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THE IMPACT OF VIRTUAL INSTRUMENTS IN THE ROMANIAN EDUCATION SYSTEM

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Abstract: *For over 100 years, the Romanian education system has not undergone major changes. Since the time of the Industrial Revolution, it has primarily relied on the ability of students to memorize a large volume of information, emphasizing the utilization of IQ, and its bureaucratic system being a heavy one. Implementing a blockchain systems in the Romanian educational system can bring several potential benefits, The findings in this article reveal that blockchain technology offers significant advantages for the education sector, including enhanced transparency, immutability, and traceability of educational records. Blockchain can streamline processes such as student enrollment, issuance of diplomas, and student-teacher interactions, leading to improved efficiency and data security.*

Key words: *technology; education; student; Romania; sustainable development*.

1. INTRODUCTION

The Organization for Economic Cooperation and Development (OECD), through the 2021 Digital Education Outlook report, discusses the intelligent technologies that are already transforming the education system worldwide (OECD Report Digital Education Outlook, 2021). In the context of the changes brought about by the pandemic, it is shown how digital intelligent technologies such as blockchain, artificial intelligence, and robots are transforming the educational realities. In his comments, Andreas Schleicher, the Director of the OECD Directorate for Education, states that the majority of "online classes do not mean smart classes. They have rather been a temporary measure to keep learning operational, preserving existing practices instead of transforming them."

This paper analyzes the impact of using intelligent technologies on the global education system. It acknowledges the significant changes brought about by the COVID-19 pandemic and emphasizes how digital intelligent technologies, including blockchain, artificial intelligence, and robots, have the potential to transform educational practices.

Andreas Schleicher, the Director of the OECD Directorate for Education, offers insights into the situation. He suggests that simply shifting to online classes during the pandemic does not necessarily equate to smart or innovative educational practices. Instead, he notes that many educational institutions adopted online learning as a temporary solution to maintain learning continuity, without fully leveraging the transformative potential of intelligent technologies (OECD Report Digital Education Outlook, 2021).

This perspective highlights the need for a shift in mindset and pedagogical approaches to fully harness the capabilities of digital intelligent technologies. While online classes served as a short-term solution, the report suggests that there is a broader opportunity to reimagine education by integrating these technologies in ways that go beyond replicating traditional classroom practices.

The OECD report likely delves further into the challenges and opportunities associated with the integration of intelligent technologies in education. It might explore topics such as personalized learning, adaptive systems, data privacy, teacher training, and the potential

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impact of these technologies on educational equity.

We are in a period when, globally, continuous changes are taking place in the educational system, both concerning the emergence of new technologies and the digitalization of the educational environment itself.

HolonIQ, a company that collects, processes, and analyzes data in this field of education, believes that "population growth will be a key challenge for the education sector. By 2035, it is projected that there will be 2.7 billion students worldwide", with just over 500 million at present (Spies, Brothers, 2020).

HolonIQ identifies four innovative technologies for the education system, for which expenditures will increase by 2025: augmented/virtual reality (AR/VR), artificial intelligence (AI), Blockchain, and Robotics (Spies, Brothers, 2020).

Since 2008, the concept of blockchain technology has been introduced by an individual or a group of individuals using the name Satoshi Nakamoto, in the groundbreaking work "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008), has expanded its applications beyond cryptocurrency transactions. While initially designed for financial purposes, blockchain technology has found utility in various non-financial sectors.

In 2015, the book "Blueprint for a New Economy" by Melanie Swan explored the potential applications of blockchain technology in fields such as education, culture, public administration, arts, and healthcare (Swam, 2015). This publication contributed to raising awareness about the broader possibilities offered by blockchain beyond cryptocurrencies. As a result, an increasing number of experts and researchers in this field are embracing the use of blockchain technology.

As early as around 2017, the use of blockchain technology began to become increasingly prevalent. It opened new avenues for exploring innovative approaches to educational processes, data management, and credentialing. Blockchain in education offers several potential advantages, including increased security, transparency, and efficiency in managing educational records, certificates, and credentials. By utilizing decentralized and immutable ledgers, blockchain can help establish trust and prevent tampering or falsification of academic achievements.

Some specific applications of blockchain in education include (Drescher, 2018):

- Credentialing and Certification: Blockchain can provide a secure and verifiable method for issuing and verifying educational credentials, such as degrees, diplomas, and certificates. This enables employers, educational institutions, and other stakeholders to easily authenticate and verify an individual's qualifications;
- Academic Record Management: Blockchain can serve as a decentralized ledger for storing and managing academic records, including grades, courses, and achievements. This ensures the integrity and security of the data while allowing students to have ownership and control over their educational records;
- Microcredentialing and Lifelong Learning: Blockchain technology enables the creation of microcredentials, which are digital badges or certificates that recognize specific skills or accomplishments. These microcredentials can be stored on the blockchain and easily shared, allowing individuals to showcase their diverse skills and achievements beyond traditional degrees;
- Secure Peer-to-Peer Learning and Collaboration: Blockchain-based platforms can facilitate peer-to-peer learning and collaboration, enabling students and educators to interact, share resources, and collaborate in a secure and transparent manner.

However, it is true that the application of blockchain in the education sector is still in its early stages, with very few educational institutions currently using this technology. When we consider the research findings in this regard, blockchain technology appears to have tremendous potential, both in higher education (Gipp & Söllner, 2019), (Ark, 2018) and pre-university education.

2. MATERIALS AND METHODS

In the present article, we discuss the possibilities of using blockchain technology

within the Romanian higher educational system. Additionally, we highlight the advantages of using this technology, the prospects it can offer, as well as the risks that may arise with the utilization of this technology. The potential that technology can bring is suggested, through various aspects it can address, such as: registering students through data collection and processing, facilitating the educational process itself (teaching, evaluation, etc.), as well as issuing digital diplomas upon the completion of studies.

Furthermore, the structure of blockchain is presented, from the creation of the unique hash to the formation of the chain itself, with prior validation through the consensus protocol.

Regarding the literature reviews, the authors conducted a comprehensive literature review to gather information on the current state of the global education system, population growth, high school graduation rates in Romania, and the implementation of blockchain technology in education. Sources like reports, articles, books, and research papers were consulted.

Also, the authors obtained data from reliable sources, including the Ministry of Education in Romania and the global education market information company HolonIQ. These sources provided statistics, projections, and insights related to the education sector and the adoption of innovative technologies.

Moreover, the authors analyzed the gathered information to identify trends, challenges, and opportunities for the integration of blockchain technology in the field of education. They examined the benefits, risks, and challenges associated with implementing blockchain-based solutions, as well as the potential impact on different levels of education.

Specifically, they mentioned Learning Machine's collaboration with the MIT Media Lab to initiate the Blockcerts toolkit and Matt Pittinsky's perspective on design decisions and data storage using blockchain.

Also, in this paper, the authors explained the fundamental concepts of blockchain technology, including its origin, the use of protocols, data decentralization, data authenticity, and the consensus protocol for validating new blocks.

Practically, the authors used their knowledge and expertise to compile the gathered information, research findings, and analysis into a coherent article. They structured the content logically, ensuring clarity and readability for the readers. It is essential to consider that the part of the process followed by the author may vary, and additional methods or materials could have been used in the writing of the article.

3. RESULTS

3.1. Blockchain technology – tools used in education

According to data provided by the Ministry of Education in Romania, the high school graduation rate has been increasing in recent years, reaching 72,8% of the total high school graduates. After completing these studies, graduates choose either to enter the workforce, continue their studies at a university, or pursue specific vocational training programs. The most sought-after specializations among students are in the following fields: IT industry, banking sector, medical services, and engineering.

The are a lot of advantages, risks, and prospects of blockchain technology for its utilization in educational institutions in Romania. Blockchain technologies can help conventional information quantification systems in ranking universities by measuring them both digitally and physically. They can measure the level of interaction between students and teachers, as well as their level of engagement.

From the very beginning, the use of technology in education has drawn attention to security, a crucial consideration for the decision-making process. The blockchain technology has gained prominence, particularly for its security aspects integrated into its utilize.

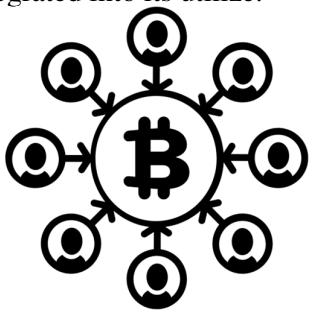

Fig. 1. Outline data blocks

As examples, Learning Machine, a software startup with over 10 years of experience, who partnered with MIT Media Lab to initiate the Blockcerts toolkit, which it is a platform that, using this technology, provides an open infrastructure for certificates, from their creation to their verification.

Another example comes from Matt Pittinsky, CEO of Parchment, that manages and provides academic transaction services, and who believes that many design decisions need to be made before widespread use of credentials. He believes that "blockchain will store locations in systems that record complete data – a balance between permanence and portability" (Ark, 2018). One of the issues that the education sector faces is the proliferation of learning applications and services. As examples, platforms like Blockstack and uPort can be considered. They assist users in uploading their identities online. Moreover, on the Blockstack platform, registered individuals can access applications from other networks and perform data transfers.

Protocols are highly important elements in the use of Blockchain technology as they come with a set of basic rules that ensure data sharing. They are essential because, first and foremost, they ensure data decentralization, so that the entire database is used throughout the network without the need for third-party intervention. Another aspect is related to data authenticity, where practically no party involved should worry about the quality of using this data. The rules can variate and evolve according to the system in which these protocols are used in Blockchain technology. In practice, each block has a unique identifying hash but also stores the hash of the previous block, hence the idea of a chain. All users in the network hold a copy of the chain. Validation of a new block is done through the consensus protocol (50%+1).

3.2 Uses of blockchain technology in the Romanian education system

In order to enhance performance in educational institutions, the utilization of blockchain technologies could become a highly tangible option. Therefore, the following aspects are proposed in this regard. Figure 2 presents a series of advantages of using blockchain technology, as follows:

- *Transparency and immutability* – the information can be viewed by anyone with access, and as users upload data and information, a history is created, and they remain permanently unchanged. This implies that the information is authentic.
- *Engaged users* – as more nodes are added, more users become involved in the process. Each entity contributes with their own information in their respective field of activity.
- *Integrated process* – blockchain technology, with the information it provides, creates an integrated process. Here, information can be selected, tracked, or even synchronized, and users have access to it in the desired form.
- *Simplified ecosystem* – since information within a blockchain is accessible in real-time, the entire ecosystem can be greatly simplified. There is no waiting time, verification of information, or uncertainty about its authenticity, as each authorized user can utilize it.
- *Fast transactions* – monetary transactions within the blockchain are secure and fast. Electronic information is stored in a digital format through the database. It should be noted that blockchain is the underlying technology for the use of the cryptocurrency Bitcoin, the first digital currency that can be used without the need for a third party, thereby eliminating the need for additional time and expenses.
- *Sustainable development* – It *Improved traceability* – Retrieving the history of a specific entity is a defining feature of blockchain technologies. Additionally, a traceability system based on blockchain could provide all users with a unique opportunity, flexibility, and authority to track their information and create a transparent and sustainable information channel.
- is a long-term process, as demonstrated by its traceability and immutability. Trust is established over the long term through the veracity of information and the fact that the process is fostering direct relationships.

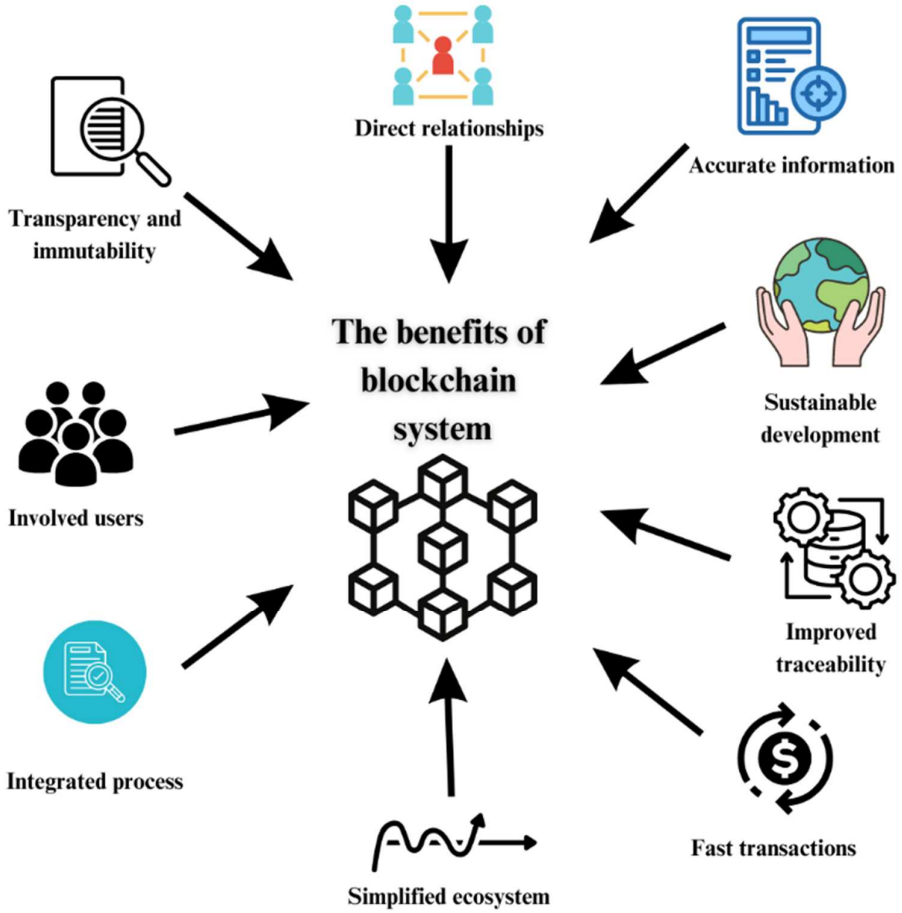

Fig. 2. The advantages of blockchain system

- *Accurate information* - The stored and distributed data can be modified, can be accessed in real-time, and most importantly, cannot be altered. The information is transparent, easily accessible, has a history, and has a traceable lifecycle, accessible to users with database access.
- *Direct relationships* – The relationships established between nodes of entities within the blockchain are made directly, excluding third parties. The concepts of temporality and spatiality are minimized to a maximum extent.

In Figure 3, a series of blockchain applications that can be used in the educational system are presented. Among these, we can find applications for facilitating the teaching process, information regarding students' diplomas and transcripts (issuance, archiving, required documents), information about the history of faculty members, student enrollment in universities, and student-teacher interaction. The example can also be relevant for representatives of a high school.

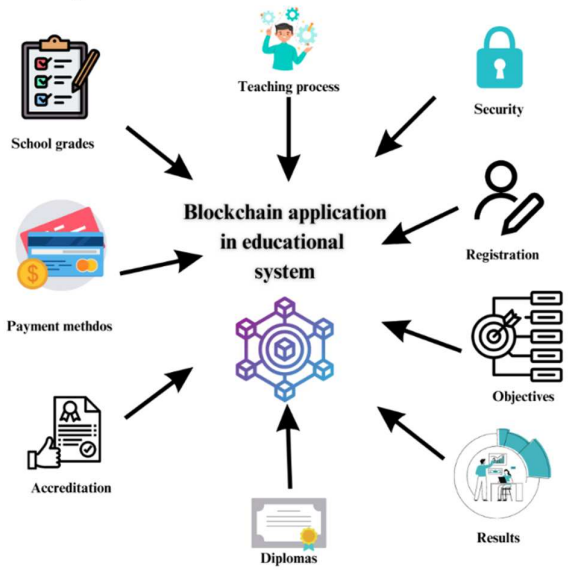

Fig. 3. Blockchain application in education system

Practically, blockchain can be implemented on a multi-platform basis, meaning it can be used starting from the e-learning process, student enrollment, to the use of libraries, tuition fee payment, and other necessary educational needs that may arise from students, their teachers, and auxiliary staff within an institution. Thus, the entire process will be carefully monitored, secured, and easily accessible (Terzi, Ioannis, Votis & Tsiatos, 2021).

Facilitating the teaching process is perhaps the most important aspect that could be improved using blockchain applications. In addition to the interactivity of platforms that can be made available to students, they could easily track their educational progress by continuously validating it with their teachers, tracking their set objectives, receiving feedback from faculty members, and even monitoring the courses themselves both in terms of information and duration.

Registering students in a university or in a high school would bring increased transparency using a blockchain application. This would reduce the time required for verifying students' documents, ensure immutability for each individual student, and provide immediate access to information regarding a particular student.

Regarding the use of blockchain technology for diplomas, several advantages can be identified. Firstly, it represents an innovation in the certification process, making it more secure by utilizing a security key and a much more transparent process. Essentially, blockchain is a distributed computer network where the digital fingerprint of data (such as diplomas, students' academic records, etc.) can be stored. This distributed database is designed to store small amounts of data such as IDs, hashes, addresses, and transactions. To achieve complete decentralization and eliminate third-party involvement, there is the option of implementing a combined system of Blockchain - IPFS (IPFS being a decentralized cloud where data itself can be stored, not just its hash).

At the same time, the use of blockchain in a high school could ensure the security and authenticity of offered diplomas. Digital diplomas would be provided instead of traditional ones. Moreover, such a diploma would be difficult to counterfeit, and the information within it could easily be shared with both employers and future universities.

Figure 4 presents a general framework of what blockchain technology could entail in the field of education.

The scheme illustrates how the use of blockchain technology leads to the permanence and transparency of data, easily identifiable, all happening in real-time. The cryptographic use of this technology will replace third parties, ensuring overall integrity. For example, in the figure, it can be observed how a student is given their own immutability, which can later be accessed by collaborators, such as a company looking to recruit a specific candidate with a profile already shaped by blockchain technology. Students have rapid access to information and dialogue with educators, who can guide them in terms of information, evaluate them, and even reward them. Another beneficial aspect is related to digital certificates, diplomas, and student records, which cannot be altered but can be evaluated and validated by anyone with access rights. The documents in question are stored in a shared registry, and, for example, certificates can be validated even if the issuing organization no longer exists.

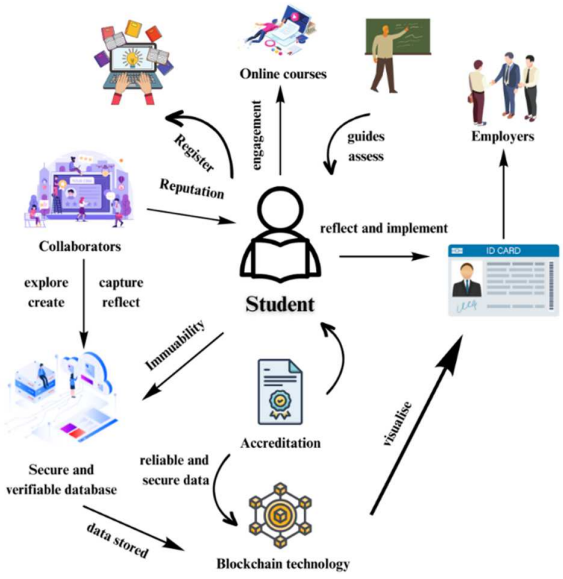

Figure 4. General framework of blockchain in the field of education

Using this technology, records or files will never be lost. Another benefit related to diplomas, transcripts, and certificates is that in

case of loss or destruction, they no longer require certification. Everything will be validated and consolidated in blockchain format. In blockchain technology, all certificates and accreditations will be stored and can be retrieved at any time. Likewise, information regarding students or educators can be quickly verified and confirmed. Additionally, tuition fees can have a much-simplified payment method. Furthermore, votes within these institutions could be electronic. In practice, an electronic voting system could be established for decision-making at the school level. Each member would have access to their own blockchain account, through which they would record votes, cryptographically sealed. All these positive aspects can lead to increased involvement within an institution, thereby increasing its performance. Moreover, these approaches would ensure transparency and integrity in the processes carried out.

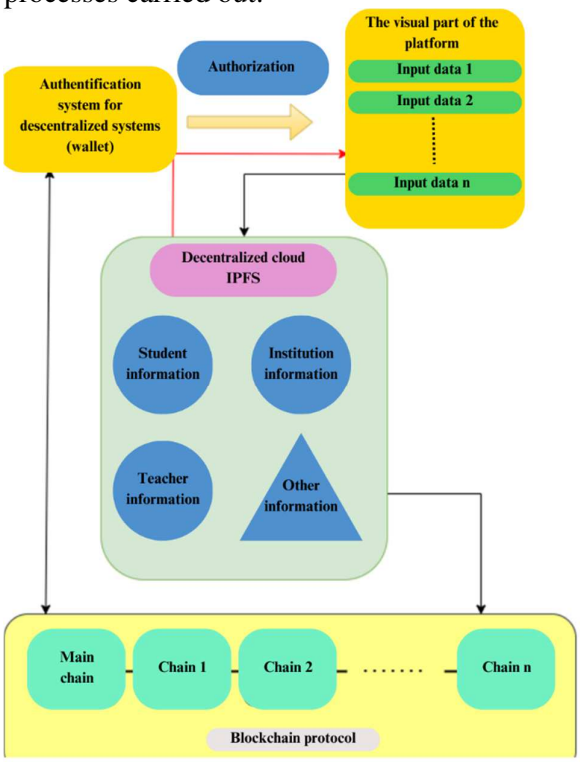

Fig. 5. The block diagram of a decentralized data storage application in the education domain - combining Blockchain technology with IPFS.

Through such a blockchain system, an educational plan could be generated for each student. There would essentially be a virtual teacher accompanying the student throughout their educational journey, from admission to graduation. In this regard, the teacher would continuously record and monitor their progress. They would be able to consistently evaluate and provide feedback, generating a detailed history of observations and guidance given by the virtual teacher. They could also grant the student access to relevant educational resources for their studies, while communicating and providing the necessary assistance throughout their studies.

In Figure 5, the block diagram of a decentralized data storage application in the education domain is presented, combining Blockchain technology with IPFS. The diagram depicts a specific authentication system used in decentralized systems, like the wallets used for cryptocurrencies. After the authentication process, the user interacts with the platform's frontend (the visual part), where they transmit data to the backend (server). In the given example, the backend consists of a decentralized cloud (IPFS) and Blockchain. Complete data is stored in IPFS, while the digital fingerprint of the data from IPFS is stored in the Blockchain. Before the data reaches the Blockchain, it undergoes an irreversible function (such as SHA256), resulting in a hexadecimal code that goes directly into the Blockchain.

4. DISCUSSION

All the results of the information presented in this article indicate that blockchain technology has the potential to bring significant benefits to the field of education in Romania. By leveraging blockchain, educational institutions can enhance transparency, immutability, and traceability of information, leading to improved data integrity and security.

The use of this technology can streamline processes, for example student enrollment, issuance of diplomas and transcripts, and student-teacher interactions. Additionally, blockchain technology can facilitate the teaching process by enabling continuous tracking of educational progress, feedback exchange between students and faculty, and monitoring of courses.

These findings align with previous studies and support the working hypotheses that the

presented technology can be a valuable tool in the domain of education. The potential benefits identified in the presented study, such as transparency, immutability, and fast transactions, are consistent with the broader advantages of blockchain technology reported in the literature.

Previous research has highlighted the possibility of useing blockchain in many and variated sectors, like education, by ensuring data authenticity, decentralization, and enhanced security.

The implications of implementing blockchain technology in education are significant. With the projected increase in the global student population, blockchain can provide a scalable and efficient solution for managing educational data and credentials.

It can mitigate issues related to document verification, credential fraud, and data manipulation. By utilizing blockchain-based systems, educational institutions can establish trust, simplify processes, and improve the overall efficiency of the education system.

However, it is important to note that the utilization for this technology in education is still at the beginning stages, and only a few institutions have implemented it thus far.

For the successful use of this technology, certain challenges and risks need to be addressed. Some obstacles include technological infrastructure requirements, regulatory considerations, interoperability with existing systems, and data privacy issues.

The prospects for the use of this technology should focus on addressing the challenges presented and on developing usage guidelines. (Grech, 2017).

Additionally, further research is needed to explore the long-term effects and scalability of blockchain-based solutions in education. It is important to assess the cost-effectiveness, usability, and user acceptance of blockchain applications in diverse educational settings. Comparative studies between traditional systems and blockchain-based systems can provide insights into the potential advantages and limitations of blockchain technology in different educational contexts.

Moreover, future research should concern on the integration of other emerging technologies, like artificial intelligence (AI) and augmented/virtual reality (AR/VR), with blockchain in the domain of education. The synergistic combination of these technologies can open new possibilities for personalized learning, adaptive assessments, and immersive educational experiences.

The results of this work highlight the potential that blockchain technology has in both higher and pre-university education in Romania. The identified benefits, risks, and challenges provide valuable insights for policymakers, educational institutions, and researchers.

By embracing blockchain technology and addressing the associated challenges, the education system can harness the advantages of transparency, immutability, and data integrity, leading to improved efficiency, trust, and innovation in education.

5. CONCLUSION

Since the time of the Industrial Revolution, the education system has primarily relied on students' ability to memorize a large amount of information, emphasizing the use of intelligence, and employing a cumbersome bureaucratic system. Implementing a blockchain system in the Romanian education system can bring several potential benefits.

The conclusions from this article reveal that blockchain technology offers significant advantages for the educational sector, including increased transparency, immutability, and traceability of educational records. Blockchain can streamline processes such as student enrollment, diploma issuance, and interactions between students and teachers, leading to improved efficiency and data security.

Using blockchain technology in education can be a beneficial decision, even though implementation may be challenging, especially considering the lack of a legal framework to recognize the authenticity of records in such a digital ledger. However, these limitations are perfectly normal given the early stage of the technology, but the innovative nature of ensuring data traceability is immense.

Based on the information presented earlier, it can be concluded that transforming blockchain in the field of education and exploring its applications will contribute to the efficiency and improvement of the educational system in Romania.

There is a positive influence on the options for implementing blockchain technology in education, one of which is the application of blockchain in diploma issuance, which can reduce the percentage of forgery and eliminate the need for lengthy verification processes, saving time, effort, and cost.

The performance of blockchain technology, which can also be introduced in teaching methods, will lead to the creation of an interactive education system that benefits both students and educators. Another opportunity in applying technology in education is data security, such as document archiving and authenticity, which means that the performance of blockchain technology cannot be falsified and has undeniable immutability. Transparent results lead to easy verification and validation.

Based on the research results, several managerial implications can be outlined. Continuous improvement of educational quality standards is desired in education, providing good quality based on technological advancements applied as needed in each institution.

Education is expected to implement technological policies that can be uniformly used. The educational sector is expected to optimize the quality of educational regulations to minimize undesirable situations such as document forgery and data insecurity.

In conclusion, adopting blockchain technology in education can bring significant advantages, despite the accompanying implementation challenges.

Developing a solid legal framework and fostering cooperation among educational institutions, decision-makers, and technology experts are essential to recognize and validate blockchain-based records.

Integrating blockchain technology in education can revolutionize administrative processes, enhance data security, promote personalized learning, and facilitate skills certification.

By collaborating with blockchain startups, technology providers, and research institutions, Romanian educational institutions can explore innovative solutions and adapt blockchain implementation to specific needs and challenges.

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Utilizarea tehnologiei Blockchai în sistemul de învățământ superior

De peste 100 de ani, sistemul de educație românesc nu a suferit schimbări majore. Încă din timpul Revoluției Industriale, acesta s-a bazat în principal pe abilitatea studenților de a memora o cantitate mare de informații, punând accent pe utilizarea coeficientului de inteligență (IQ) și având un sistem birocratic greoi. Implementarea unui sistem blockchain în sistemul de educație românesc poate aduce mai multe beneficii potențiale. Concluziile din acest articol dezvăluie că tehnologia blockchain oferă avantaje semnificative pentru sectorul educațional, incluzând creșterea transparenței, imutabilitatea și trazabilitatea înregistrărilor educaționale. Blockchain poate simplifica procese precum înscrierea studenților, eliberarea diplomelor și interacțiunile dintre studenți și profesori, ducând la o eficiență îmbunătățită și securitatea datelor.

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