

Systematic review of the implementation of Blockchain in the education sector

Revisión sistemática de la implementación de Blockchain en el sector educativo

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Abstract:

This research presents a process of systematic review of the implementation of Blockchain technology in the education sector. In particular, the research focuses on identifying the applications made through Blockchain in recent years. The results show that there are opportunities for the application of technology in the education sector. In addition, the low implementation of Blockchain in the education sector, inspires to draw future lines to benefit the areas of payment management, student registration, among others mentioned at the end of the document.

Keywords:

Blockchain, education sector, systematic review, Blockchain technology

Resumen:

En esta investigación se presenta un proceso de revisión sistemática de la implementación de la tecnología Blockchain en el sector educativo. De manera particular, la investigación se centra en identificar las implementaciones realizadas a través de Blockchain en los últimos años. En los resultados se observa que existen oportunidades de aplicación de la tecnología en el sector educativo. Además, la poca implementación de Blockchain en el sector educativo, inspira a trazar líneas futuras para beneficiar las áreas de gestión de pagos, registro de estudiantes, entre otras mencionadas al final del documento.

Palabras Clave:

Blockchain, sector educativo, revisión sistemática, tecnología Blockchain

1. Introduction

In the last years Blockchain technology has been applied in various kinds of knowledge area like: finance [4, 6], medicine [9], education [16], and more. The Blockchain technology resides in a chain of characters.

Blockchain, known as distributed ledger, contemplate four main characteristics [5]: decentralization, traceability, immutability and monetary properties. About the characteristics mentioned before, derive advantages that blockchain technology takes advantage of:

- *Reliability*: avoids single point of failure and ensures high reliability of technology-based applications.

- *Trust*: Maintains trust through decentralized network where nodes share tamper-proof data.
- *Security*: avoid corrupting the data through a mathematical function consisting of a one-way hash function.
- *Efficiency*: all data is run automatically through preset procedures.

Although the emergence of Blockchain in finance goes beyond this decade, the use of Blockchain in the education sector is recent; few researches were found in the bibliographic sources analysed that demonstrate the contribution of Blockchain in education. Derived from the previous and due to personal interests, the motivation

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arises to further study the benefits of Blockchain in the educational field in order to identify future lines of research.

In a particular way, in this research a systematic review is carried out that includes from 2010 to 2019. In the review, it is proposed to identify the benefits of the implementation of Blockchain technology in the improvement of educational processes. The main focus of this systematic review is to identify all the possible aspects involved in the educational system. To mention a few, for example, the way of teaching, processes to manage qualifications and issuance of degrees and / or certificates, etc.

The rest of the structure of the article is composed as follows: section 2 mentions the methodology used in the review, section 3 describes the execution of the entire systematic review process, section 4 mentions the Results obtained from the review, in section 5 the discussion of the results is presented, finally in section 6 the conclusions of the work developed are mentioned.

2. Methodology

This research has been performed under the guidelines established by Kitchenham in [1] defines a systematic research as "The medium to identify, evaluate and interpret all available research relevant to a research question, thematic area or phenomenon of interest".

The systematic review was developed in three stages consisting of: planning, execution and reporting of results, described in the Kitchenham report. In each of the stages, different activities were carried out according to the objective of the study and adapted to the present systematic review. Furthermore, the research process used in [2] and [8] to build a methodology according to the fulfillment of the objectives of the study.

As part of the methodology, subsection 2.1 describes the Planning stage. Sections 3 and 4 describe the process of execution and presentation of results, respectively.

2.1 Planning

Some of the stages associated with planning consist of: identifying the need for a systematic review and developing a review protocol.

2.1.1. Research question

In an investigation, it is necessary to define one or more questions to develop an investigation. This section shows the research question (RQ). The research focuses on the area of computer science, and specifically on the use of Blockchain technology in education.

For this reason, the research question that gives meaning to the systematic review is defined as:

RQ1. What are the benefits found in the literature of implementing Blockchain technology in the educational field?

2.1.2. Study language

In the present investigation, investigations carried out in various languages have been located. Therefore, only articles written in the English language have been considered.

2.1.3. Keywords and search chain

In this systematic review, a number of keywords have been considered and they have also been used to formulate the search in the different databases selected in this investigation.

The keywords selected and adapted to the research question are mentioned below:

- Blockchain
- Blockchain technology
- Benefits
- Implementation
- Education

Once the keywords were extracted from the set of words in the research question, a combination of these keywords was made with the AND, OR operators. As a result of the keywords, two search strings (CB) were defined. Each of the chains was adapted according to the search format of the bibliographic sources.

The defined search strings are:

CB1) Blockchain AND Education
 CB2) (Blockchain AND (Benefits OR Implementation)) AND Education

2.1.4. List of bibliographic sources

The articles that contribute to the systematic review have been obtained from six research sources recognized by the scientific community. The list of defined sources is mentioned in Table 1.

Table 1. List of bibliographic sources in the research

Code	Source	Web
FB1	IEEE Computer Science Digital Library	https://www.computer.org/csdl/home
FB2	Science@Direct	https://www.sciencedirect.com/
FB3	Springer Link	https://link.springer.com/
FB4	ISI Web of Knowledge	Access through the Spanish Foundation for Science and Technology. (FECYT)
FB5	ACM Digital Library	https://dl.acm.org/
FB6	Scopus	https://www.scopus.com

Access to bibliographic sources has been possible through the access privileges of the research authors.

3. Execution

As defined in section 2.1.3., the search chain and in section 2.1.4., the bibliographic sources, it proceeded to locate in the scientific databases the articles that would contribute to the objective of the systematic review. For this reason, each of the database websites was accessed and the corresponding search string format from each of the search engines was used.

Once the search was run, the resulting jobs were sorted according to the following filters provided by search engines:

- Year of publication between 2010 and 2019.
- Area of interest related to computer science and education.
- Language of the article in English.

In the Table 2. Shows the results of the search in the scientific databases selected after applying the filters. The filters were applied to each of the search strings executed in the databases. The total of articles found in all FBs and with the total of CB, and applying the established filters, was 603 articles. To obtain these results, only the filters for publication year, area of interest and language have been considered. In the following section, the inclusion and exclusion criteria are applied to discard those duplicate articles or those that are not related to the research.

Table 2. Selected articles applying filters

Code	Source	# Documents found	
		CB1	CB2
FB1	IEEE Computer Science Digital Library	3	14
FB2	Science@Direct	74	143
FB3	Springer Link	10	12
FB4	ISI Web of Knowledge	22	9
FB5	ACM Digital Library	275	13
FB6	Scopus	18	10

3.1 Inclusion Criteria (IC) and Exclusion Criteria (CE)

The inclusion and exclusion criteria (see Table 3 and Table 4 respectively) are an important part of the systematic review process because they aim to filter and select those primary studies that generate and provide reliable results with direct evidence that allows answering the research question.

Table 3. Inclusion criteria

Code	IC
IC1	The article contains in the title and / or in the keywords defined in the search string

IC2	Has not been selected before
IC3	The abstract is related to the application of Blockchain in education
IC4	The content of the article is related to research

Table 4. Exclusion criteria

Code	EC
EC1	The article does NOT contain in the title and / or in the keywords defined in the search string.
EC2	It has already been selected before.
EC3	The abstract is NOT related to the application of Blockchain in education.
EC4	The content of the article is NOT related to research.

3.2. Article selection procedure

Once the articles were compiled from the bibliographic sources consulted, the IC and EC defined in the previous subsection were applied. In the first place, a preselection of articles was made where IC1, IC2, EC1 and EC2 were applied, later the IC3, IC4, EC3 and EC4 criteria were applied.

The application of these filters consisted of making an exhaustive review of the articles in the summary, results and discussion sections. In the Table 5 shows the results obtained when applying the IC and EC.

Table 5. Articles selected by applying the IC and EC

Code	Source	# Documents found	
		CB1	CB2
FB1	IEEE Computer Science Digital Library	0	0
FB2	Science@Direct	1	0
FB3	Springer Link	3	0
FB4	ISI Web of Knowledge	7	0
FB5	ACM Digital Library	0	0
FB6	Scopus	0	3

In total, 14 articles were obtained that were used in the results section, of which CB1 represents the highest percentage of articles for the review. While, the bibliographic source ISI Web of Knowledge represents the highest percentage.

4. Results

In this research, the areas of education have been defined, in which it is possible to implement Blockchain principles. The results were divided into the areas: a) knowledge accreditation; b) grade adjudication; c)

student registration management; d) degree fraud and e) knowledge acquisition management. In the

Table 6 presents the manuscripts obtained from the literature review and subsequently describes the contribution of the papers according to the identified areas.

Table 6. Blockchain implementation in education sector

Item	Title/Author	Education area
1	On the use of blockchain-based mechanisms to tackle academic misconduct [13]	Not mentioned
2	Exploring blockchain technology and its potential applications for education [5]	Student registration management
3	Blockchain-based approach to create a model of trust in open and ubiquitous higher education [12]	Accreditation of knowledge
4	Managing lifelong learning records through blockchain [14]	Adjudication of grades
5	Blockchain in the university: a digital technology to design, implement and manage global learning itineraries [19]	Accreditation of knowledge
6	Blockchain Technology: A Data Framework to Improve Validity, Trust, and Accountability of Information Exchange in Health Professions Education [7]	Accreditation of knowledge
7	Blockchain and smart contracts for higher education registry in Brazil [15]	Accreditation of knowledge
8	Does competency-based education with blockchain signal a new mission for universities? [21]	Knowledge acquisition management
9	Design of Student Capability Evaluation System Merging Blockchain Technology [22]	Accreditation of knowledge
10	Process Design of Cooperative Education Management System by Cloud-based Blockchain E-portfolio [20]	Adjudication of grades
11	Application of Blockchain Technology in Online Education [17]	Accreditation of knowledge
12	Implementation of blockchain technology in education system [11]	Fraud of grade
13	Blockchain and the Future of Digital Learning Credential Assessment and Management [10]	Accreditation of knowledge
14	EduCTX: A blockchain-based higher education credit platform [18]	Accreditation of knowledge

In the case of [13] proposes a new method of academic publication to strengthen confidence in scientific production, however the area of education that it impact is not specified.

According to the analysis made to the work, the scientific community benefits from this method of academic publication through the accreditation of scientific publications.

4.1. Implementation in areas found

This section includes the contributions according to the areas found in the systematic review. It should be noted that Blockchain is used with greater incidence in the area of knowledge accreditation.

4.1.1. Accreditation of knowledge

In the area of knowledge accreditation, the proposal of a trust model in higher education was found. This model

records the acquisition of knowledge and validates it in real problems adapted to the business context. This decentralized model allows institutions to have a quick and effective mechanism to evaluate teaching and adapt to the changing job market.

The implementation of a system for recording the results of the activities was also found, which allows the students to follow a personal itinerary and the teacher of the subject to carry out formative evaluation and accreditation of their work. Important indications on the feasibility and relevance of the use of Blockchain in education are found in the research.

On the other hand, a research was located that gives value and confidence within educational institutions of health professions educators. In this study found that with use the Blockchain could make the management of educational systems faster, more reliable and transparent. This is achieved through the implementation of competency-based education, creation of educational portfolios based on values and value units, and establishment of credentialing systems without third guarantors.

In addition, one of the authors proposes a system for the digitalization of degree certificates and academic credits for higher education in the Brazilian educational system. In this system, the reliable and decentralized issuance of degree certificates is realized through the validation of a historical database and the activation of transactions through smart contracts.

Regarding the evaluation of knowledge, the application of Blockchain in the evaluation of students' professional capacity was carry out. This proposal offers possibilities to create and ecosystem of student capability assessment for the future. Continuing with the evaluation, a solution was found that gives credibility of an academic course, credit certification and certificate of students' privacy and course sharing of online education base on Blockchain technology.

In this aspect, it is observed that the integration of Blockchain technology is a promising trend in the development of online education.

Similarly, the application of Blockchain through evaluation and management tools for student credentials was located and found that Blockchain benefits universities by reducing administrative costs and bureaucracy. Finally, in the area of knowledge accreditation, we cited the implementation of a Blockchain-based global higher education credit platform. The proposal leverages Blockchain to create a globally trusted higher education credit and rating system.

4.1.2. Adjudication of grades

In aspect, first found the implementation of a Blockchain platform that connects the learning records of students at the different institutions attend into a single, public record. This platform solves the problem of transferring

educational data between different institutions as students move from one institution to another.

In addition, other authors proposed a cooperative education management system through Blockchain. This system helps to make the result of digital competence assessment credible to open up de digital job market.

4.1.3. Student registration management

In the field of Student record management in educational institutions, an analysis of possible educational applications was located and explores how Blockchain technology can be used to solve some educational problems. In addition, researchers found that for students and teacher, Blockchain has great potential applications in instructional design, behavioral recording and analysis, as well as formative assessment.

4.1.4. Knowledge acquisition management

Currently, the management of knowledge acquisition is carried out on technological platforms. For this an analysis was found that answers whether universities should outsource parts of their courses and assessments to remain competitive. As results obtained that there is the possibility of converging artificial intelligence, data analytics and Blockchain technologies as part of an authentic learning curriculum.

4.1.5. Fraud grade

Technological developments around the word have led to the spread of degree fraud through the creation of fake degrees. This being so, a research that seeks to mitigate degree fraud was located.

In this research, the application of Blockchain to smart contracts is performed to reduce general frauds and manipulation of degrees and certificates. Thus, it is demonstrated that, the educational system can take advantage of this scalability of Blockchain and can be effectively useful in educational institutions.

5. Duscussion

In relation to the methodology established for this study. The period for the review of the researches has been defined. In the results it was found the areas where Blockchain technology has been used. These areas are five: knowledge accreditation, grade adjudication, student registration management, knowledge acquisition management and grade fraud.

Regarding the area of knowledge accreditation different proposals were observed that allow comprehensive systems for information management to be developed considering the main characteristics of Blockchain, which are reliability, trust, security and efficiency.

Therefore, among the implementations, proposals are observed from a trust model for institutions in order to evaluate teaching considering the changes in the job market. Also, there are proposals that record the training

activities of students. In addition, in health education Blockchain is applied to manage educational systems in a fast, reliable and transparent way without external agents to the system that violate the information. Other proposals demonstrate that the digitization of degree certificates and credits is possible to issue reliably and decentralizing the information between distributed systems. This application proposal also applies to online education.

There are students who study in different educational institutions. For this there is a need to solve the problem of transferring educational data between different institutions as students move from one institution to another. Blockchain maintains a unique record of each student by keeping a unique historical record.

It is possible to make artificial intelligence, data analytics and Blockchain technologies as part of an authentic learning curriculum in student knowledge acquisition management.

The educational system can leverage the scalability of Blockchain and can be effectively useful in educational institutions in order to prevent grade fraud in the issuance of certificates or degrees.

6. Conclusions

In the application of Blockchain technology brings the possibility of improving aspects such as the creation of structures for information management, use of cryptocurrencies for the generation of university payments, allows users to verify the validity of certificates through a Blockchain, replace the system of issuing paper certificates. In other words, the application of technology would come to replace a large part of the processes that are executed in the educational system of any institution.

Regarding the educational system, there is a great opportunity to explore the application of Blockchain in the areas of awarding grades, awarding licenses, and student registration management, intellectual property management, payment management, all of the above derive from the proposal in Grech's report [3]. However, there are opportunities in the areas of grade fraud or degree awarding fraud, knowledge academy work management.

It is important to highlight these last two areas of opportunity to implement Blockchain technology in order to reduce the impact on the issuance of degrees outside of educational institutions, due to the fact that it is increasingly notorious to find false degrees. On the other hand, the work carried out by knowledge academies through proposals for improvement in educational programs leads to the generation of ideas and didactic material that must be protected through mechanisms that guarantee integrity.

According to the above, in this article the areas of application of Blockchain in the educational field are

mentioned. The areas of opportunity are demonstrated in order for the scientific community to find specific lines of application by involving the areas of education and information technology to solve the problems that exist in the security of information in general in the educational field.

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