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# A SURVEY OF BLOCKCHAIN IN EDUCATION FROM THE PERSPECTIVES OF APPLICATIONS, CHALLENGES, AND OPPORTUNITIES

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## Abstract

The blockchain technology is gaining considerable scientific and social interest among academicians, researchers, policymakers as well governments. Blockchain is widely disrupting the various sectors such as supply chain, health care, e-governance, smart cities as well education. The paper discusses the blockchain applications in education such as platforms for smart contracts, sharing information through distributed consensus, transaction verification, transferring value among peer and stakeholders, generating Cryptocurrency/Incentives, creating smart Property with features of security, immutability and uniqueness. The papers also addresses the various formats through which countries such as Japan, Singapore, USA, Netherland, Canada, Chile, Switzerland and India as well as institutes like University Grants Commission, Oxford University, MIT, Sony Global Education, Inc., Deft university of Technology, Netherlands etc. have taken steps for blockchain applications in education. However, certain challenges such as lack of regulatory support, lack of interest and knowledge among various stakeholders, privacy and security, illicit activities are being faced as well while implementing blockchain applications in the education sector. Hence governments have to make concrete and stringent efforts to ensure sustainable results of blockchain applications in education.

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## 1. INTRODUCTION

The significant growth of information and communication technologies has an effect on existing economic sectors such as transportation, manufacturing, retail, health care and services (Queiroz et al., 2021; Wendland et al., 2019; Schuetz & Venkatesh, 2020). Because of the rapid digital transformation and advancements, firms are forced to reconsider their business models in order to adjust to and support technological changes (Gong & Ribiere, 2021). One of such breakthrough technology that has changed traditional business models is blockchain technology.

The blockchain technology is gaining considerable scientific and social interest, makes positive use of permissioned network design which plays a dispersed role across various domains while being decentralised (Arndt and Guercio., 2020). The adoption of blockchain technology is strongly favoured across each area in real world application with societal needs due to its devoted disruptive nature. Blockchain was first developed as a way to manage Bitcoin but it has now advanced to the point where it is viewed as an introduction technology for many decentralised applications. It is promoted as a useful tool for managing private data, particularly in fields of health, supply chain management and especially in the higher education. It is considered as a revolution as it offers a vast impact on number of sectors which can now enable to programme a data sets or any information records in a decentralized way and can be privately shared with the concerned parties eliminating the outsource entities (Crosby et al., 2016).

### 1.1. Concept of Blockchain

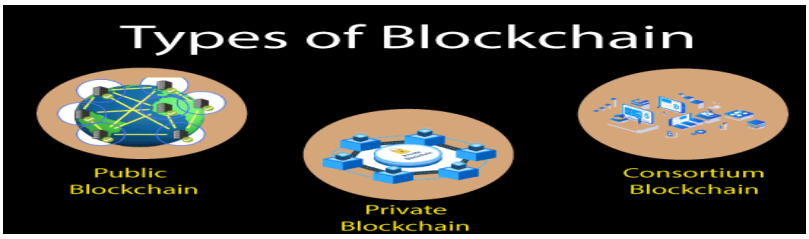
Back in 1991, a group of researchers proposed the initial conceptual model for Blockchain. Blockchain was very firstly used in bitcoin cryptocurrency, a ledger which is used to keep the record of transactions with the help of cryptography **(**Nakamoto, S., 2008).

**Figure 1: Blockchain**


**Source: https://blogs.iadb.org/**

Blockchain is referred as "a comprehensive technology with significant impact across an extensive range of sectors, allowing the development of decentralised applications that are networked together and share the data which is stored securely without the need for intermediaries" (Salah et al., 2020) as shown in Fig.1. It is termed as an e-book consisting of sequential encryption which is saved on various PC's in a private and public network including blocks or data records. Every transaction creates a block, and then it further gets linked to another number of blocks in an irreversible chain, through which a transaction flows and blocked together (Ali et al., 2020). There exist three major classifications of blockchain i.e. Public, Private and Consortium as depicted in figure 2.

**Figure 2: Types of Blockchain**




**Source: https://www.getsecureworld.com/**

1.1.1. **Public Blockchain:** In public blockchain, anyone who wishes to participate in the peer-to-peer system may access these. Nobody has to take any permission to access a public domain of blockchain (Salah et al., 2020). Peers can create and verify transactions, perform smart contracts, obtain and view all data once they are linked. Public blockchain provides the highest levels of transparency, decentralisation, and immutability, but they are non effective because a

sufficient amount of consensus is required for processing electricity, storage, and power. Both the speed and volume of transactions are quite low. Examples of this kind include Bitcoin and Ethereum (Swan, M., 2015).

1.1.2. **Private Blockchain:** In private blockchain, people who have been invited can only participate. Blockchain transparency and immutability are constrained in these centrally controlled systems (Gates, M., 2017). The network is often more shorter and more focused, with a low number of peers. As a result, the system is relatively more productive, allowing for increased transaction volumes and speeds, which reduces costs and resource utilisation as in case of Hyperledger (Bashir, I., 2017).

1.1.3. **Consortium Blockchain:** The consortium category of blockchain combines the two aforementioned categories. Similar to a private blockchain, members can join only if they have been invited; however, a set of organizations rather than a single one control the network. They are more restricted and regulated, but they still keep the decentralised aspect of a public blockchain with reference to governance. As a result, the volume, speed, and resource utilisation of transactions are all improved (Chowdhury, N., 2019)

Large number of efforts are being put for various methodologies which are currently in development (Swan, M., 2015) as research on blockchain in the field of education is expanding widely. Bashir, I., (2017) has discussed the features of blockchain that will benefit the society, especially education industry. The paper has been divided into five section followed by the introduction, second section discusses the extant literature available on blockchain in higher education sector. The third section discusses the features of blockchain implemented in education followed by fourth section which deliberates the blockchain based initiative taken at world level as well as Indian context for the development of education sector. Section five concludes the study.

## 2. Blockchain In Higher Education Sector

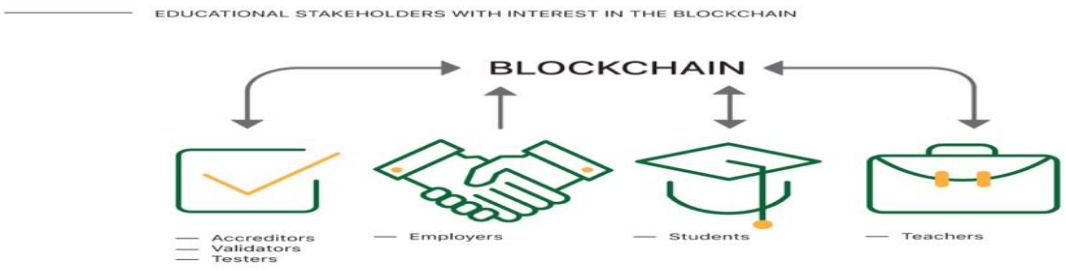
Blockchain technology is popular in various industries, such as “banking” (Guo and Liang, 2016), “supply chain management”, (Grima et al., 2021; Alazab et al; 2021), “health care” “(Yaqoob et al; 2019); “E-government” (Batubara et al; 2018) , “Smart cities” (Bhushan et al 2020), etc. The emergence of novel technologies and educational environment digitalization leads to significant alterations in the worldwide educational system today. At the same time, education is becoming more universal and customised. It is among the societal foundations that influences everyone's current and future in the neighbourhood (Liu and

Zou, 2019; Lam and Dongol, 2020). There is a huge potential of blockchain technology in the educational industry (Bashir, I., 2017). A number of research scholars (Harthy et al., 2019, Alammary et al; 2019, Ayub et al; 2021, Bhaskar et al; 2020, Wang and Qiao 2020) have investigated the different aspects of blockchain adoption, implementation and challenges thereof in case of education.

It can provide a platform that has decentralized advanced education credit move, can be internationally trusted, and has worldwide acknowledged reviewing framework for undergraduates and post graduates educational foundations, including different partners, like institutes, organizations and other associations (Turkanovic et al., 2018; Taherdoost, 2022).

Higher education is regarded as a system which consists of two major stakeholders (among others) i.e. students and Higher Education Institutions (Alam, 2022; Mohammad and Vargas, 2022). Due to the trust forming capacity and decentralization, education is considered as a possible sector for blockchain technology as it is commonly used in smart contracts i.e. permitting all stakeholders (Fig. 4) such as students, professors and other non-teaching staff to run identity management and certify their leading records (Kosasi et al., 2022; Savelyeva et al., 2022). All the higher educational institutes can access their authority with such technology to share data among each other to approve the correct information and discard the falsified qualification certificates and degrees (Ge at al., 2020). Additionally, smart contract automatically run through numerous levels of student's administration while providing best of the security and privacy. Blockchain has a capacity to share ledger technology among all participants on that network. No changes can be made within the document of that network without everyone's consent. Students can effectively share their qualifications with interesting parties (Han et al., 2018).

**Figure 4: Stakeholders in Higher Education Sector**




**Source: (Grech and Camilleri, 2017)**

## 3. Features of Blockchain in Education Sector

3.1. **Distributed Consensus:** With the help of this functionality, a blockchain-based system with many users can agree on a unique version of data maintained across the system without aid of a centralised authority (Arndt and Guercio, 2020). Certificates, portfolios, competencies, grades and other student data are currently held within every accredited university and are only partially exchanged with authorized academic institutions in the sphere of education (Bálint et al., 2019). It is challenging to make these documents available to other stakeholders or outsider parties. Through distributed consensus, businesses may be able to work together, share information on a single platform, and make it readily accessible to others (Badyal and Chowdhary, 2019).

3.2. **Transaction Verification:** Before being added to a block in the blockchain, all suggested transactions are checked by the network's active users in accordance with established standards. As a result, the stored data can be regarded as reliable (Choi et al., 2019). This blockchain functionality in an educational sector is very crucial to issue, maintain, and revoke information that must be reliable, stored in a tamper-proof stage, and traceable to prevent falsification (Delgado-von-Eitzen et al., 2021). For instance, (Ocheja et al., 2019) provide a solitary stage for tracking students' academic accomplishments and helps them in independently accessible towards various educational institutes.

**3.3. Platforms for Smart Contracts:** Smart contracts facilitate the capacity of performing tasks on the user's behalf by carrying out specific operations in a genuine manner and by using a tamper free and responsible method of keeping all associated transactions (Ghazali and Saleh, 2018). There exist number of studies that include the use of different platforms for smart contracts in education sector as mentioned in Table 1

**Table 1: Blockchain Platforms used in previous studies**

| Platform | Publication |
|---|---|
| Bitcoin | Bálint et al., 2019 |
| ARK Blockchain | Turkanović et al., 2018 |
| Tangle | Wahab et al., 2018 |
| Ethereum and also | Arndt and Guercio., 2020 |

| | |
|---|---|
| BigChainDB | |
| Ethereum | Choi et al. 2019; KARATAŞ, E., 2018; Novikov et al., 2018; Ocheja et al., 2019; Palma et al., 2019; Daraghmi et al., 2019 |
| Hyperledger Fabric | Badyal and Chowdhary, 2019; Lam and Dongol, 2020; Saleh et al., 2020 |
| Ethereum and Bitcoin | Jeong and Choi., 2019 |
| Quorum | Prinz et al., 2020 |

**Source: Delgado-von-Eitzen et al., 2021**

3.4. **Transferring Value among Peers:** With the help of tokens, blockchain leads the trustworthy transfer of value between participants. In the realm of education, various uses for tokens have been introduced (Turkanović et al., 2018). They can serve as a financial bonus or a compensation for students' academic accomplishments as a source of reputation, superficial status and learning units, for instance EduCTX (Bálint et al., 2019; Lizcano et al., 2020; Rooksby and Dimitrov, 2019)

3.5. **Generating Cryptocurrency/Incentives:** For peer's encouragement, verification transactions and maintaining the security of the system, certain blockchain networks may develop additional incentives or coins. Each organization may have certain network participants who are in charge of managing the blockchain. For generating, validating, and attaching new blocks, the proposal contains an incentive system that is evidence with the Proof of Authority consensus mechanism (Bálint et al., 2019). Although it falls short of meeting all the criteria for a cryptocurrency, yet encourage users to add to the framework (De Angelis et al., 2018).

3.6. **Smart Property:** This feature enables the permanent, reliable, and tamper-proof connecting of digital or physical assets to the blockchain, ensuring that they remain the sole property of the original owner until transferred.. The most common "products" managed in the educational sector are marks and certificates that are assigned or withdrawn by an educational institution to students, former students, or experts (Ocheja et al., 2019). Data can be utilised for a variety of things, such as tamper free storage (Arndt and Guercio., 2020), exchanging with recruitment agencies (Badyal and Chowdhary., 2019), recognizing support for an event (KARATAŞ, E., 2018) awarding badges for specific accomplishments (Choi et al., 2019; Guo et al., 2020), or

registering competencies (Novikov et al., 2018). Additionally, institutions of higher learning may be objectively ranked using academic standards (Lizcano et al., 2018; Novikov et al., 2018). Some smart properties have a connection to educational resources and can be put in use to control the multimedia's digital rights of content (Guo et al., 2020) as well as to verify user identity (Dai et al., 2019) or provide access (Islam et al., 2018). The smart properties given to students, experts, or organisations rely on the specific application environment. However, a significant distinction from other usage sectors is that academic data are typically owned by their creators. Since they represent a person's abilities, expertise, or reputation, they may be shared but are unable to transfer to the final recipients (Turkanović et al., 2018).

3.7. **Security Provision:** Due to its structure and technology, blockchain ensures that the stored transactions will be secure in terms of consistency, accessibility, authenticity, and nonrepudiation (Choi et al., 2019). Since information (such as competencies, grades, and certificates) cannot be changed means it is verified, and kept safe since it is approved by lenders, and is easily accessible because of its peer-to-peer allocation which ultimately helps to minimise the risk of security in education. This encourages the creation of reliable data even in unconfident environments (Daraghmi et al., 2019; Ghazali and Saleh, 2018). Additionally, these blockchain properties are combined with some other technologies for the purpose of verifying the accuracy of educational materials in MOOCs for instructors and students (Dai et al., 2019) and control how exam questions or multimedia resources are accessed and used (Guo et al., 2020; Islam et al., 2019). Further, apart from original content of the records held encrypted and off-chain, information's hash codes are maintained in the blockchain to address this issue. Hence, smart controls are used to operate the system (Gervais et al., 2016).

3.8. **Immutability:** Due to high-cost requirements to change a transaction in a blockchain, depending on platform type and network participant count, they are therefore regarded as being unchangeable in reality (Hofmann et al., 2017). Having tamper less, accessible, validated, and security against forged data on credentials, competences, grades, etc. is very essential in the educational sector (Emmadi and Narumanchi., 2017). The immutability property guarantees that data will never change and that any modifications made by others will be fixed. For instance, (Ubaka-Okoye et al., 2020) suggest using the expert to monitor educational data on its own and guard against unauthorised changes.

3.9. **Uniqueness:** In a blockchain, each transaction is tracked and is unique. This feature eliminates the chance of an asset or token being used or owned twice. Moreover, when token-related initiatives in the educational sector are equivalent to money or financial incentives, uniqueness is required (Bálint et al., 2019; Lizcano et al 2019)

## 4. THE WORLD SCENARIO

In recent years, many sectors are emerging with the help of blockchain technology. It has proved its wide application in the different areas all over the world due to its infinite applications. Chivu et al., (2022), has discussed the application of recent concepts of blockchain for the upliftment of smart cities such as City of Yokohama, Japan and university campuses. William, P., (2019) has discussed the benefits of blockchain technology considering it as an open data and decentralized source for safe storage of information by institutes such as MIT, USA. Record sharing facility among employers and institutions through blockchain enhances the blockchain usage in providing academic grades/credentials directly to the students instead of educational organizations while empowering the student's control over their identities and assessments digitally (Kwok and Treiblmaier, 2022). In recent times, digital certificates have emerged as a main illustration of blockchain technology application in field of education. Blockchain certificates and transcripts were implemented by Maryville University in 2019 which helped in making it the foremost university to give their student's right on their academic details. Its huge potential is therefore being investigated by various nations.

Sony Global Education, Inc., a Japanese company working align with the "Ministry of internal Affairs and Communications" in Japan has introduced the novel service of managing score card and transcripts of the students in higher education through a digital platform backed by a blockchain.

With the help of Blockcerts and a smartphone app, MIT has created Virtual Diplomas, allowing students to communicate a tamper less e-copy of their degrees with recruiters (Durant & Trachy, 2017). Blockcerts is an open standard for forming applications via smart contract that was first created at the "Massachusetts Institute of Technology" by the "MIT Media Lab" and the "Business Learning Machine" which include tools and open-source libraries.

A handful academicians at Oxford University intended to create an online university known as Woolf University in 2018 which leads the educators to promote their areas of expertise and also let students

to select their areas of interest for degree credits. A cryptocurrency named Woolf Tokens would be used to pay fees of the selected course (Broggi et al., 2018).

The Dutch Government is pairing up with the educational institutions and its related industry to develop the systems backed by the blockchain to utilizing it to the public levels. Deft university of Technology, Netherlands is considered as a largest research institution in terms of blockchain technology. Professors, PhD students and researchers involves in running codes with new approaches to strengthen the cyber currency field. Their focus area of interests is logistics, transaction process and e-commerce. Netherlands is likely to adopt a new EU policy which will be based upon open standards for blockchain in education. Dutch universities; for example are focusing on the stand-alone research projects which describes the process of standardisation over the public blockchain.

In Singapore a company has developed ATTORES which is a distributed app (DAPP) platform which assists in providing Blockchain Smart Contracts as a Service. It also provides open certificates which will be used in the educational institutes. Major services offered by the company are: issuing of digital certificates, digitally signing the documents and other custom smart-contract projects. Similarly OPENCERT is a Singapore government-linked project with an open-source and considered as a one of the largest application related to the blockchain which is launched globally. The certificates issued under the OPENCERT are tamperproof as if created once; the data will form a hash and get stored on a decentralized blockchain called Ethereum. Any random attempt in editing or changing the data will get detected by comparing it with new hash which will get formed on changing the original data. Thus, OPENCERT helped the schools and other educational institutes in eliminating the paper certificates and replacing them with digital ones. It assists in checking the authenticity of the certificate. Third parties like employment agencies can also validate the credentials of the job candidate over the portal.

The Canadian and government of Chile are focusing on providing transparency by using Ethereum as a platform to track data and finances like government grants. Sweden whereas, is concentrating on real estate deals. Switzerland became one of the first country in accepting tax payments in the form of bitcoin. They have also formed a blockchain based systemized voting platform and guide other companies towards the upliftment of blockchain technology. In UAE; Dubai has taken a “Smart Dubai Initiative” which ultimately focuses on becoming first city in the world to be fully backed by blockchain i.e. from healthcare to education and from environment sustainability to traffic control managements (National Strategy on Blockchain, 2021)

### 4.1. INDIAN SCENARIO

Blockchain technology has a capacity to transform how people, government and businesses, interact with one another. Although it is frequently lumped with technologies like Internet of Things and artificial intelligence, the technology is distinct due to the nature of its base. Blockchain has the capacity to restructure the existing processes and unlock new sources of efficiency and value, in contrast to other technologies that have the ability to provide customers and other users entirely new services. Given the size, range, and complication of the systems required to deliver a wide range of public services, governance in India confronts huge difficulties. Blockchain presents special opportunities for tackling problems pertaining to better governance. India may make significant progress in increasing the "Ease of Doing Business" in the business world by allowing "self-regulation," which enables companies to communicate over a reliable channel with less reliance on burdensome regulatory scrutiny and compliance. Blockchain would aid in enhancing comfort of life by empowering citizens through qualities like transparency, decentralisation, and accountability.

In the field of education, the University Grants Commission (UGC) has been responding to a number of these accusations and routinely puts universities and organisations on a watch list, yet ethical organisations continue to proliferate. The issue has quite a monetary cost as it costs businesses a lot of money to check the records of prospective employees. It is also difficult and time-consuming for students who want to continue their education in India or overseas. Many organizations have switched to digital certification processes to deal with the problem. But the existing structure of digital signatures and certificates depends on a number of reliable outside parties. As demonstrated in the 2018 incident in which the CEO of CA Trustico delivered the private encryption information of 23,000 certificates, prompting the Root CA to invalidate the certificates, this method is equally vulnerable to fraud and hostile attacks. Thus, a decentralised reliable system that is traceable, genuine, fraud-proof is required. The “Indian School of Business” (ISB), Bitgram, and NITI Aayog collaborated to form a blockchain-based solution to solve the problems regarding educational credentials. The SuperCert method, which uses decentralisation, identity interlinking and smart identification encryption for issuing the academic qualifications, features a blockchain network architecture. The procedure entailed:

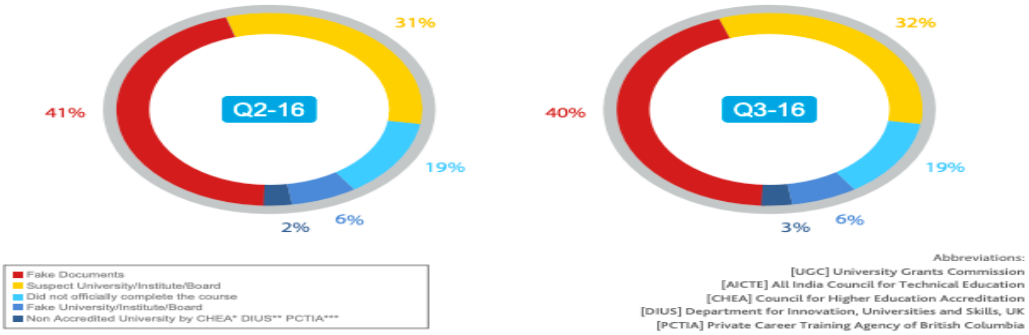
a) Development of the student's Superidentity. The identity is represented on the blockchain in a distinct way, and a set of public and private keys are also provided.
b) The university will issue a certificate and the student's Superidentity.

c) Create a block of student certificates using SuperCert, which creates a hashed form of the document on the blockchain.

d) Certificate verification using the user's as well as the university's public key. Both on- and off-line authentication options are provided by the solutions.

Because of the immutability of blockchain technology, it is impossible to alter a certificate's contents or identities the owner of that particular certificate (Aayog, Niti., 2020). According to the report by First Advantage, 2016; University Grants Commissions (UGC) received several complaints regarding the frauds and tampering of the educational certificates as shown in figure 5 . There exists nearly 7500 entities that provides fake credential certificates and employment cards (Aayog, Niti., 2020). Namchi, New Delhi and Mumbai are the top rated cities of India in faking documents and other education related discrepancies the year 2016 (First Advantage, 2016)

**Figure 5: Challenges in Higher Education Sector**




**Source: First Advantage report, 2016**

Figure shows the comparative view of quarter 2 and 3 of the year 2016, when first advantage company did a background screening of the educational institutions in India. In quarter 2 of year 2016, large portion i.e. 41% is related to the fake documentations and 32% by suspect institutions. 6% of the total Categorization of Discrepancies is related to the fake universities/educational institutions. Other discrepancies like “did not completed the course” remains at 19%. Remaining 2% is associated with universities with no accreditation. Whereas in quarter 3, numbers did not show much of the difference. To overcome all such kind of practices, India came up with the approach called SuperCert which assists in identity encryption, decentralization of information and identity interlinking for issuing the academic records. Supercert is an anti-fraud identity intelligence blockchain solution for academic certificates. It creates the student ID bind by the private and public keys and issue certificate provided. By the university to the student. It helps in

detecting any tampering of the data. Also, it has less tangible cost involved in verification of the report cards of the students and also keeps the data private.

Other initiative is LEGITDOC which is a start-up in Maharashtra powered with implementing the blockchain based issuing of tamper proof academic certificates. It is owned by Crossforge Solutions Pvt Ltd and is helping the Government of Maharashtra in proving a unique SaaS based Ethereum and cryptographic techniques to provide nearly 1 million digital academic certificates to the students of the "Maharashtra State Board of Skill Development" (MSBSD) for the purpose of instant verification of documents in any part of the world. With this, every student gets a digital file "certificate_legitDoc.zip" which contains their original documents in pdf form, issued by MSBSD. Government of Maharashtra came up as the fourth government entity for such achievement of remarkable scale of document verification in the world after Malta, Singapore and Bahrain.

Similarly, CERTICHAIN Kerela Blockchain Academy, an initiative of a Kerela Government has taken some steps with some by collaborating with international organizations under IIITM i.e. Indian Institute of Information Technology and Management, for investigating possibilities of blockchain technology through capacity building. Under this, CertiChain has been developed to assist educational institutes in order to issue and verify the certificates with blockchain technology. It was designed for providing number of advantages not only to students but to all the stakeholders related with the educational institutes in number of ways.

## 5. CONCLUSION

Blockchain can thoroughly revolutionize the education sector as technology has impeccable impact on the education. Universities, Colleges and other educational institutions should encourage the use of blockchain as it can be used to securely store and share student records, certifications, and other important data. The number of initiatives taken by various countries demonstrate that by using blockchain technology, educational institutions can reduce the risk of data breaches and other security threats. Blockchain has showcased its promise in various aspects in the areas of education by revolutionising an industry with important features like anonymity, persistency, auditability and decentralisation, (Williams., 2019). But as of now, the blockchain in the education field has received little attention in India. Further, regulatory support also plays a very crucial role in helping institutions to adopt blockchain technology by creating a favourable environment for innovation i.e. creating a work space where institutions can test new

blockchain-based solutions without fear of regulatory backlash. Hence, government in India should provide clarity on legal and compliance issues which helps institutions in reducing uncertainties and risks. Moreover, government should encourage the use of blockchain technology to the higher educational institutes by providing financial incentives like research grants/ funding and technical staff to deal with the technology

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