Usability of Blockchain Technology in Higher Education: A systematic review identifying the current issues in the education system

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Abstract. Blockchain facilitates the creation of a shared document of a digital transaction in a distributed way where no third-party regulates any data or related activity. Earlier blockchain was used to transmit money, but today it has a huge scope of utilization in various domains like banking, health care, the Internet of Things (IoT), and many more. Inside the educational domain, blockchain offers many circumstances for disperse administration of records in an interoperable way in higher educational institutions. The primary purpose of the study is to address the current issues relevant to educational institutions and to identify the appropriate blockchain characteristics that can solve these issues. To recognize and extract significant knowledge from the selected research studies, a systematic literature review approach has been followed by us. Our research study represents the current problems in three forms, i.e., financial, digital, and physical. The consequences of the study show that the main problems faced by education institutions are the risk of manipulation, the tough of authenticating, and difficulty in interchanging records among institutions. This research analyzes the blockchain characteristics such as fragmentation, traceability, and consensus system, focusing on a few problems relevant in this domain.
Keywords: Blockchain; Educational institutes; Higher education; Systematic review; Traceability

1. Introduction

In 2008, the concept of blockchain was initially popularized when Satoshi Nakamoto presented a white paper on Bitcoin titled "Bitcoin: A Peer-to-Peer Electronic Cash System." Satoshi's suggested mechanism was established on cryptographic evidence rather than trust, allowing any individual or organization to perform business with no need for a reliable mediator. This proposition resolved the issue of dual payment [1], and it was also the initial blockchain purpose.

Multipurpose blockchain characteristics like open, decentralized knowledge sharing, smart contracts, transaction speed, etc., may help enhance different functions. The broad and potential capacity of blockchain caters improved educational support to students and other higher education institutions, like qualifications and official recognitions [2], confirmed and authenticated records [3] guide's recruiters in the staffing process [4], record keeping [5] and facilitating access to those records. Considering all into account, blockchain technology's scope is not restricted to the applications mentioned above but also provides an opportunity for the

university administration to handle their department of accounting and finance by just putting all campus charges and dues using this technology [6].

This study deals with the support of blockchain and its importance in the field of higher education. This research sheds light upon some of the active problems that can be solved by blockchain characteristics in the field of higher education. However, there are still a few flaws, including personal privacy exposure [7], privacy and public key protection, and scalability issues. By fixing these shortcomings, we can mold this technology to have productive advantages [8].

The structure of our paper is designed in the following way. The 2nd section is on correlated research and analyzes the characteristics of blockchain technology. Analysis methods, research issues, and searching strategy are discussed in the 3rd section [9]. The 4th section uncovers the result of the issues of research. In the 5th section, blockchain applications in higher education are presented. The 6th section addresses the different hazards to validity. Finally, the 7th section ends our review's assumptions and constraints and also presents the directions for the future [10].

2. Related Work

This section shows several central concepts and hypotheses associated with the blockchain from existing research and the various realistic applications in the field of higher education. Also, this compares the latest secondary research to one another.

2.1 Digital Ledger Technology or Blockchain

Digital Ledger Technology or Blockchain technology implies a scattered framework [11] that permits the organization to dispersed transaction records digitally, shared between network nodes rather than saving on an essential server [12] Currently, the blockchain technology or the distributed ledger technology (DLT) is classified into four types: public, private, consortium, and hybrid.

2.2 Characteristics of Blockchain Technology

Blockchain or the DLT has the subsequent key characteristics:

Decentralized: In the blockchain, all nodes are joined together in an interconnected network [13], in which all the information and ability to make decisions is present and it is distributed between the different machines [14].

i) *Traceability:*

The traceability of Blockchain [15] encourages the ability to remember an event because each of the data is saved in blocks secured by the cryptographic unidirectional hash utility [16]. The mining pools manage the whole chain of blocks, which offers websites based on cloud computing for the blocks so that they can be explored.

ii) Consensus system:

The consensus system points out the shared agreement of all blockchain-related nodes [17]. Therefore, it does not depend on intermediaries. Consensus system techniques also consist of Proof-of-Work (PoW), Proof-of-Stake (PoS), and Delegated Proof-of-Stake (DPoS) [18].

iii) *Dependability:*

Data is saved in the form of the ledger in the blockchain, and if at all there is any alteration by the outside network, the values of the hash key will be modified as they are cryptographically connected to earlier and former blocks, and the data alteration would disrupt the keys' continuation [19].

iv) Smart contract:

It is a program developed for computers that runs by itself on the blockchain dispersed set of connections

v) Currency:

One of the properties of the blockchain is a cryptocurrency, a type of virtual or digital currency that ensures a safe and trustworthy end-to-end transaction. Various mining methods [20] ensure the creation of this virtual currency. Therefore the combination of cryptocurrency with blockchain can thus be used in numerous forms such as financial and accounting business.

Hence to perform this analysis, the above defined characteristics together will be used to identify the major studies.

2.3 Usability of Blockchain Technology in Higher Education

Education's importance to the development and promotion of a country is not neglected [21]. Therefore, innovative technologies like blockchain have always been a challenge to support the field of education. Of data storage management, the most visible benefits are seen [22]. Additional advantages are seen in information security, the system reliance, the universal database of the world (Skiba, 2017), influential assessment and several advantages from smart contract expenses. Several initiatives by the educational institutions have been taken to store students' and faculties' information with the help of blockchain. The Nicosia University for the first time has been implementing blockchain to handle the student documentation, i.e. MOOCs certificates [23]. A learning system technology based upon blockchain was developed by the Massachusetts Institute of Technology (MIT); also a wallet has been formed for their students' that contain the students' educational record. The Holberton School adopts blockchain to maintain students' educational documents, e.g. marks, behavior during learning as well as classroom activities [24].

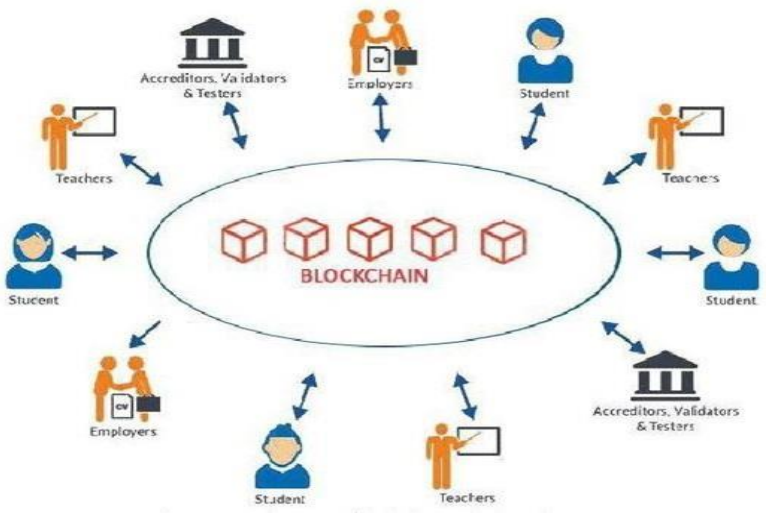

Figure 1: Various application of blockchain in higher education

Figure 1 highlights the applications of blockchain in higher education. It is a regularly expanding theory that can suggest many various improvements to a lot of educational collaborators. Blockchain as an account book document agreements, and additional necessary actions executed in educational institutions.

2.4 Comparison of subordinate research

Blockchain technology is a speedily expanding field and offers some high expenses for study in recent years. We only observed two studies discussing study trends during examining secondary studies. First, we identified a study released by the European Commission that concentrated only on the physical and digital aspects. Second, the qualitative study showed that monetary experts

with guardian obligations in some educational institutions addressed the views of distributed ledger technologies.

3. Proposed Research Methodology

A Systematic Literature Review (SLR) can be described as an approach of collecting, classifying, and translating all the studies that are accessible to resolve a distinct question of research. By pursuing the instructions presented by Barbara K., we have executed a systematic review to look for significant research. In the following paragraphs, the steps of the instructions are discussed.

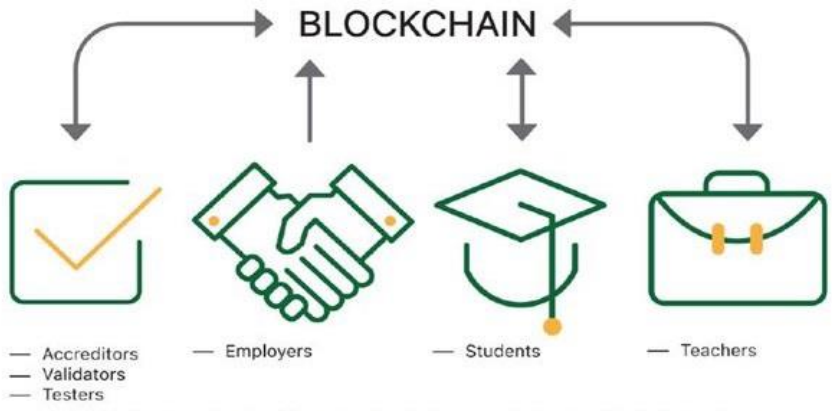

Figure 2: Educational collaborators with interest in blockchain technology

This preliminary study points out the significance of distributed ledgers, specifically which are depending on blockchain, may deliver to collaborators inside the educational domain, with an exact target on its ability for the digital certificate of private and scholarly research as shown in Figure 2.

3.1 The necessity of regulating Systematic Literature Review

The characteristics of secondary studies in consonance with the allocation of this research are explained above. It is found that few inconsistencies are present that have been ignored and it requires being replete for more pragmatic conclusions by inspecting the current secondary research. For instance, it has concentrated primarily on digital and physical certificates, although has concentrated primarily on the monetary dimension, which addresses financial professionals' impressions of distributed ledger technology. Besides, both used the qualitative approach of study through case studies, consultation, and conclusion and article reports. None of the earlier studies was addressing all conditions of current issues in institutions and to investigate recent elementary studies using significant research approaches. Therefore, to accomplish the goals and using a quantitative analysis methodology, we carried out a systematic literature review.

3.2 Research Question and its purpose

The initial stage of our systematic research involves deciding the research queries. These questions are as follows:

Research Question 1: What are the areas-related problems?

(Purpose: To show the problems that can be solved by blockchain in the current educational field)

Research Question 2: Which characteristics of blockchain can be considered to resolve the problems?

(Purpose: To find the blockchain characteristics to resolve the problems of the existing higher education structure accurately)

Research Question 3: What are the problems that have not been dealt with?
(Purpose: To emphasize on unresolved problems that can be resolved in coming days)

3.3 Search approach

In keyword type, we have adopted the label based path to look for associated articles. Such keywords, e.g., "blockchain" and "higher education" and "educational institutes" were searched in the Scopus database. All documents published from the start to the current day have been collected and downloaded (ignoring the year of publication and its quality). Through many publications and seminars, we have discussed numerous journals, articles, and research studies.

3.4 Selection and Rejection Criteria

All the primary studies have been examined to identify relevant data relating to our contexts following the research questions. Twelve primary studies for data extraction have been labelled, and the leftover studies are disqualified as they are unrelated by us and found that such studies are on "blockchain" particularly, rather than "blockchain in higher education".

3.5 Data Eradication

The labeled prime research was taken to the data eradication process after listing these studies to be incorporated into our SLR. During this stage, the significant facts were collected from the particular primary studies, mainly concentrating on current higher educational institutional problems and finding blockchain features to resolve them exceptionally. Twelve crucial studies covered problems and features, while ten studies covered unaddressed problems.

A data eradication structure was considered to extort information from the incorporated research papers. The structure was constructed particularly for our review, and it was trained on a model of thirty to forty papers. The structure consists of the 11 components given in Table 1.

Table 1: Data eradication form research papers

Data Item	Description
Title	Title of the paper
Author(s)	Name(s) of the author
Type	e.g., journal/workshop/conference
Date	Year of publishing
Country	Author's country
Aim of the system	The aim of thesystem as mentioned by the author
Implementation	Implemented summary of the application
Benefits	Actual/potential benefits of the application
Challenges	Actual/potential challenges of using the application
Future areas	Areas ofinvestigation in the future
Remarks	Remarks about the quality of the paper

3.6 Trend of publication

While the research was started in Blockchain with Bitcoin's invention in 2008, rapid progress and adoption have occurred since then. Nevertheless, the initial research covering blockchain and educational utilization was published in 2016. Five records were discovered in 2017, while six were identified until March 2018.

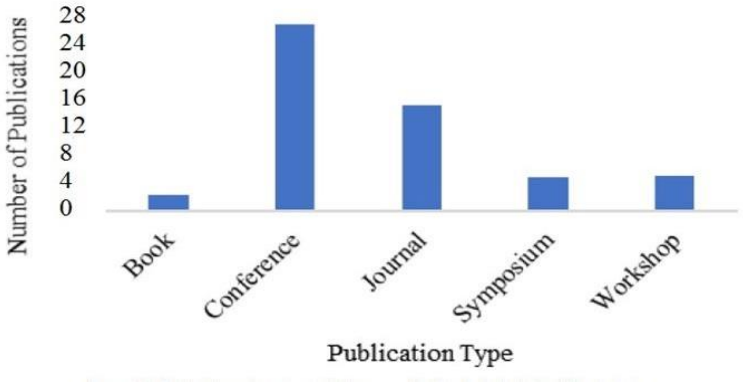

Figure 3: Research papers from some renowned publishers with blockchain keyword in the title by type

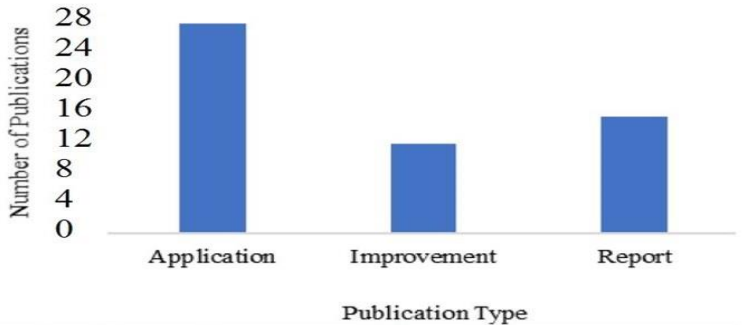

Figure 4: Research papers from some renowned publishers with blockchain keyword in the title by classification

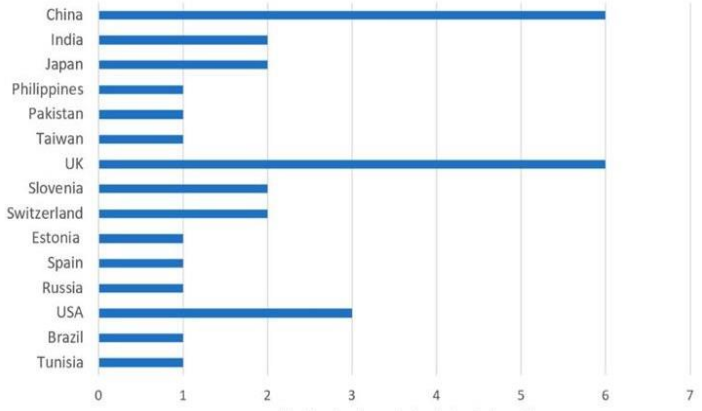

Figure 5: Distribution of the incorporated research papers geographically

In Figure 3, the number of articles published at the conference is very critical, followed by journal publications. This may indicate a lack of published journals pertaining to blockchain technologies.

Whereas in Figure 4, the no. of applications is 26 out of 50, comprising slightly above 50%. This is suggestive of the complete latent for blockchain applications in different domains. Figure 3 and Figure 4 represent the number of research papers by year and by type correspondingly. Figure 4 presents data regarding the type of publication of the research papers incorporated in our research.

Figure 5 represents the geological allocation of the incorporated research papers. Publications were mostly from Asia, Europe, North America, South America, and Africa. Similarly, the United Kingdom and China also added the maximum no. of research papers, pursued by the United States of America. Slovenia, India, Switzerland, and Japan with other countries also contributed a few articles.

4. Results

Each portion is categorized into 3 subparagraphs. The first paragraph deals with the basic problems of the education structure. The second paragraph explains the characteristics of blockchain which overcome the existing system of education, and the third paragraph outlines the unease concerns which can be solved in the future.

4.1 Research Question 1: What are the areas-related problems?

The aim is to recognize the general challenges facing knowledge institutions. The problems are categorized into 3 dimensions: physical, digital, and financial to simplify and clarify this discussion.

i) Physical dimension:

The physical dimension involves the features which certain people do or avoid physical activity. It contains problems caused by handling the instructional records or by handling them physically.

Risk of manipulation: The development of physical records requires a variety of individuals, i.e., tests are taken and graded in platforms. Manipulation assault occurs when certain educational documents have been produced by an illegal individual, i.e., the attacker may make changes in students' markings that could contribute to the communal malaise. The system used to protect academic details such as the graduation and transcripts is reproducible and is difficult to distinguish from the original text. They are also more likely to be tampered with.

Tough to authenticate: The record of students in the physical structure can be difficult to verify. The one-third countries of the world that do not keep consolidated evidence of every university face this particular problem In comparison, since it's an extra cost, an individual is faced with insurance resistance. Therefore, the universities can't validate documents manually.

Human resource demand: In conventional teaching, both students and the institution still need a human resource. He could lose his academic credential, for example, if a student is involved. In this case, he will write several applications and undertake an expensive and time absorbing procedure. However, the organization wishes to validate the request over different measures, for instance, through checking and matching the previous student record and keeping long-term physical records of students.

A distinct point of breakdown: The students' documentation is structured and controlled by one person in the education facility. Even if some sort of distributed architecture is used within its borders, a group of untrustworthy parties can still directly share it. Within a certain location, standard educational records are kept and are converted into a distinct point of breakdown. So it means that if the physical records are burnt for unforeseen reasons, then it will be impossible to recover.

ii) Digital dimension:

The digital dimension assigns to the document or operation which is electronically or digitally recorded or executed. Network dimension problems are discussed below.

Approval of the third party required: An instructor for a student produces the degree from the academic record. However, the proof of the record is provided by a third party, either digitally or physically. The third party is therefore empowered to make forged educational documentation.

Security violation: Digital files can be penetrated from a consolidated resource in the same way as a distinct point of breakdown of physical records and can lead to changes of data by third

parties either intentionally or incidentally, or by other illegal means. It means every digital information will be lost if the source is compromised.
Difficulty in interchanging records among institutions: Exchanging records is a time-consuming as well as very sophisticated procedure. It is unlikely in some situations. For starters, it is hard to share records if a student wishes to transfer from one institution to another. We also face problems when applying for admission, as all their education records must be submitted. There is no global standard system that can provide all universities with such services.

iii) Financial dimension:
The term "finance" specifies an analysis of money and administration. In this field, problems are highlighted which have to do with currency and accounts.
Third-party charge: The educational institutions handle various activities with staff members, students, dealers, merchants, and government departments monthly. Higher officials are at risk of corruption. Decentralized auditing can only be eliminated if it is incorporated into the institutions' financial system.
Performance verification: There is not a precise monitoring and assessment system for students and teachers in education institutions. Students and teachers are also discouraged when their hard work is not rewarded. They must be compensated if they are successful, and there should be a confirmation and evidence to help them and inspire.

4.2 Research Question 2: Which characteristics of blockchain can be considered to resolve the problems?
Section 2 addresses Blockchain functionality, and this section demonstrates how they can be used to resolve previously defined problems.
a) Decentralized:
It features a shared network keeping duplicate records. It can contribute to reducing:
Risk of manipulation: This makes it hard for an attacker to modify a log kept by many nodes. On comparing to an individual node that manages most of the records as per the current central mechanism, this is challenging.
Tough to authenticate: Offering a distributed free platform that includes prints of the various transactions and distributes them to any node inside the organization.
Human resource demand: In minimizing organizational burdens in various situations, like in testing or moving situations, that reduces conventional manual labour costs and effort. For example, when a university student transfers from one institution to another, the university faculty can easily verify a student's record from blockchain. It also allows employers, instead of requesting an issuing institution, to interpret and confirm a certificate while the recruitment procedure is in a single operation.
A distinct point of breakdown: Maintaining a replica of the information on every node so that the out-of-line node is kept, the data does not lose when kept on an unnecessary network.
Difficulty in interchanging records among institutions: Through serving the educational institutions transfer knowledge freely via the freely available blockchain, viz. for transfer, and more studies, simply and conveniently.

b) Traceability:
The power to track and touch anything back to its source refers to traceability. The following problems can be overcome by traceability:
Risk of manipulation: The traceability feature can be reduced in a manner that allows you to monitor the linked block information from the constant blockchain when somebody attempts to create unauthorized transactions or variations to the blockchain. Therefore, a particular instance can immediately detect any modification or fraudulent activity.

Security violation: The proof of life and possession models was developed. For any transaction that cannot be recreated as compared to electronic signatures, blockchain technology creates a digital stamp.

c) Smart contract:
It is an automatic compiling computer algorithm distributed across blockchain nodes under certain conditions. It can help in solving:
Performance verification: Using smart contracts to deposit in real-time, the deposit can be done naturally with the help of smart contracts and based on students' and teachers' performance, they can get the real-time benefit.
Human resource demand: By robotizing human actions like internal surveys, the advancement of students to new divisions after the payment of fees, etc., into smart contracts.
Third-party charge: By robotizing the operation of the mediator into intelligent contracts, like the authentication of degree among platforms of the blockchain can be carried out. Systems pay fixed fees for the execution of the contract by keeping the whole procedure clear.

d) Consensus system:
It implies the collective confirmation of every linked node with the network of blockchain. It will help to solve the following problems:
Risk of manipulation: Since the data is compiled using a particular consensus system in blockchain, not a single individual is dealt with. Fraud and errors are less likely as the other nodes of the network are checked for all new incoming transactions.
Approval of the third party required: It can also be overcome since the blockchain system performs without an intermediary on an agreement process. Blockchain allows governance protocols that operate as intelligent contracts rather than adopting main control to handle activities.

e) Currency:
Cryptocurrency implies a kind of virtual or digital money that adopts a robust cryptographic approach and it is developed by various mining methods. It can be used to resolve:
Performance verification: The implementation of an instructional currency will allow some best students and teachers to obtain the reward in a crypto currency via an intelligent agreement. This kind of cash might be stored and exchanged with other currencies within the educational wallet.

4.3 Research Question 3: What are the issues that have not been dealt with?
While blockchain possesses a huge ability to solve educational problems with its remarkable characteristics, the study is yet in the early stages. Therefore, while implementing it bears questions and some risks. This study issue features certain missed questions that will be solved in the time to come.
i) Dependability:
In the blockchain, it cannot be changed or modified after the data has been placed there. This exchangeability can affect its useful functioning because no often-needed changes or changes are permitted. Suitable use of blockchain greatly enhances this requirement and eliminates undesirable reactions.
Approval of the initial network node will be given by whom?: At first, any entity will be the first network node and no existing node may exist to check this, so it could be considered a security risk for a specific attribute. Nevertheless, we expect that these safety concerns will be limited by the increase in the number of nodes.
Personal privacy disclosure: As blockchain technology is freely available and translucent, anyone can access or share data or personal information of students without their consent.

Scalability issue: Digital ledger technology must rate organization activities per second exploring fields like “side chains”.

5. Utilization of blockchain technology in higher education

Once blockchain’s distinctive advantages in education have been achieved, demand is global. Various applications are currently running blockchain and other applications are being processed. Echolink is an ideal universal blockchain platform that stocks verifiable accreditations, accomplishments, and experience of work in a secure and unchangeable way. The competent bodies enter all data and therefore ensure that all information remains confidential. Echolink has acknowledged Microsoft's partnership in offering blockchain Azure cloud application services.

One more use case, Disciplina, develops and maintains verified personal profiles for academic and business careers, is a multi-function blockchain platform. This helps to attract students with proof of authenticity through the production of digital CVs created during their educational careers. An open certificate application developed by attorneys assigns the education certificates block-proof using smart Ethereum contracts. The Singapore educational institutions have announced their partnership. Figure 6 shows potential use cases of blockchain in higher education.

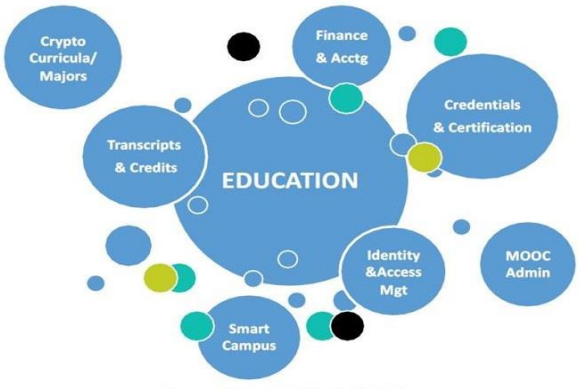

Figure 6: Potential use cases of blockchain in higher education

6. Threats

We have attempted to compile a lot of associated dominant applications so that we can extract learning to sum up current evidence concerning the usability of blockchain in the domain of higher education. A very few similar literature reviews conducted by peers were observed in this domain because most of the associated studies were in the preliminary stages. Since the approach of our determined queries of analysis was the basis of our extraction scenario, the reader might be able and willing to identify certain attributes that we did not take into account. Moreover, the work was largely concerned with features and innovative applications. Finally, there may be work that we could not mention during the publication period because the researchers focus constantly on solving problems at educational institutions via blockchain.

7. Conclusion

For this research, we agreed in a systematic literature review approach to chart all possible primary studies. By analysing and testing all the functionality of blockchain, we have proposed the correct solutions for coping precisely with educational problems. Since the approach of our determined queries of analysis was the basis of our extraction scenario, the reader might be able and willing to identify certain attributes that we did not take into account. Moreover, the work was largely concerned with features and innovative applications. Finally, there may be work that we could not mention during the publication period because the researchers focus constantly on

solving problems at educational institutions via blockchain. This technology is therefore still undergoing an evolutionary process since it is in initial experimental stages. It is assumed that an advanced analysis can be composed in the coming times as the society is adapting and advancing technologically further and the planet is approaching modernization and innovation.

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