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Applications of Blockchain Technology 4.0 in Education: A Systematic Review

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ABSTRACT: The 5G, internet of things and machine learning will shape the future of education in a way that makes the exchange of Big Data at stake, mainly the financial, personal and academic credentials of students and faculty. The 4.0 technology, known as the fourth industrial revolution, has arrived to fix issues germane to trust, transparency and security. This article focuses on how education could take advantage of this fourth industrial revolution 4.0, mainly through blockchain applications. This article is an outcome of a critical systematic review of the state of the art on the use of blockchain technology in education. The literature sampled have responded largely to the following question: how can blockchain improve the sector of education? It explores the different benefits of Blockchain in operating the online data of students, faculty, partners, etc., providing them with a sense of ownership and ease of access. It also focuses on how the blockchain technology revolutionizes the way educational data will be stored and exchanged by means of safe, quick and transparent blocks. The state of the art has revealed that the benefits of blockchain technology to education are numerous, ranging from management to enabled educational platforms. The outcome of this article provides institutions and educators with a framework of reference to implement the blockchain applications effectively. It is also a catalyst work for researchers who aim at delving into the mainstream of the indispensable debate of how education could take advantage of this fourth industrial revolution 4.0.

KEYWORDS: Blockchain, Security, Big Data, Exchange, Smart Education.

"Everything will be tokenized and connected by a blockchain one day."

Fred Ehrsam

INTRODUCTION

In the 1970s, the internet was just a couple of computers that rarely got connected to each other. Today, everybody uses the internet and we even start experiencing the internet of things. Blockchain, which was first introduced for use in Bitcoin cryptocurrency, is now being used across many industries, including education. One may ask what is meant by blockchain and how is it going to revolutionize the sector of education and develop it? Well, blockchain is usually termed as digital ledger. The blockchain is the distributed database that gives an alterable and semi-public record of the digital transactions (Audrey Watters. 2016). Every block gathered at a timestamped batch of the transaction is to be incorporated in the ledger or in the blockchain. Every block is recognized by the cryptographic signature (Nielson. 2020). In other words, the blockchain is a distributed database that provides an unalterable, (semi-) public record of digital transactions. Each block aggregates a timestamped batch of transactions to be included in the ledger – or rather, in the blockchain. Each block is identified by a cryptographic signature. These blocks are all back-linked, meaning they refer to the signature of the previous block in the chain, and that chain can be traced all the way back to the very first block created. As such, the blockchain contains an un-editable record of all the transactions made (Audrey Watters. 2016). Furthermore, blockchain serves as a platform for achieving and maintaining integrity in distributed peer-to-peer (PTP) systems, obviating the need for a central authority or clearinghouse. Here's how it works at a high level:

- **Each user maintains his or her own information**, including transactions, contracts, certifications, credentials, assets and identities, as well as anything else that can be recorded in digital form.
- **Because entries are permanent**, transparent and secure, community members can view transaction histories in their entirety.

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- **Each update is a new "block"** added to the end of a "chain." A blockchain protocol manages how new entries are initiated, validated, recorded and distributed.
- **Cryptology replaces third-party intermediaries** as the keeper of trust; all blockchain participants run consensus algorithms to certify the integrity of the whole (Jain 2018).

The universities and academia around the world are faced with persistent operational challenges (Broggi et al., 2018). Most colleges in different parts of the globe are finding problems and difficulties just with the educational system and are not equipped even with laptops. Whatever is the true depiction of university operational restrictions, most will come to the idea that innovative solutions are needed. The modernization of universities is one of the best solutions that might solve all universities' problems. Here, we are talking exactly about smart university. The concept of a 'Smart University' is an emerging and fast-evolving area that represents the creative integration of innovative concepts, smart software and hardware systems, Smart Classrooms with state-of-the-art technologies and technical platforms, Smart Pedagogy based on modern teaching and learning strategies, Smart Learning Analytics and academic analytic (Uskov et al. 2018, 2). Consequently, with the growth of technology nowadays, the exchange of Big Data is considered a challenge for faculties and even societies in general. In this regard, the aim of this work is to introduce researchers all over the world and especially in Morocco to the new field of blockchain technology and show how it can be used in the educational sector to improve it.

It is necessary to develop a trustable, reliable and secured data storage method to record the process of students' learning during their whole lives. Blockchain technology is an eligible tool to vanish all the problems of education such as data insecurity, poor certification, trust transparency and many others. Currently, the technical features of the blockchain can inspire a set of good solutions to the problems of education. From this perspective, a critical systematic review is followed in this work to provide educational institutions and educators with a framework of reference to implement the blockchain applications effectively to solve all the problems facing them.

RESEARCH QUESTIONS

These research questions were formulated based on the aim and the objective of this study.

- How can blockchain technology improve the sector of education?
- What are the challenges of implementing blockchain in education?
- Why blockchain technology is important for improving education?

METHODOLOGY

A critical systematic review of the state of the art on the use of blockchain technology in education was performed following the guidelines of the PRISMA statement. The following steps are the key elements of the protocol.

1. Identifying the purpose of the study by answering the question "why do this review"? It also addresses the importance of the review and provides information about current gaps in the literature and describes the intervention, how the intervention might work, and why it is important to investigate.
2. Recognizing the objectives of the review by including the research question and a statement about the population and outcomes on which the review focuses.
3. Characterizing methods: this section should outline the process for conducting the review. Key components of the methods section are:
   a) **Selection Criteria:** determining which articles to include in the review and which are to be excluded. Items to consider when designing selection criteria include:
      i) *Type of intervention:* Considering the types of intervention to be included in the review and describing the components of interventions to include and exclude.
      ii) *Type of Outcome:* considering possible outcomes, including potential consequences such as risks as well as benefits, and identifying primary and secondary outcomes that are most relevant to the targeted intervention and study population.
      iii) *Type of studies:* Considering the study designs to include.
      iv) *Type of publication:* Considering whether the review will include published research studies only or if it will also include gray literature.
      v) *Publication date:* Considering whether the studies in the review will be limited to a specific time frame.

vi) *Language:* Considering whether the review will be limited to studies in English or include studies written in other languages.

b) Search Strategy: the protocol provides a list of the databases and other sources used during literature searches to identify potentially relevant studies. This section will also include the search strategy, such as keywords and criteria for the searches.

c) Data Collection: this section will include a description of the process for selecting studies and extracting data from eligible studies. It includes variables and definitions for each variable for which data is collected from eligible studies. This section will also provide details about how many members of the review team reviewed each article and how disagreements over the data extracted were resolved.

d) Displaying Data: A flow diagram was used to lay out the data in a clear and organized way. It includes information such as the number of studies identified, reviewed, included, and excluded.

e) Analysis and Synthesis: the reviewer will determine how to analyze the data extracted for the review. The reviewer will use a standard approach to assess the body of evidence used in the review by considering study limitations, consistency of effect, imprecision, indirectness, and publication bias. The analysis section should also include a description of how risk bias in included studies will be assessed. This section will also address how the reviewer will handle missing data. Moreover, reviews will contain a section on limitations.

The researcher came out with the following subsections that will show how the previously mentioned steps were performed within the systematic review.

CHARACTERIZING METHODS

In order to determine which articles to include in the review, we resorted to different reliable databases: ResearchGate, Open Access, Scopus, EBSCO, IACEE, MDR, NECTEC, InformED, PeDocs, EUSSET, Blockchain Research Institute, digital Education, semantic scholar and AllAfrica. All these databases index high quality articles related to the education sector and emerging technologies in learning. The study designs to include randomized controlled trial [RCT] which relies on four phases (enrollments, allocation, intervention, follow-up and data analysis). The date of the last search was published in 2020. Furthermore, researchers used the following terms in the study: "Blockchain Technology, Education," "Blockchain Technology, Higher education," "Blockchain, Learning," "Blockchained education, Big Data," "Blockchain, Learning" as shown in the table below. Also, the review is limited only to studies in the English language.

Database	Keywords and Criteria
ResearchGate Open Access IACEE MDR NECTEC InformED PeDocs EUSSET Blockchain Research Institute DigitalEducation Semanticscholar AllAfrica	Blockchains, Smart contracts, Adaptive learning, Curriculum, Certification. Blockchain, Educational evaluation, Instructional design, Learning is earning. Blockchained education, academic institutions, higher education, learning experiences, big data. Blockchain, Education, Certificates. Blockchain, Education, Education Certificates, solution, benefits. Blockchain, education, Information Security, Student Ownership of Learning, Interactive Learning. Blockchain, education, technology, empower learners. Blockchain, Certificates, education, certification authorities, educational institution, educational institution. Blockchain revolution, identity, student records, the new pedagogy, the meta university. Learning Itineraries; Blockchain in Education; University; Digital Education; Privacy. Educational records, blockchain, privacy. Blockchain, education, young students, learning

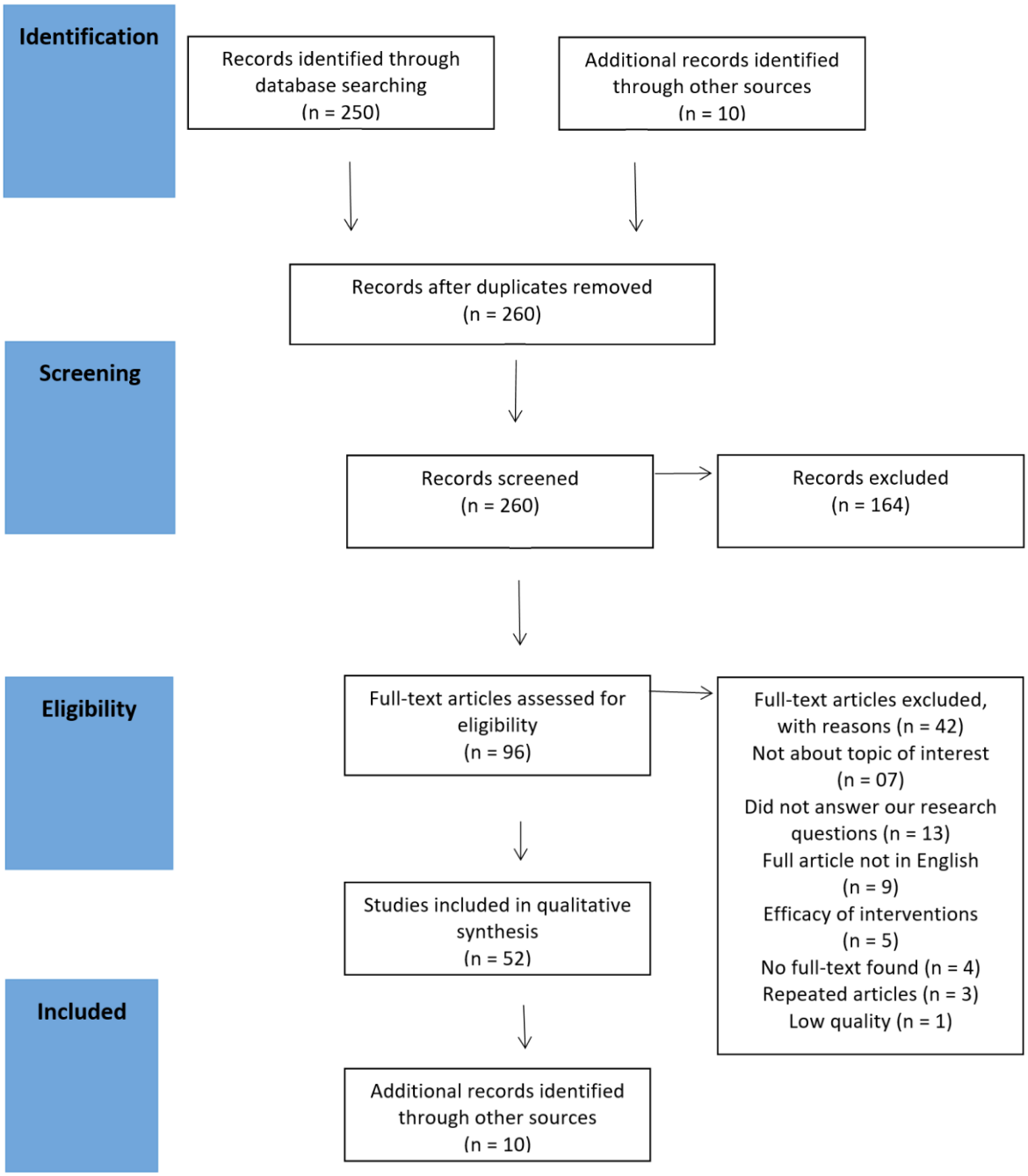
COLLECTING AND DISPLAYING DATA

The process for selecting studies and extracting data from eligible studies of the retrieved literature was evaluated independently based on a set of predefined exclusion and inclusion criteria (diagram below). A flow diagram was used to lay out the data in a clear and organized way. It includes information such as the number of studies identified, reviewed, included, and excluded. Before introducing the literature in the bibliographic manager (language, subject area and document type restrictions), some exclusion criteria were used. Based on very specific and crucial norms, articles that met one of the exclusion criteria were excluded and attached to the reason of exclusion. Thereafter, full-text articles review got the attention of the researcher, and again extra articles were excluded and sorted by reasons. Any inconsistency regarding the importance of the reviewed articles was resolved through double check process. After all, hundreds of studies were excluded since they did not meet the criteria of our study.

ANALYSIS

Data analysis was performed after extracting the data from papers. 250 articles were explored from the previously mentioned journals and databases in addition to 10 articles from google scholar search. Based on these articles' titles, abstract, introduction and keywords, all of them were screened and we were left with only 96 articles after the exclusion of 164 ones. This number of excluded articles was done on the purpose that they were not relevant to the subject we are dealing with. An additional 45 articles were excluded because of their scope; 1. they were not about topic of interest. 2. Did not answer the research questions. 3. Full article not in English. The remaining 54 articles included in quantitative and qualitative synthesis were deemed suitable for inclusion in this systematic review and were included in the data extraction process in the study (figure 1).

Included articles were divided by the year of publication. They were published in the last five years. During the year 2016, only two relevant articles were found. Whereas, this number increased rapidly in 2018 and 2020.



Flow Diagram of the systematic review process

Articles that were included in the review mentioned a variety of Blockchain applications. Consequently, they can be classified as follows: smart contracts, certification, educational evaluation, learning is earning, challenges, higher education, big data, student records, student ownership of learning, interactive learning, empowerment of learners, digital education, smart services, open digital badges, lifelong learning, data privacy, data security and digital diplomas.

Applications categories identified in the reviewed articles

Application Category	Number of Included articles
Smart contracts	5 articles
Certification	10 articles
educational evaluation	13 articles
Learning is earning	17 articles
challenges	6 articles
higher education	20 articles
big data	5 articles
Student records	23 articles
Student ownership of learning	14 articles
Interactive Learning	9 articles
empowerment of learners	27 articles
digital Education	7 articles
smart services	9 articles
open digital badges	15 articles
lifelong learning	2 articles
data privacy	10 articles
data security	12 articles
digital diplomas.	20 articles

The majority of articles used in the review mentioned almost all the categories of blockchain related to education. Furthermore, all of these categories can be split and put under three main themes.

RESULTS

The reviewer read and classified all articles according to the themes that relate to the research questions. The themes included: benefits of blockchain technology, challenges, and future area of application.

BENEFITS OF BLOCKCHAIN TECHNOLOGY TO EDUCATION

Schools add more security cameras and sensors, and they need to protect their networks from hackers as well. Blockchain technology could improve the educational sector in a variety of ways. The use of Blockchain technology in education assures security and privacy of all users' data, which is exchanged between intended parties. Blockchain network uses the one-way hash function which is a mathematical function that takes a variable-length input string and converts it into a fixed-length binary sequence. The output bears no apparent relationship to the input. The process is hard to reverse because, given just the output, the input is impossible to determine (Yli-Huumo et al. 2016). Furthermore, the newly generated block is strictly following the linear sequence of time (Chen and his colleagues, 2018). To illustrate, information and communications can be secure if considered as transactions of the blockchain (Prisco, 2016), based on cryptographic protocols. Thus, for example, blockchain offers the potential to make degree records more secure (Turcu and his colleagues). Each learning block is composed of several types of data related to a learning activity; in order to protect these data, an encryption algorithm was performed before sending it to other participants.

Furthermore, the system ensures permanent indestructible records that can keep students' records safe and secured. The ledger in the Bitcoin blockchain is 'append-only'– which means that transactions can only be added, and *cannot* be edited or deleted (Grech, Camilleri. 2017). While every new transaction is linked to a block, each single block is connected to the previous block to form a chain. All information are stored on a blockchain; with just a few clicks, a person can obtain a complete, verified record of content courses and all academic achievements. Thus, hacking the chain would require not only changing the transaction, but also recalculating and changing the header information of every block created since that transaction, and doing so on over half the computers on the network – a highly

impractical proposition (figure 4) (Grech, Camilleri. 2017). Storing all educational or school records in one place, where it can be easily accessible, will increase the accountability and transparency of using such records (Alammary et al. 2019).

Issuing certification using digital signatures is another benefit that can be brought to the field of education to improve it. All solutions for digital certification use a system of digital signatures to issue certificates (Grech, Camilleri. 2017). It provides instant and self-verification of academic qualification; even when the university does not exist anymore (Gopane, 2019), a digital syllabus can be stored in a blockchain. Once blocks have been created, the authorized university will sign it using a private key. After that, a cryptographic hash of the course syllabus will be issued to ensure that no one can tamper with the content. In order to validate the authenticity of these data, the university verifies it by the hash and the key that belongs to the original institution (Bandara, I.B.; Ioras, F.; Arraiza, M.P. 2018).

The use of blockchain technology in education makes trust present in the whole process. Only trusted parties can be engaged in adding blocks to the network and only trusted parties can gain access. Trust is a big concern when dealing with different authorities from different regions. Universities or any educational institutions can build a trustworthy community by implementing secure and reliable blockchain-based systems (Alammary et al., 2019). This basic concept of trust remains unchanged in the digitized world where we have to rely upon many actors, whom we will never meet, to act in good faith and on our behalf: trust is often granted only for a very specific application, within a specific context, and for a set period of time. In a global, digital economy, the challenges of maintaining trust - with the resultant checks and balances – are becoming increasingly expensive, time consuming, and inefficient (Piscini et. al (2016). Indeed, blockchain can really enhance the sector of education.

These are only few advantages that Blockchain Technology can bring to life of education; still, it can bring hundreds of benefits, including low cost, enhancing learners' interactivity, enhancing accountability and transparency, prepaid cards, supporting learners' career decisions and many other ones.

THE CHALLENGES OF IMPLEMENTING BLOCKCHAIN IN EDUCATION

Despite the fact that Blockchain can revolutionize the field of education in a positive way to be improved, still a number of challenges might occur if using blockchain in this sector. In this review article, we have gathered most of these challenges into certain categories. Blockhain's scalability, which is the slow speed of blockchain transactions, can affect the process in the education system. Educational systems also have plenty of data to keep track

of students who are constantly moving from school to school. This can increase the block size. Every transaction requires peer-to-peer verification that can become time consuming as the number of blocks increase. This is a big challenge of blockchain technology that Bitcoin technology can handle with only three to seven transactions per second (Zheng and his colleagues. 2018).

Many educators have a problem with the idea of education as big business, and yet companies like Pearson and McGraw-Hill make their fortunes by providing the classroom content, additional teacher training, classroom and school administration systems, and the testing content and platforms—the results of which lead to credentials, not just of high school diplomas and college entrance but of individual licensures and professional certifications. These companies have considerable budgets for lobbying the state (Don and Alex Tapscott. 2017). The cost of the adoption of blockchain is really high. To store big student data, there need be a huge size which will be costly somehow. Without managing this development and operational cost, it will be difficult to use this technique in traditional education systems (Bore and his colleagues.2017).

Absolutely, it is difficult to provide security while using blockchain technology and keep privacy at the very same time. While security is the main feature of the blockchain technology, the risk of malicious attacks cannot be removed (Zheng and his colleagues. 2017). this puts one's whole life career at risk. In 2013, the Education Advisory Board (EAB) published a list of 157 strategies for collecting data about students and alumni for colleges and universities to exploit in fundraising efforts, and institutions have become good at doing so.3 When it comes to protecting these data, however, colleges and universities are no less vulnerable than other large organizations (Don and Alex Tapscott. 2017). And, in this way, user's transactions can be linked to reveal user's information. Adequate storage and protection of private keys of all members is also a security issue that should be amicably handled (Turkanovi´c and his colleagues. 2018). Different kinds of leakage may occur while using blockchain technology in the educational field.

Different other kinds of challenges might occur with the use of this technology in the education sector. But still, it is one of the greatest innovations that will revolutionize all sectors, including the educational one. All of the previously mentioned challenges can be overcome with more effort to develop blockchain technology.

AREAS OF BLOCKCHAIN APPLICATION IN EDUCATION

There are many potential ways how blockchain can improve education. Most higher education institutions keep students' completed course records in proprietary formats. These databases are structured for exclusive access by an institution's staff and in dedicated online

systems, with little or no interoperability. The majority of institutions have their own specialized system for keeping students' completed course records, which can preserve the proprietary data structure of the database. In contrast, blockchain records are stored permanently, and documents such as degrees and course certificates can be secured and verified regardless of whether or not a user has access to an institution's record-keeping system. Even if the institution that issued the certificates were to close, or if the entire education system collapsed, those certificates would still be verifiable against the records stored in a blockchain. In addition, once institutions issue certificates, no further efforts are required to confirm the validity of those certificates to third parties since the certificate can verify itself directly on the blockchain. (Jain 2018). Instead of storing a document that contains information about students, Blockchain will store documents' data. All the parts that are contributing to the field of education can be connected via Blockchain technology, which can lead to Credentialing Students' data through Blockchain (Jain, 2018).

The revolution and evolution of blockchain applications appear to be driven by the technology's capacity to handle problems that involve double-spend, consensus, immutability, transaction, trust, identity and general data security. Such blockchain applications will vary according to design-characteristics, including the content of what is stored on the ledger, the process used to reach consensus, and the degree to which the ledger is permissioned (Pisa & Juden, 2017). Blockchain could provide a more durable and flexible system for storing student credentials as they move from course to course throughout their professional careers plus their secondary education. Via blockchain, credentials cannot be modified, providing a more reliable system of storing credentials for a lifetime of learning, ensuring Durability and Flexibility with Micro-Credentialing (Jain, 2018).

Moreover, (Thabo J. Gopane. 2019) has gathered the payoff of blockchain application by universities from Nakamoto (2008), Swan (2015), Pisa and Juden (2017), and Broggi (2018) and came out with following table as the benefits that universities will gain when using blockchain in education.

Blockchain Application Opportunities for Universities

No	Application	Benefit
	Blockchain Possibilities for Universities I: Universal Usage	
1	Smart Contracts	To store and activate transaction contract when they are due, automatically.
2	Disintermediation	Removes the need of the trusted middle party, with its associated cost, risk, and time inefficiencies.
3	Serve as Registry	Provides time-stamped systematic record of assets.
4	Process Integrity and Immutability	Through transparency should reduce risk of dishonesty, tampering
5	Preservation of Intellectual Property	Removes the need of intermediaries for the management and preservation of personal works of art, and innovation
6	Advantages of Data Security through Decentralisation	Decentralised data ledgers removes the risk of onestop data failure (malicious, or system malfunction)
7	Digital Identity	To digitise personal identity details: passports, national identity document, online account login, birth certificate, proof of residence
8	Decentralised Notary	To capture the time-stamped attestation of document. Document not stored but its existence is stored in hash format.
Blockchain Possibilities for Universities II: Academic Specific Usage		
9	Digital Academic Certificate	Provides instant and self-verification of academic qualification, even when the university does not exist anymore.
10	Massive Open Online Courses (MOOCs)	Cryptocurrency and blockchain may be used to facilitate recording and payment for the MOOCs.
11	Smart Learning Contract: financial Sponsor to Student (S2S) peers.	Smart contracts will be triggered by academic performance or built-in rules to release bitcoins, or learncoins, or local fiat from sponsor to student (S2S).
12	Learncoin	Institutions, or individual students can publish their funding needs, and receive learncoins from spontaneous learning donors, even pseudonymously.
13	Learning contract exchanges	Suitable for continuing professional education (CPE), and could benefit institutions offerings to government workers, and private sector.
14	Journalcoin	The intuition of bitcoin wallets used as journalcoin may be used to incentivise and earn academic brown points for journal editors, reviewers, and examination moderators.

What can be noticed from the discussion is that blockchain technology will be of great help to the educational sector and especially higher education since it can solve the majority of problems that are faced in the non-stop process of learning; it will bring added values and extra benefits that can make it revolutionize the educational sector.

CONCLUSION

The article has followed a critical systematic review of the state of the art on the use of Blockchain Technology in Education. It is found that the digital world of big data exchange is improving in a faster way than ever before. The objective of this study has been to provide educational institutions and educators with a framework of reference to implement the Blockchain applications effectively to solve all the problems facing them from trust, transparency to security. Blockchain technology is an important technological advancement as found through the whole study that can be considered as an added value to university smartness and academia. The review was guided by research questions that relate mainly to how blockchain can improve education, and the challenges of implementing this technology. The systematic review has found that providing educators and students with a sense of ownership, ease of access, and security across the globe are the most important benefits of using blockchain technology. The study is also a catalyst work for other researchers who aim at delving into the mainstream of the indispensable debate of how education could take advantage of this fourth industrial revolution 4.0 (Blockchain Technology).

REFERENCES

[1] Alammary, A., Alhazmi, S., Almasri, M., & Gillani, S. (2019, June 1). Blockchain-based Applications in education: A systematic review. *Applied Sciences (Switzerland)*. MDPI AG. https://doi.org/10.3390/app9122400

[2] Bakken, J. P., Uskov, V. L., & Penumatsa, A. (2019). Smart Education and e-Learning 2018. *Smart Education and E-Learning 2016*, *99* (1), 15–27. http://dx.doi.org/10.1007/978-3-319-92363-5_11

[3] Bandara, I.B., Ioras, F.& Arraiza, M.P. *The emerging trend of blockchain for validating Degree apprenticeship certification in cybersecurity education. Proceedings of the 12th Annual International Technology, Education and Development Conference, Valencia, Spain, 5–7 March 2018; pp. 7677–7683*

[4] Cerdan, A. & Jardí, A. (2018). Blockchain in Education: On the Limit Between the Real, the Possible and the Dreamed. *Digital Education Review*, *0*(34), 109–111. https://doi.org/10.1344/der.2018.34.109-111

[5] Bore, N., Karumba, S., Mutahi, J., Darnell, S.S., Wayua, C.& Weldemariam, K. (2017). *Towards Blockchain Enabled School Information Hub. In Proceedings of the 9th International Conference on Information and Communication Technologies and Development, Lahore, Pakistan.*

[6] Broggi, J.D, Gallagher, M.A, Duquette, J., Nimura, C., Pattenden, M., Arbide, L.S.M., Avin, S., Kelley, K., Lidova, M., Rodríguez-Pérez, D., Slater, G. & Winkler, A. (2018). Building the first Blockchain University. *White Paper, Woolf Development Ltd*. https://www.slideshare.net/eraser/woolf-building-the-first-blockchain-university-whitepaper

[7] Chen, G., Xu, B., Lu, M., & Chen, N.-S. (2018). Exploring blockchain technology and its potential. *Smart Learn*ing Environment 5, 1 (2018). https://doi.org/10.1186/s40561-017-0050-x

[8] Jain, K.A. (2018, March). *Blockchain Goes to School.* Cognizant. https://www.cognizant.com/whitepapers/blockchain-goes-to-school-codex3775.pdf

[9] Gopane, T. J. (2019). Blockchain Technology and Smart Universities (Vol. 12, pp. 72–58). EasyChair. https://doi.org/10.29007/rkv5

[10] Grech, A. and Camilleri, A. F. (2017). *Blockchain in Education*. Inamorato dos Santos, A. (ed.) EUR 28778 EN; doi:10.2760/60649

[11] Nielson. B. (2020, Jan. 23). How Blockchain is Changing Learning and Development. https://www.yourtrainingedge.com/how-blockchain-is-changing-learning-development/

[12] Okoli, C.& Schabram, K. (2010). A Guide to Conducting a Systematic Literature Review of Information Sytems Research*. Sprouts: Working Papers on Information Systems*, 10(26). http://sprouts.aisnet.org/10-26

[13] Pisa, M., & Juden, M. (2017). Blockchain and Economic Development: Hype vs Reality. *Center for Global Development Policy Paper (107)*, (July), 47. https://www.cgdev.org/sites/default/files/blockchain-and-economic-development-hype-vs-reality_0.pdf

[14] *Prisco, G. (2016). Slock it to Introduce Smart Locks Linked to Smart Ethereum Contracts, Decentralize the Sharing Economy. Bitcoin Magazine. https://bitcoinmagazine.com/technical/slock-it-to-introduce-smart-locks-linked-to-smart-ethereum-contracts-decentralize-the-sharing-economy-1446746719*

[15] Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where is Current Research on Blockchain Technology? -A systematic review. *PLOS ONE*, *11*(10). https://doi.org/10.1371/journal.pone.0163477

[16] Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H. (2018). Blockchain Challenges and Opportunities: A Survey. *International Journal of Web and Grid Services*, *14*(4), 352–375. https://doi.org/10.1504/IJWGS.2018.095647