of copying others work and here Blockchain is considered as important in proper development and management.

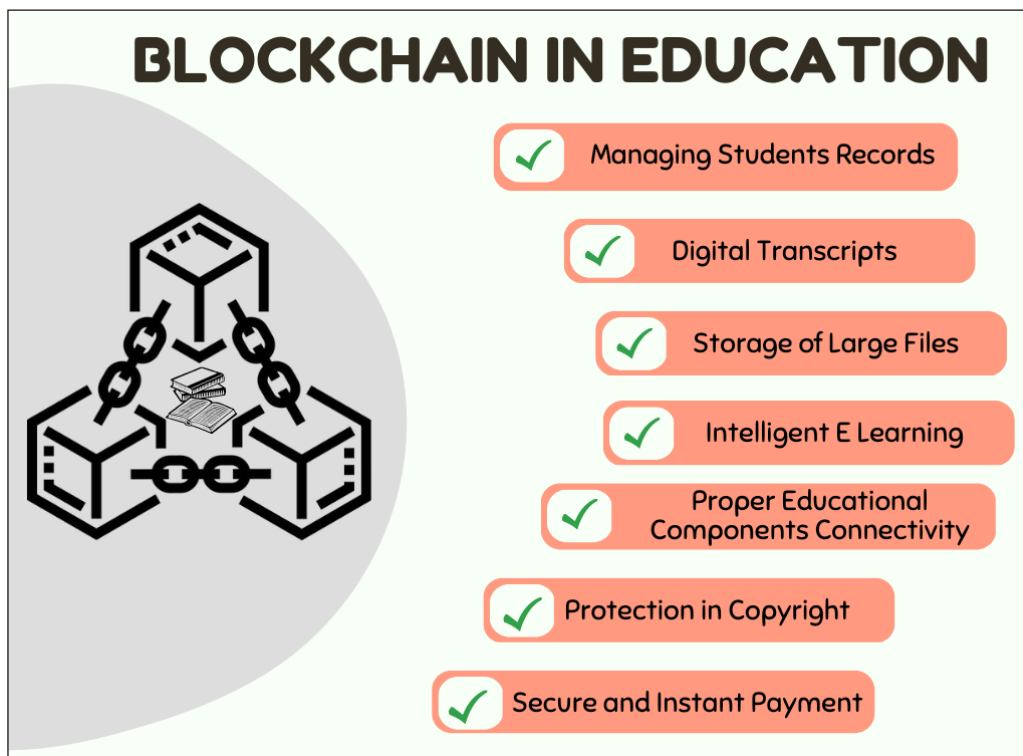


Fig. 3: Wider application sectors and areas of Blockchain in Education

In healthy lesson and course execution

Blockchain is important in improving traditional educational management and conventional educational institutions. In the university system, Blockchain is impactful in simplifying the process of syllabus management and storing and receiving the same in the digital context. Here institutions basically use hard drives and store digital syllabi without the concern of security systems. Blockchain based educational systems is enriching secure educational systems with robust and flexible storage systems^{[2],[21],[36]}. Though, expenses can be an important issue for its implementation as of now. Blockchain based educational systems can be considered as worthy and impactful in designing and delivering smart contracts and other distributed ledgers in the classrooms. Blockchain is effective in proper educational management and proper course and lesson management using ICT. In other context, smart contract is also applicable in automating the payment process for teachers and students and making intelligent education systems.

Cost Deduction in Educational Systems and Infrastructure

As far as cost saving aspects are concerned Blockchain is impactful and valuable in different educational activities. This technology is fruitful in facilitating record sharing, improving the verification process, and transfer of technologies. Blockchain is applicable to atomize services, uses of wallet for students for a fee and other payments, reduces different administrative expenses, etc. Regarding own identity related data generation and management Blockchain enabled system can be used for cost saving. Blockchain is useful in transforming paper based transcripts into digital ones and thus ultimately it saves educational costs regarding storage systems^{[21],[40]}.

Table 1: Digital Education and flexibility using Blockchain Systems

Storing Data and for its Tracking	For the Digital Badges	Cryptocurrency uses for security	In Decentralized e-Learning
Using Blockchain it is possible to change the blocks whenever required	Creating and developing Digital badges and certificates may be verified and also displayed	As a reward bitcoins may be availed to the students upon performance and here blockchain is important	Blockchain supports decentralized education and especially peer-to-peer learning experiences

Blockchain is significant in improving e-Learning with a greater extent in addition to extending traditional educational systems. It would be completely safe and secure and different technology organizations are doing well in implementing Blockchain applications in education, training and research. Ultimately Blockchain is useful in enhancing more support to flexibility (as depicted in Table 1).

ISSUES AND CONCERNS

Blockchain has various impactful attributes in educational systems including traditional face-to-face education and online or distance education. Blockchain though offers a lot of opportunities in education, teaching-learning process, and educational management but still concerned with several issues and concern. Like any other technology Blockchain also has some of the challenges and issues such as—

Mining & Extraction of the Data and Information—It is a fact that adopting Blockchain in the educational system has been obstructed due to a lack of interest and lack of trust in adopting such technologies. Here in Blockchain an immutable ledger is basically generated and able in the peer verification process and

this doesn't require any intermediary^{[5],[37]}. Thus, it offers more effective educational management than traditional one, but a higher degree of willingness must be ensured with technical and philosophical constraints must be entertained.

Lack of Financial Resources and Management—Blockchain and its arrangement in the educational systems suffers with the problem of financial resources and this is due to implementing different allied technologies into the systems^{[6],[38]}. Institutions need more investment in their infrastructure, including in training and expertise and therefore it is a need of the hour for complete solutions.

Lack of Awareness and Unwillingness—Blockchain gives an important development and technology centric educational system but it is important to note that there are important concerns in its awareness and development among its stakeholders regarding its benefits^{[17],[29]}. Proper communication is also essential and must be endorsed with Blockchain based systems. Blockchain is must be a great solution in managing problems and better problem solving.

Concern in Peer-to-Peer Technology implementation—Blockchain is still concern with the problems of peer-to-peer technological implementation. Blockchain is comes with many advantages over traditional educational systems and it does not require any central authority and able in operating a decentralized network. Blockchain is useful in peer-to-peer cooperation for problem solving for foster innovation and newer ways of learning. In preventing fraud, it is also essential and impactful. In Blockchain systems are encrypted and here single piece of information is recorded sequence-wise. As in Blockchain information is immutable therefore no third party can alter previous blocks.

Concern in Security—As far as security is concerned Blockchain is also under threats of security in some cases as here sensitive information basically stored in the blocks. Institutions must have to think regarding way, need and implementation of data security, and this security can be enhanced with permission only. Here important must be given for improving their security and blockchain development.

Scalability and Flexibility Issues in Certain Context—Blockchain is improving its advancement in different context and at the same time proper scalability and flexibility issues considered as important in better e-Learning management. The amount of data increases means the number of blocks also increases^{[22],[39]}. The speed of the transactions slows down and all the transactions here requires peer-to-peer verification.

Adoption Rate—There are important concern in adopting Blockchain systems into the educational systems as far as Blockchain based certification is concerned, and this issue only possible to solve when companies and educational institutions solve the issues^{[36],[40]}.

Cost and Budget in Implementation—As far as development of Blockchain is concerned it requires lot of technology and allied technological involvement and it therefore saves money in infrastructure and this an alarming concern.

CONCLUDING REMARKS

'Blockchain' and 'cryptocurrency' are two important phases and it becomes widely popular in different sectors and industries in the recent past. In 2008 first Satoshi Nakamoto has been published the concept of Bitcoin which is considered as one of the first cryptocurrencies. Though Blockchain has an impact in different organizations and institutions but it is still infancy as far as its application in education is concerned. With the benefit of speed and security Blockchain offers health advantages to students and teachers. Blockchain also offers opportunities to learners regarding their document and certificate

verification. Many students are getting online educational support using Blockchain. This technology also empowers educators and other teachers for more enhancing teaching-learning process and online learning experiences. As far as data privacy is concerned role of Blockchain is also important even of different constraints. Blockchain offers wider solutions in educational systems in a wider scale for advanced Education 4.0 implementation. Education 4.0 is evolving to this stage after spreading various past stages. The advent of Information and Communication Technology leads to different phases of Education. In Education 1.0 Traditional formats were considered as important, while Education 2.0 involves with wider technological involvement and educational process and delivery. In Education 3.0 we have witnessed an intelligent system's integration and in Education 4.0 newer concepts of flexible education, and own-phase education become important and valuable. New-age educational platforms such as E-Learning, Educational Informatics, Online Education, etc. are increasing in addition to traditional education, and here use of Blockchain is considered as worthy and impactful.

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