Blockchain in education: opportunities, applications and challenges

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***Abstract*— Blockchain is a decentralized data storage technology that has received a lot of attention in recent years, extending its application to many fields. At first it was thought that this technology could be used only in the finance sector, but later its uses have expanded to many sectors including education. Blockchain technology has several characteristics that make it suitable for application in systems where transparency is required, the assurance that the data being stored is unchanged. The potential this technology has shown to democratize data, reduce fraud and eliminate data manipulation has made it a transformative tool for many sectors, both public and private. The purpose of this thesis was to investigate what opportunities this technology offers for the education sector, what are its current applications and applications for the future and what are some of the main challenges that arise during the integration of this technology. The results of the research showed that the opportunities that this technology offers for the education sector are numerous. One of them is the verification of digital certificates and transcripts. By harnessing the power of Blockchain, educational institutions can issue indestructible digital credentials where qualifications can be verified with a high degree of reliability. This reduces the risk of manipulation and preserves data integrity. Blockchain has found application in what is known as 'continuous learning' where the record is kept for the whole the student's academic journey. Also, Blockchain offers opportunities and has found application in Peer-to-Peer decentralized learning platforms where educators from all over the world connect and communicate without any intermediaries and barriers. This also helps create more personalized and individual learning experiences. In many countries, Blockchain is also used to reduce the administrative burden by automating processes such as student admission, registration, payments, etc. In this way, efficiency is increased and errors are reduced. Many popular platforms such as Duolingo and Khan Academy have implemented this technology in their systems. Some of the challenges identified were: lack of knowledge about technology, lack of infrastructure for implementation, standards that regulate its work, etc.**

Keywords— blockchain, education, application, opportunities, challenge.

I. INTRODUCTION

Blockchain technology has the ability to completely change how education is run [3]. In record time, the cryptocurrency industry has grown exponentially. The number of one bitcoin has increased significantly. In 2017, the price was around $1,000, while in November 2021, the price has gone up to $68,000. So, in a period of four years, the price for one bitcoin has increased by more than 60 times [1]. During this period, however, there have been fluctuations, often even drastic decreases that have made people doubt whether it is worth investing in this technology. But what exactly is a bitcoin? Bit-coin is a digital, virtual currency, the purpose of which is to enable parties to make payments directly through an international payment system, without the need for the intermediary of a third party/body, such as banks [1]. Bit-coin is not used by central banks, governments or other public and state institutions, as there are still no laws or articles that would enable and regulate their use [2]. So, in the world it is still not recognized as a genuine currency such as the euro, the dollar, etc. As is the case with physical gold, bitcoin's importance and what made it popular comes from the perception that it retains its value over time, is an anonymous means of payment, and therefore protects against inflation, although none of these features have yet have stood the test of time, so their validity still needs to be tested [2]. Blockchain is the technology behind cryptocurrencies. It is an open-source system that is located in a decentralized computer network (e.g. the Internet) that records transactions between parties in a verifiable and permanent way [6]. Blockchain promotes accountability as the records are immutable which offers a potential for exploitation in many cases. Blockchain is a technology that can be used beyond payments, it can be extended to supply chain management, financial services etc. [6]. Like any new technology or product Bitcoin has immediately attracted fans interested in innovation and the perceived lack of government control [5]. Traders immediately saw it as an alternative to traditional investments such as stocks, bonds, treasury bills, etc. This trading momentum led precisely to the increase in the value of Bitcoin in the market. Various companies such as PayPal, Microsoft, Starbucks, AT&T accept Bitcoin as a form of payment, such transactions are usually processed by

a third party, therefore their use in everyday commerce remains quite limited [5]. The introduction of cryptocurrencies and blockchain technology is part of a broader wave of technology that facilitates peer-to-peer communication. It supports individualized products and increased flexibility in production methods. For big platforms like Amazon, Alibaba, Uber and Airbnb, cryptocurrencies have changed the way business is done [4]. Cryptocurrencies are by far considered the most advanced application of blockchain technology. So, they create money and enable exchanges without the mediation of financial institutions [4].

Blockchain has attracted the attention of many sectors, including education. In this sector, it is thought to have the potential to change or transform many processes, starting from the verification of students' diplomas to the creation of platforms for personalized learning. These make it a technology worth investing in, but always keeping in mind the risks and challenges that will be discussed in this thesis.

II. PROBLEM STATEMENT

The field of education has undergone major changes and reforms in recent years. The transition from learning with books in traditional classrooms to learning through technology tools has opened up new opportunities for this sector. After the pandemic, it can be said that there was a revolution in the education system, since the entire learning process went completely online, that is, learning through various online platforms. This transition naturally had its challenges, but the benefits were numerous. Blockchain technology aims to revolutionize this sector even more. Although its potential is great, there is a lack of studies on how concretely this technology can contribute to education. In this thesis, it is intended to analyze how this technology can help to overcome some difficulties that are currently present in education, how it can automate some processes in order to increase efficiency and what are the challenges for the implementation of Blockchain technology in the education sector.

III. METHODOLOGY

The methodology used in the research is combined (mixed). The work is based on secondary data which have been collected from various sources such as books, scientific articles, various websites on the Internet. These data have been processed and analyzed with the help of the systematic literature review method. Through this method, the concepts related to the Blockchain technology were selected, which were then processed and in the form of theoretical findings, only those key concepts that explain what this technology is are presented. The key part of the paper deals with the analysis of the case study which is the integration of Blockchain in the field of education. Here we analyze some possible applications in automating processes and addressing some of the challenges currently facing the education sector. It is worth mentioning that some of these platforms have already been implemented and the first results of their use have come out, while some platforms are still considered as projects that can be implemented in the future (if the necessary resources exist). So, it can be said that Blockchain is a mix between theory and practice, i.e. a combination between what has been implemented and what can be implemented.

IV. THEORETICAL BACKGROUND

4.1 What is Blockchain technology?

Blockchain is a distributed data ledger that is controlled by a collection of computers that are not owned by a single entity and is regulated by established and recognized cryptographic rules [10]. A blockchain is essentially a distributed database with records of all digital transactions or events that have been executed between participating parties. This register is divided into blocks of data which are connected to each other and protected through cryptography, thus creating a chain or "blockchain". Because of this particular structure, it becomes difficult to change or falsify information after it has been added to the blockchain [9]. Each transaction in what is called a "public ledger" is verified with the joint approval of the majority of participants in the system. To use a simple analogy, it is easier to steal a cookie from a cookie jar stored in an isolated location than it is to steal a cookie from a cookie jar stored in a market, being watched by thousands of people. Blockchain works on the same principle [9].

Bitcoin is the most representative example related to Blockchain technology which is also the most discussed because it helps create a billion-dollar market with anonymous transactions without any government control [12]. Many researchers, businessmen have considered this technology an epochal discovery. The use of software that enables the circulation of digital money has the potential to transform the finance sector and beyond [12]. All of our online transactions have one thing in common: they rely on the trust we have to have that someone is telling us the truth. For example, we must believe that the email service provider is telling the truth when it confirms that the email was received by the recipient, or a bank that tells us that the transfer has arrived at the destination after we sent the money, etc. [13]. The fact is that we live in the digital world relying on third parties for the security and privacy of our digital assets. The problem is that these systems can be hacked, manipulated or damaged. This is when Blockchain comes to our rescue. It has the potential to change the digital world by allowing transactions to be verified through a common approval. They did this without infringing or damaging the privacy of digital resources and the persons involved. Common approval (consensus) and anonymity are the two essential characteristics or attributes of Blockchain technology [13].

4.2 Working Principles of Blockchain Technology

Online or Internet commerce is closely related to financial institutions that serve as trusted third parties that process and stand between every electronic financial transaction. The role

and duty of this third party is to verify, control and maintain the legitimacy of transactions [8]. However, the attacks on these systems which are almost inevitable have increased the insecurities of the users that they have to depend entirely on these institutions. Most financial institutions work with poorly designed systems, with many deficiencies in terms of security. This makes them a convenient target for a potential attacker. Figure 1 shows the realization of transactions in traditional systems in a metaphorical way, in which a third party (bank, Paypal) is the intermediary [8].

Bitcoin uses what is known as "cryptographic proof" to secure transactions between parties on the Internet. Each transaction is protected through a digital signature. Each transaction is sent to the receiver who with the public key can verify the transaction of the sender who signed it with the private key that only he/she has in his/her possession. To spend money, the owner of the cryptocurrency must verify that they own the private key. Each transaction is passed (distributed) to each node of the Bitcoin network and only after being verified is that transaction recorded in the "public ledger" [7].

Each transaction must be verified and validated before being recorded in this ledger. Before a transaction is recorded, two things must be verified [7]:

1. The spender (the one who sends money) is the owner of the cryptocurrency – this is achieved through the digital signature of the transaction.

2. The spender (owner) has enough cryptocurrency in his account – this is achieved by comparing the value of each transaction against the public ledger to ensure that the sender has sufficient balance in the personal account.

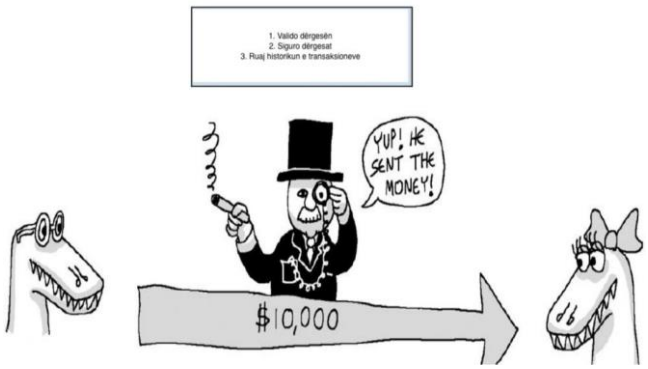

Figure 1. Realization of financial transactions on the Internet mediated by a third party (bank, Paypal, etc.)

The issue that arises during the execution of transactions is the maintenance of their queues which are distributed among all the nodes of the Bitcoin network. Transactions may not be transmitted in the order in which they were sent, therefore there is a need for a system that does not allow what is known as "double spending" [6]. Because transactions pass from node to node on the Bitcoin network there is no guarantee that the order in which they are accepted is the same as the order in which they were created (generated). So, the system must guarantee that no more than one payment can be made with the same amount. This is a challenge for distributed systems, but it is nevertheless solved in Bitcoin. When a user tries to spend their cryptocurrency, nodes in the network verify it against the blockchain to ensure that that currency has not been used before [6].

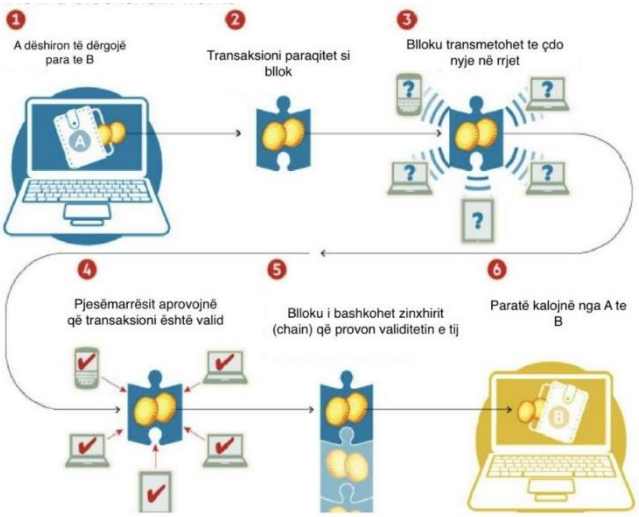

Figure 2. Schema of transaction realization in Blockchain technology

4.3 Features of Blockchain technology

According to [9], some of the characteristics that distinguish Blockchain technology from others, especially from traditional ones, are related to:

Decentralization – in Blockchain there is no single point of failure. In a blockchain network, data and transactions are verified by many participants and not just by a central authority as is usually the case with most traditional systems.

Transparency – all transactions that are carried out are visible and can be seen by all participants in the network. However, the identity of the persons behind these transactions remains unknown (anonymous).

Security – A block cannot be attached to the chain unless it has been first verified by a network of computers known as miners. So, in this case, we are dealing with a security that preserves the integrity of the data, because this information has been subjected to numerous filters and preliminary checks.

Validation algorithms – these are techniques that are used as a means to determine the validity of data. Examples include: proof of work (prof of work) or... Within this we also have the use of cryptographic algorithms which ensure that transactions are carried out by legitimate parties. Each participant is in possession of a public and private key.

There are six main components through which a blockchain is created [9]:

Block – contains a list of transactions, with details or additional data. Different blockchains can store different data. Each block has a unique hash which is a cryptographic string generated by the algorithm. When a block is created, its hash is also calculated. A change within the block will affect the hash change, thus guaranteeing data integrity. Each block references the hash of the previous block, creating a chain of blocks. This ensures that the blocks and the data within them are in a specific order and interrelated.

Chain – when blocks are connected to each other using their respective hashes, they form a chain. This chain ensures that blocks are placed in a linear, chronological order.

Nodes – There are individual computers that participate in a blockchain network. Each of them keeps a copy and can validate transactions. Nodes can have different roles depending on the blockchain: full nodes (store the entire blockchain), light nodes (store only part of the blockchain) as well as mining nodes which participate in the creation of new nodes.

Approval Mechanisms – These are protocols that are used to reach agreement within the network about the validity of a transaction and what the next block should do. They ensure that all nodes have the same (consistent) view of a version of the blockchain.

Distributed Ledger – Blockchain is distributed across all nodes in the network. Each node has an identical copy of this ledger, which is continuously updated and synchronized across all nodes in parallel.

Diggers - also known as validators. These are entities whose responsibility is to validate and add new transactions to a blockchain. They do this by solving difficult (complex) mathematical problems such as the case with "proof of work".

Figure 3 shows a simple diagram of some of the components of the blockchain and the interaction between them.

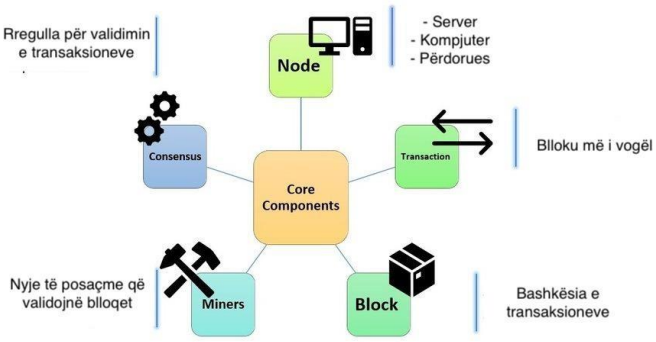

Figure 3. Components of blockchain technology

4.4 Blockchain Applications

Blockchain technology was originally intended to be used only for digital currencies, but over time it has developed to provide solutions for multiple sectors due to several features such as transparency, security and decentralization. In this part we will mention only some of the areas in which blockchain has found an application and has been successful, that is, it has produced positive results [13].

4.4.1 Voting systems

The application of blockchain to voting systems has received considerable attention in recent years. This is because of the advantages it can bring to this process. The blockchain's public ledger means that all votes can be seen and verified by authorized parties, thus ensuring the transparency of the election process. Blockchain encryption ensures that once a vote is recorded, it cannot be changed. This enables remote voting, allowing citizens, especially those with mobility difficulties, to cast their vote easily. An unaltered registered vote means that the results can be audited even after the election process is over. The voter's privacy is preserved through the blockchain. As long as all the votes are transparent, the identity of the voter will remain secret thus maintaining the secrecy of the vote [4].

Before voting, a voter must be verified. This can be done in various ways, such as digital identification systems. Once logged in, the voter accepts a digital ballot. They cast their vote which is then converted into a transaction on the blockchain. This vote (transaction) is then validated by the nodes (these can be special nodes created for this work) and the same is added to the blockchain. Once the voting period is over, the votes are tallied by the blockchain, ensuring a transparent and secure voting process. The results can be announced and verified by third parties independently, through access to the blockchain [13].

4.4.2 Health systems

The application of blockchain technology in the health sector offers numerous opportunities to address challenges related to privacy, interoperability and security. Because the data in the ledger is immutable, it means that once a patient's health data is recorded, it cannot be changed. With the increasing number of cases where healthcare systems are attacked, the decentralized nature of blockchain and its cryptographic nature provides a more secure method to store patient information. Another problem with traditional systems concerns their interoperability. Different service delivery systems often encounter difficulties in exchanging data. Blockchain provides a standard platform so that different systems can communicate and access records [14].

By implementing Blockchain, patients can view their medical history, from different providers. Patients can control who can access their data. Instead of a centralized database, the data is stored in several nodes thus increasing security. So, it can be seen that the advantages of Blockchain

implementation in this sector are many, therefore many countries have started to do so [14].

4.5 Blockchain Benefits and Challenges

The reasons for such a big boom in Blockchain technology are precisely related to the many advantages it offers in the various environments in which it is implemented. The first advantage is about transparency. All participants in the network have access to the blockchain and audit stages [14]. All transactions are encrypted and linked to previous transactions, which increases their security. By eliminating intermediaries such as banks or other state-owned financial institutions and by automating processes, the cost of operation can be reduced. For each transaction, its origin is known, which can be used to prove the authenticity of the assets. Through blockchain, efficiency is also increased, as transactions are processed faster than in traditional methods [7].

Despite the advantages and benefits, this technology has its own challenges. The first challenge is that the concept and technology behind Blockchain can be difficult for a wider public to understand. For businesses and institutions, integrating blockchain into existing systems can be challenging [5]. The decentralized nature of the blockchain makes it difficult to create a mechanism that regulates its operation. Governments and regulatory organizations are still at a loss as to how they can regulate Blockchain activities, especially cryptocurrencies. There are platforms and protocols in the market that do not follow certain standards. This can cause problems in adoption and interoperability. Another challenge is memory space. As new blocks are created, the size of the blockchain increases [5].

V. APPLICATION OF BLOCKCHAIN IN EDUCATION

5.1 Opportunities that Blockchain offers for education

That being said, Blockchain has the potential to change an entire industry, including education. Its decentralized nature offers a host of promising opportunities for the education sector. Many of these opportunities have been used, that is, they have been implemented in practice, while other opportunities are expected to be used in the future. Because the core of this technology is decentralization, it paves the way for the creation of transparent, secure and efficient systems. Since these characteristics are known mainly in the field of finance, i.e. cryptocurrencies, their application in the field of education opens other possible paths [11].

One of the most transformative aspects of Blockchain in the field of education is the issuance and verification of digital certificates and transcripts. So, gone are the days when you had to wait for the verification and validation of a transcript. By harnessing the power of Blockchain, institutions can issue invulnerable/vulnerable digital credentials, easing the process for students and institutions themselves, as qualifications can be verified with a high degree of reliability. This reduces the risk of fraud, manipulation and maintains the integrity of qualifications in the field of education [11].

Nowadays, education is not limited to the four walls of a classroom or the years spent in formal education. The new and current paradigm is 'lifelong learning' or what is becoming known as 'lifelong learning'. Blockchain offers students to have in their hands the register that contains their entire academic journey from formal schooling to various work groups. This helps to create a more complete picture of the individual's academic journey, which is useful for the students themselves but also for potential employers [16].

In parallel, Blockchain shows a potential for Learning Platforms which are based on a decentralized Peer-to-Peer system. This is an opportunity for students and educators from all over the world to connect directly, eliminate barriers and not need intermediaries to communicate and collaborate. This helps create a more personalized and individual learning experience. These platforms democratize the sphere of education, making quality education more accessible and affordable for everyone [16].

Blockchain technology also offers potential in the governance of educational institutions. The reduction of the administrative burden, which is achieved through the automation of tasks through smart contracts, can improve processes such as admission, registration, student payments, making these processes more efficient and less error-prone. The transparency that Blockchain offers can also be used for the distribution of scholarships, ensuring that scholarships, funds, are allocated accurately and according to merit. This increases the trust between the recipient and the applicant [16].

By decentralizing the space where notes are stored, students gain more control over their data, i.e. they are given more autonomy to determine who can access this data, thereby increasing the degree of privacy which further helps reduce of the possibility of data misuse and manipulation [17].

5.2 Applications of Blockchain in Education

Blockchain technology looks very promising for the education sector due to its potential to provide transparency, security and records that are tamper-proof. Although it is still in the early stages of testing, it is beginning to find application. Some of these applications are:

Digital transcripts and certificates

One of the most applicable forms of blockchain in education is the distribution of digital diplomas and transcripts. Through this technology, a person's academic record can be stored securely and permanently, which can then be easily shared and verified. In this way, the possibility of creating false diplomas is excluded and the verification process is simpler [16].

Peer-to-Peer Learning Platforms

Peer-to-Peer learning platforms represent a shift from the traditional top-down learning model to a more decentralized

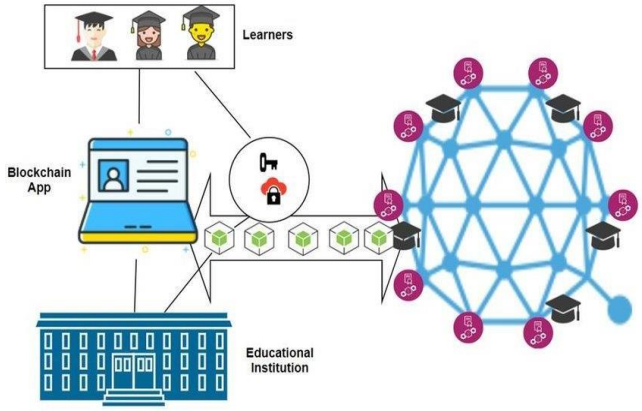

Figure 4. Application of Blockchain in Education

approach where individuals learn from each other. In these platforms, users interact and learn from each other without the help of a central (controlling) authority or an instructor who leads the process. This can be in the form of online platforms, applications or offline communities [17].

Blockchain technology can support decentralized peer-to-peer platforms where educators and learners can interact directly without the need for intermediaries.

Blockchain facilitates payment and other obligations imposed on users on these platforms. Blockchain on these platforms can be applied in several ways [17]:

Verification – Blockchain technology is used to verify the authenticity of educational content and the credentials of content contributors.

Smart contracts – these can facilitate processes such as automatic payments for premium content or the formalization of collaboration between mentors and students.

Immutable Logs – Blockchain creates permanent logs for the progress of the student's engagement, for the achievements and evaluations received during different periods of using the platform.

Two of the very successful platforms that work according to the 'Peer-to-Peer' principle are Khan Academy and Duolingo [17]. Although Khan Academy started as a video lecture series, this platform has evolved to encourage community participation, discussion and feedback. On the other hand, DuoLingo is a language learning platform that also works according to the principle or approach of collaboration, where different users contribute content and translations [17].

Figure 5. Duolingo – Peer-to-Peer platform which supports Blockchain technology

In Duolingo, users go through different lectures, earn points according to the experience they accumulate and practice the language through interactive exercises. Duolingo works according to the client-server architecture, while users access the platform through web browsers or mobile applications that connect to Duolingo servers to read and process lectures, record progress, and synchronize data [17].

Khan Academy, on the other hand, offers educational content in the form of quizzes, videos and articles on various subjects and topics. Similar to Duolingo, Khan Academy relies on a client-server architecture where content is accessed from a web browser. Both platforms have found space and opportunities to integrate blockchain. In both, users (students) after completing a course or developing a certain skill, are provided with a certificate. These digital credentials must be verifiable by third parties, such as employers or educational institutions. Blockchain technology enables such a thing [17].

Khan Academy offers courses in various subjects and fields and therefore it integrates Blockchain to issue certificates which validate the student's achievements in a particular field.

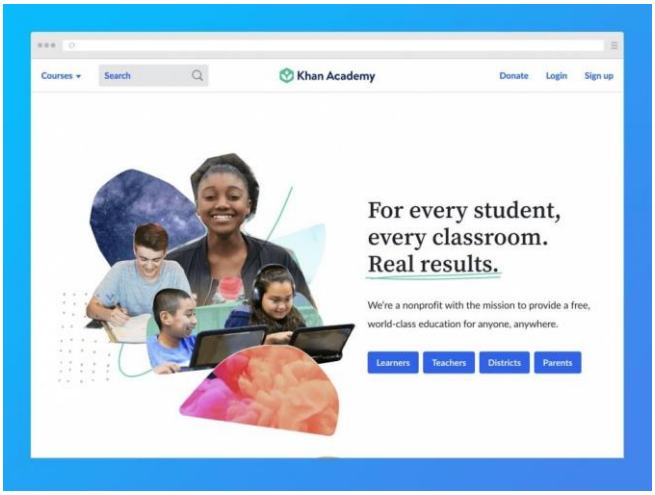

Figure 6. Khan Academy – Peer-to-Peer platform which supports Blockchain technology

Platforms for the protection of intellectual property

Blockchain technology has emerged as a tool with the potential to change the way intellectual property is handled and protected. The steps to accomplish this are as follows [18]:

Proof of Authorship – Blockchain can be used to timestamp the moment an intellectual property work is created. In this way, the connection between the one who wrote it and the actual work can be made.

Content Authenticity Verification – All creators of a work can register their original work on the Blockchain. This ensures that a registry exists unaltered and original of a work which cannot be claimed to belong to anyone other than the person who wrote or created it.

Digital Rights Management – Blockchain can facilitate digital rights management by creating a decentralized and transparent system where content creators can create rules around how their content is stored and distributed. For example blockchain can be used to ensure that only authorized users can access, modify or distribute certain content.

Licensing – Through blockchain, authors can license their work through what are known as smart contracts.

Decentralized learning resources

Decentralized learning resources are a good opportunity to share, store and access data. Using the principles of decentralization, these libraries aim to create an open platform for the distribution of information and knowledge. These systems operate on a peer-to-peer network instead of using a centralized server. This means that the content, be it books or other supplementary learning materials, is stored on several nodes or computers on the network, making the system more resistant to data loss or what is known as a 'single point of failure' where in case of failure of the single node where the data is stored, the whole system goes out of order [18].

If several copies are stored on this network, the loss of data on one node does not impair the availability or accessibility of the content. This decentralized nature of the system makes it more difficult for authorities or other actors with malicious intent to censor or delete content. Decentralized libraries aim to make information more accessible to all those who have an Internet connection, thus overcoming geographical barriers or other obstacles that arise during access to data. Most importantly, Blockchain technology that relies on the principle of decentralization ensures that content remains unaltered and authentic [18].

Creating such a system has its advantages but of course also its challenges. The main advantage is that this system ensures that information is preserved for future generations regardless of whether the central servers or specific organizations cease to exist. Also, not needing a centralized infrastructure can reduce maintenance costs. In this system, everyone is free to contribute and this affects the enrichment of the content. Finally, removing or placing a material is a transparent and visible process for everyone [18].

Some of the challenges have to do with the fact that because data is stored on nodes, a large memory space is needed. Also, efficient search and categorization of content is more challenging for a decentralized system than a centralized system. Without a central authority that controls and analyzes the quality of the material being posted, concerns may arise about the accuracy and quality of the material [18].

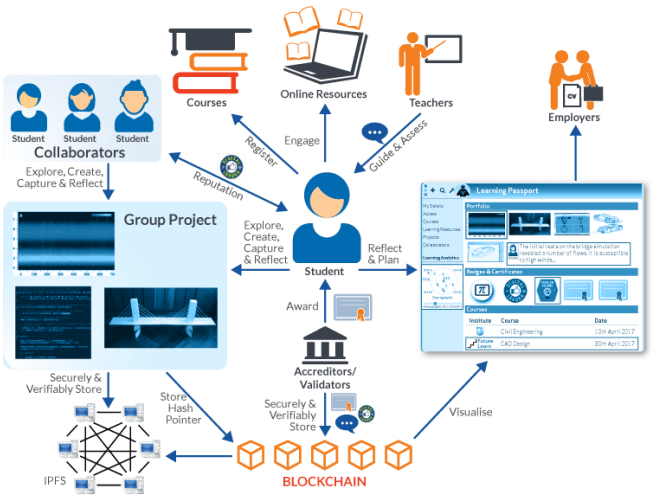

Figure 7. A possible application of Blockchain in the field of education

5.3 Challenges of applying Blockchain in education

Despite the fact that Blockchain technology offers numerous opportunities and potential for the education sector, a significant number of challenges are announced when considering the implementation of this technology. Some of the challenges for the integration of this technology according to the study of [15] may be the limited knowledge that educators and other parties have about the use of this technology. This inevitably leads to misunderstandings, resistance to technology adoption and inappropriate applications. On the other hand, most institutions do not have their IT infrastructure developed enough to implement this technology in the right way. Most of them still work with traditional systems and integration implies quite large investments [14]. Integration is not only technically challenging but also costly. For the proper implementation of the technology, staff training is needed, the reorientation of the processes, which must be carefully considered [14]

One of the important challenges identified for Blockchain is security. While Blockchain has fairly solid security, the immutable nature of this technology means that once data is written, it cannot be altered [15]. This can cause consequences, especially with data protection regulators, which grant and guarantee individuals the right to change/improve or delete their data [15].

Another challenge is related to laws and regulations. The dynamic space of Blockchain regulators, especially in terms

of data protection and verifications outside the country of origin, can be an obstacle for institutions that have goals to adopt this technology [12]. The lack of standards regarding the use of this technology is another concern. In order for it to be recognized in a general (universal) way, there must be a standard for which all parties agree. Without this there is a risk of fragmentation, where different institutions apply and use different standards, causing these interoperability problems [12].

VI. CONCLUSION AND DISCUSSION

Blockchain technology can be said to have significantly changed or transformed the digital space. This innovation is quite promising and it is thought that its integration will create new standards for the way different industries operate. The characteristics of this technology such as decentralization, immutability and transparency make it a technology with the power to impact almost any field or activity of human life.

The fact that Blockchain technology is finding application in almost every sector shows how adaptable it is. From the finance behind cryptocurrencies like Bitcoin to supply chain, healthcare, real estate, the arts, this technology seems to know limits. The possibilities offered by technology are numerous. Through it, organizations are protecting sensitive data from unauthorized intervention by third parties. The purpose of this diploma topic was to analyze what opportunities this technology offers for the education sector. From the analysis, it was understood that there are many opportunities for this sector. Currently, the number of educational institutions that have implemented this technology is not large, but in the future such a thing is expected to change. The reason why we do not have a mass adoption of Blockchain in education is related to some of its challenges or limitations. The main ones are: limited knowledge about this technology, inadequate infrastructure for implementation, lack of standardization, interoperability with current systems, those considered as 'legacy systems', etc. Moreover, putting this technology into use requires quite large investments not only in equipment and infrastructure but also in knowledge and development of skills for the people who will use it. The complexity of this technology together with the aforementioned aspects are a serious barrier to a possible and rapid adoption of the technology.In terms of applications, Blockchain technology has today found a place in popular education applications such as Duolingo and Khan Academy. So, the applications are in both the private and public sectors. Both platforms use Blockchain to issue certificates to students who successfully reach the various assessment stages. These certificates are protected against forgery and can be used by third parties for various verifications. Also, many universities in the world, mainly those from developed countries such as the United States of America, have integrated or are in the process of integrating Blockchain into their student management platforms.

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