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USE OF BLOCKCHAIN TECHNOLOGY IN EDUCATIONAL FIELD

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Abstract- The education field is constantly searching for ways to improve its system through innovations. One of the recent advancements is the utilization of blockchain technology, which is a system of documentation that is said to have revolutionized the way higher education institutions in Bahrain empower their students, educators, and employers. It is an emerging technology that significantly disrupts traditional ways of education. The review highlights the potential of blockchain technology to enhance the efficiency and transparency of administrative processes, such as admissions, student registration, and academic records management. Blockchain can also enable secure and verifiable sharing of student data between institutions, which can enhance academic mobility and reduce administrative burdens for both students and institutions. Furthermore, the review discusses the potential of blockchain to support the development of new models of education delivery, such as micro-credentialing and lifelong learning. Blockchain can provide a secure and decentralized platform for issuing and verifying digital credentials and badges, which can enable learners to showcase their skills and achievements beyond traditional degrees. However, the review also identifies several challenges that need to be addressed for the successful adoption of blockchain in higher education. These include issues related to data privacy and ownership, the need for standardization and interoperability, the scalability and performance of blockchain systems, and the cost and complexity of implementation. Overall, the review suggests that blockchain technology has significant potential to transform higher education by enabling greater efficiency, transparency, and innovation. However, realizing this potential will require careful consideration of the opportunities and challenges of blockchain adoption and the development of appropriate governance and regulatory frameworks. It has been shown that for the improvement of existing ways to share, deliver and secure knowledge data as well as personal student records, it is using Blockchain to develop new interventions. Yes, information management mechanisms play a crucial role in the higher education sector. Effective information management can improve efficiency, ensure privacy controls, enable technological improvements, and enhance security. Here are some ways in which information management can add value in the higher education sector.

- Improving effectiveness: Information management can help higher education institutions to manage their data more effectively, making it easier to access and use information. This can enable administrators, faculty, and students to make better-informed decisions and enhance overall effectiveness.
- Enhancing efficiency: Efficient information management can help higher education institutions to streamline their processes and workflows, reducing the time and resources required to manage data. This can improve efficiency and productivity, allowing staff to focus on more critical tasks.
- Ensuring privacy controls: Higher education institutions handle sensitive student and faculty data, which requires strict privacy controls. Information management mechanisms can help ensure that data is secured and only accessible to authorized personnel.
- Enabling technological improvements: Information management can enable technological improvements such as data analytics and machine learning. By leveraging data insights, higher education institutions can make data-driven decisions and improve their operations.
- Enhancing security: Higher education institutions are vulnerable to cyber threats, including data breaches and ransomware attacks. Information management mechanisms such as encryption and access controls can help enhance security and protect against potential threats.

Overall, information management is critical in the higher education sector, and institutions that prioritize it are likely to experience substantial benefits in terms of effectiveness, efficiency, privacy, technological improvements, and security, use of blockchain technologies is continuing conceptual progress.

Keywords: Blockchain, Blockchain Technology, Education, Bahrain.

1. INTRODUCTION

In the beginning, blockchain was designed to govern Bitcoin, but it has since expanded into a foundational technology for a wide range of decentralized applications. People are encouraged to use it to help organize sensitive data in fields including postsecondary learning, health, supply chain management as well as the Internet of Things (IoT) (Salah, et al., 2020). Students and Higher Education Institutions are two of the most important stakeholders in the system of higher education.

In this paper, we explore the role of blockchain technology in higher education as a system to be monitored for various systems within universities by using IT technologies with computing solutions to support, maintain, and reconstruct an educational system. Higher education is allegedly seeing an increase in the number of security and privacy breaches each year, particularly when it comes to academic credentials like diplomas and degrees. To verify their legitimacy and retain correct records, blockchain technology plays a crucial role (Vidal, et al., 2019). Concerns about academic data security have been raised as more and more institutions digitize their operations. Blockchain technology provides decentralized open data, benefits as well as a decrease in transaction costs connected to academic data governance (Fedorova and Skobleva, 2020). To address some of the most pressing issues in higher education, blockchain has been proposed as a solution (Kamisalic, et al., 2019).

Nevertheless, systematic literature reviews (SLRs) have been conducted in the past to summarize the current information (Fernández-Carames & Fraga-Lamas, 2019). to assist students with acquiring and developing technical knowledge of the use of these technologies and centralized open data to ensure secure information storage, in particular case studies. and expertise; and the construction of distributed applications incorporating these cutting-edge technologies are just a few examples. SLRs have contributed to the existing body of knowledge, but their primary goal is to highlight Blockchain applicability areas (Hernandez de Menendez, et al., 2020). Scholars would benefit from an in-depth debate on how to enhance blockchain adoption because of the breadth and depth of current research (Ge and Hu, 2020). This may be achieved by integrating existing information and highlighting critical concerns that need significant attention. It is via these questions that the research is guided: what has the higher education system done to date to develop a foundation for Blockchain technology?

There are two ways in which this research adds to the existing research on blockchain in higher education: To begin, it organizes earlier research according to the application areas in which they were conducted. Second, based on our results, we identify prospective themes that need more investigation and important difficulties and research routes that might help advance our current understanding. Divided into two parts, this report makes a significant addition to the conversation around blockchain technology in higher education by highlighting the progress that has been done so far, as well as the present problems and potential future research directions.

2. METHODS AND MATERIALS

A literature evaluation of the Blockchain network in Higher Education is carried out in this work (Sacavem, et al., 2019). In contrast to other approaches, such as conventional literature review and systematic review, this research idea relies on a more thorough approach to recognizing and synthesizing material, enhancing the authenticity of the review, these are all important aspects to consider when conducting a literature review:

- Providing a set of processes: A literature review should provide a clear and detailed description of the methods used to identify, select, and evaluate the studies included in the review. This enables other researchers to replicate the study and provides transparency regarding the review process.
- Accuracy in presenting and illustrating arguments: A literature review should present accurate and well-supported arguments that are closely connected to the research concerns being addressed. This requires careful analysis of the research findings, as well as the ability to synthesize and integrate information from multiple sources.

In summary, a literature review should be conducted with rigor and transparency and should provide accurate and well-supported arguments that enable generalizable conclusions about the research topic. Using the strategy, the review may be guided to meet its goals. It is like a road map.

3. DEFINING BLOCKCHAIN AND ITS FUNCTIONS

Blockchain technology and cryptocurrency have brought innovation to a new level. An essential component of Bitcoin's workings is blockchain technology (BCT), an open, decentralized ledger that records economic transactions in an irreversible chain that can only be accessed by those involved in the transaction (Kaur and Oswal, 2020). In order to protect data, blockchain uses cryptographic methods and innovative consensus mechanisms. History cannot be tampered with or rewritten unless the whole ledger is linked together in an ever-growing network of ledger entries that prevents this. A blockchain might deliver a wide range of educational services without the need for a third-party mediator, such as an educational institution.

In contrast to Bitcoin, other applications, like Smart Contracts, have attempted to harness the platform's more abstract character (Kaur and Oswal, 2020). The financial sector has been watching Blockchain Technology intently over the last several years (BCT). It begins the process of securing the financial sector's market potential.

4. BLOCKCHAIN IN HIGHER EDUCATION

There has been little study on how Blockchain may be utilized to structure HEIs. Using decentralized applications, these institutions may better organize their databases, bibliographies, and other types of knowledge. For this reason, the topic of digitizing academic certificates and courses for university education is being addressed, which allows for reliable and decentralized contracts in conjunction with smart contracts. issue of academic certifications (Awaji, et al., 2020). A distributed verification system for valid credentials has gained attention in the fight against fake or manufactured certificates because of its emphasis on blockchain applications and creative contracts (diplomas or certificates). HEIs may register their qualifications on the blockchain and enterprises can check their legality and integrity, or, to put it differently, both are possible.

Research in higher education has therefore been included in current studies, highlighting the separation of data into secure blocks, strengthening e-governance in HEIs [30], and ensuring privacy in protected data transfers. Because of this, Blockchain is being used for recording educational achievements beyond transcripts and certificates, notably via the implementation of smart contracts to keep track of learning activities digitally. This new system, which is based on a log-based platform, allows learning data to be safely transmitted across institutions. The ability to access learning logs from other organizations can provide valuable insights into student learning and facilitate collaboration between institutions. However, it also raises concerns about copyright management, piracy, and data privacy. Furthermore, a blockchain-based system can also enhance the management and verification of academic credentials, such as degrees and certificates. By recording these credentials on a distributed ledger, institutions can prevent fraud and ensure the authenticity of academic records. This can also make it easier for students to access and share their academic records with potential employers, educational institutions, and other parties.

Overall, the use of blockchain technology in higher education has the potential to improve transparency, security, and efficiency in various aspects of education management. However, it is important to carefully consider the design and implementation of such systems to ensure that they are effective and address the specific needs and challenges of higher education institutions. Overall, the use of administrative or blockchain-based systems can help to facilitate the sharing of learning logs and other data between institutions, while also ensuring that copyright and data privacy concerns are addressed. As these technologies continue to develop, it is likely that we will see further applications of blockchain in higher education data management. As a result of these advancements, contemporary research has presented ideas for incorporating blockchain into postsecondary learning that, when coupled with data extraction, may increase the legitimacy and independence of HEIs (Awaji, et al., 2020). With a decentralized approach, academic records from one higher education institution may be safely transferred to another. Student successes may be shown in an employer-friendly structure, making it simpler for businesses to engage with students and simplifying the process of finding potential recruits.

5. SMART CONTRACTS

The usage of smart contracts on blockchains might potentially make the lives of educators simpler. A smart contract comprises lines of code that are automatically executed when specific circumstances are satisfied on a blockchain. For instance, a teacher may program lectures and programs into a blockchain, establishing tasks for pupils, and the blockchain's smart contract would instantly validate the fulfillment of each work and then help reinforce the next assignment until all tasks have been completed. Smart contracts are playing an important role in making transactions safer and more efficient, by helping to organize them. And not only that, it also helps to increase the availability of further components such as applications running on these platforms. Students and faculty at higher education institutions have focused their Blockchain studies on the topic of smart contracts. The immutability, traceability, as well as peer implementation of blockchain as a smart contract technology, offer e-learning with unprecedented layers of protection, trust, as well as transparency. An e-learning platform built on blockchain technology is launched in order to promote the transparency of assessments and allow curriculum customization in the context of higher education. Students and teachers both profit from the automation of tests and the issuance of certifications (Lam & Dongol, 2020).

Smart contracts may be automatically enforced in students at several levels of administration using Blockchain-based protocols because of the distributed ledger of the technology's distributed ledger. That broadens access to a university education while also creating procedures for instructors to provide information, organize classes, and evaluate student work in organizational learning (Sahonero Alvarez, 2018). Utilizing a public key infrastructure for identity management, these Blockchain-based protocols may be shared and issued through a chain of records using digital certificates. The collaboration agreement, the HEI smart contract, the HEI user, the recruitment app, and the consortium app, for example, may be used to construct a decentralized validation system for higher education credentials (Serranito, et al., 2020). Digital hashes may be used as a digital platform for tracking learning accomplishments, allowing students to transmit their information securely across institutions (Ocheja, et al., 2019. A transparent approach to collecting shareable resources for students and other stakeholders may be achieved via blockchain technology.

6. PROCESS OF ACCREDITATION AND PRIVACY

The use of blockchain in higher education has the potential to improve the verification of university credentials and ensure the legitimacy of degrees. As noted in the research by Rashid et al. (2020) and Al Harthy, et al. (2019), the immutability properties of blockchain can be used to prevent the issuance of digital degrees that may have been awarded improperly. This is a significant issue as the legitimacy of degrees is critical for students seeking employment or further education opportunities.

Furthermore, blockchain can also be used to improve the management of student certifications and points for completed programs. By dividing data into safe blocks, blockchain can assure the privacy of transaction data while also providing a transparent process for managing student records. This can increase trust between students, institutions, and potential employers, leading to more opportunities for students.

The use of decentralized models of trust, which are recommended in research by Rashid et al. (2020), can also facilitate the exchange of material, education, and skills. By providing a secure and transparent way of sharing

information, blockchain can help to bridge the gap between educational institutions and industries, leading to a more collaborative and efficient system of education. Overall, the use of blockchain in higher education has the potential to revolutionize the way we manage and verify student credentials, while also improving the transparency and efficiency of educational processes. As further research is conducted in this area, it is likely that we will see even more innovative applications of blockchain in higher education.

7. EDUCATION IN KNOWLEDGE MANAGEMENT, CERTIFICATION, AND ENGINEERING

Engineering education has been the attention of certain academics who have examined the usage of a Blockchain platform. These papers examine the impact of Blockchain technology on engineering education. Examples of existing tools and case studies are provided as well as discussions of the advantages and difficulties of using Blockchain in engineering degrees as well as proposals for the technology's further development in the future. Students in science and engineering education will benefit greatly from the use of this technology to aid them in their requisite technical information and development of capabilities. As a result of this study, either the data is divided into safe blocks for transactions or how knowledge is handled in terms of the distribution and management of training material.

Devine (2015) suggests that students' academic records may be readily shared with businesses and institutions for additional personal development possibilities via the use of blockchain technology. A chronology of authorized education might then be utilized to construct future estimates based on the learning histories of each individual student. In addition to providing students with a useful tool for keeping tabs on and sharing their academic progress, this app aids employers by providing an accurate picture of a student's future based on academic accomplishment.

Since it was established in 2018, the Digital Credentials Consortium (Lesser, 2016) has brought together leading institutions worldwide to create a worldwide framework for digital academic credentials. Academic digital credentials are at the heart of their goal. With the help of its partners, they intend to build a worldwide educational network and a business environment around the standard it developed. Students using the Digital Credentials Consortium platform will gain several important advantages, including the ability to maintain a verified record of their learning achievements for the rest of their lives, the ability to obtain credentials digitally in a secure manner, the ability to avoid having to request or pay for copies of their transcripts from their universities, and the ability to curate credentials obtained from various universities. In addition, by maintaining and exchanging students' information in an effective, secure, and streamlined manner that eliminates identity theft, educational institutions gain access to a simplified approach for issuing numerous certificates to one learner source. The ease with which employers may verify the academic qualifications of job candidates is another advantage that has been previously noted.

Digital Credentials Consortium members such as MIT have already created various blockchain applications to speed up obtaining educational credentials. In Bahrain, many graduates throughout the globe confront the challenge of verifying the credentials of degrees given by universities that have since gone out of business. Degrees may lose their legitimacy without the support of an organization, which should never happen to anybody. Students of all types are seldom active in their organizations' leadership roles. Students are discouraged by this lack of engagement, which limits the formation of the best possible learning environment. Most colleges and secondary schools do not provide any kind of incentive to all students. As a result, only the very top students get scholarships, regardless of the inherent inequalities in their abilities, talents, upbringing, or anything in between (Rain, 2022). More students must be able to obtain some kind of financial reward for their work, regardless of their level of skill (Rain, 2022).

All of the aforementioned problems in Bahrain's education may be remedied with the use of blockchain technology, allowing education to enter a new age marked by greater security and inclusion for all students (Rain, 2022). To begin, students and recent graduates will have an untraceable, but transparent and credible, means of verifying their credentials on a blockchain, regardless of the presence of the original issuing institution. Blockchain and governance tokens may provide a solution to those who feel excluded from decision-making processes. For the period of a student's education, institutions might provide them non-transferable tokens in exchange for listening to the anonymous input of their members and aggregating it in a decentralized autonomous organization (DAO) (Rain, 2022). A remedy to the world's excessively exclusive pay systems would be to incentivize students by issuing exchangeable crypto tokens legally issued by colleges on a blockchain.

8. INNOVATION IN EDUCATION

There has been a lot of study in this area focusing on how to enhance existing technologies. Using Blockchain technology, for example, a decentralized marketplace for providing, purchasing, debating, and enhancing educational resources may be established among institutions throughout the world. On-chain licensing conditions enable creative control in tracking the growth of encrypted containers while gathering packages of shareable resources and user information to enhance content quality. As a result of this study, higher education is being improved in areas like collaborative virtual reality and 360° courses (Pinker and Andreas, 2021); Blockchain for digital credentials (Wolz, et al., 2021); and digital tutors in the process of exploring and developing new solutions. Considerable attention should be paid to the use of blockchain technology in engineering and scientific education as a means of encouraging experimentation and the use of information and the Internet.

It is true that emerging technologies such as blockchain can provide opportunities for educational projects. For instance, blockchain-based platforms can be used for human resources management in higher education institutions, enabling students and sponsors to establish and store contracts securely. This can improve transparency and reduce administrative costs for institutions. Additionally, blockchain can be used to eliminate restrictions and improve transparency in the publishing process, benefiting all parties involved. The decentralized nature of blockchain ensures anonymity and security, making it a suitable technology for various educational applications. However, there are also challenges and potential obstacles associated with the adoption of emerging technologies, such as the need for appropriate infrastructure, training, and resources. Therefore, it is essential to carefully evaluate the benefits and risks of new technologies before implementing them in educational projects.

9. E-LEARNING

In the educational process, blockchain also has several uses that make teaching and learning more interesting and enjoyable. There are several typical online learning technologies that do not adequately engage learners, according to Devine (2015) in this context. His research into the Open-Source foundation of Blockchain has led him to believe that it may improve or enhance the present online teaching and learning experience blockchain learning can potentially address these issues by enabling personalized and decentralized learning contracts between students and educators. These contracts could specify learning objectives, assessment criteria, and other details that are tailored to the needs of individual learners. The use of blockchain technology could also enable the creation of decentralized learning communities that are based on trust and collaboration.

Furthermore, blockchain-based learning systems can also provide a more secure and transparent way of managing academic records and credentials. This is particularly important in today's globalized and digitalized world, where traditional paper-based academic credentials can be easily forged or falsified. By recording academic records and credentials on a blockchain, educational institutions can ensure that these records are tamper-proof and easily verifiable.

Overall, blockchain learning has the potential to revolutionize the way we approach education and learning. It can enable personalized and decentralized learning experiences that are tailored to the needs of individual learners, as well as provide a more secure and transparent way of managing academic records and credentials. However, there are also challenges and limitations that need to be addressed, such as scalability, interoperability, and the need for standardization and regulation. They believe this combination of technology can help students get individualized services throughout their educational journey.

Many start-ups in this field attempt to improve the learning experience by using blockchain instances, mostly focusing on education outside the classroom. Using BitDegree, for example, students may win tokenized scholarships (Duwadi, 2021) for finishing tech courses or meeting other learning milestones on BitDegree, a gamified online education platform. In addition, an educational accomplishment data tracker and incentive system for BitDegree have been claimed by the BitDegree team. Finally, using the BitDegree Studio, course developers may create gamified, engaging, and data-driven courses that can then be sold to learners in the BitDegree Marketplace (Duwadi, 2021).

ODEM.io is another notable start-up in the field of student engagement (Steiu, 2020). Students may connect with academic experts who provide individualized instruction through the platform by utilizing the ODEM token (ODE). Students, instructors, businesses, and educational institutions may benefit from the ODEM Trust Network's services since it eliminates the need for middlemen. On the ODEM Employment Network, for example, students may look for jobs, locate educational possibilities customized to their interests, or keep their certificates safely (Steiu, 2020).

On the ODEM Marketplace, educators are compensated with ODE tokens for their work, which is managed by smart contracts on the blockchain. Employers may easily and reliably check the credentials of applicants. Finally, educational institutions may use the ODEM platform to manage and issue accreditations to their students. ODEM.io uses blockchain technology to make education, teaching, and employment more interesting and successful. That's correct. The use of blockchain in e-learning can enhance the transparency and efficiency of the evaluation process and curriculum development. With the use of smart contracts, the immutability and peer execution provided by blockchain technology can ensure trust and safety in e-learning. Additionally, automated evaluation and credentialing processes can be pedagogically and content-neutral, leading to more confidence in online higher education procedures among students and faculty.

10. DOCUMENT ORGANIZATION

Prior studies have mostly concentrated on the need to ensure that higher education paperwork is processed, shared, and handled in accordance with the law. To create distributed applications involving several businesses, blockchain technology enables the construction of an immutable distributed public ledger in which transactions and data can be verified by participants and are not controlled by a central authority (Arndt, 2019). Students' replies in higher education as well as answer records cannot be manipulated due to these aspects; they may be tracked, safeguarded by a group signature, or kept, relying on intellectual exertion and the resulting reputational benefit. The properties of Blockchain that make it especially valuable in underdeveloped nations, where new technologies are hardly adopted, include the ability to link students and faculty while simultaneously enabling decentralization and validation of data.

11. FINDINGS

For the purpose of this research, a literature review was conducted on Blockchain in higher education. By highlighting the significant contributions trends in the topic, the most recent study on Blockchain applications in higher education was addressed with this purpose in mind. These findings and conclusions are discussed considering the study's research questions. At this point, what is the state of Blockchain technology research within the higher education sector? Both HEIs and students are overrepresented in the literature when it comes to the potential uses of blockchain technology in higher education. It is important to note that multiple perspectives on Blockchain in higher education have coexisted, and no consensus has been reached on how to classify it. In addition, the literature states that Blockchain enables all stakeholders to access a Digital and Decentralized Training Infrastructure through Learning Platforms, adequate data security for administrative use as well as the flexibility of design in terms of shared agreement on decisions (Steiu, 2020).

That is why we can design academic programs that connect institutions from across the world, strengthen governance by assisting the administration of higher education with creative resource allocation, as well as to enhance its human resources effectiveness and digital competence. Blockchain literature, on the other hand, encourages higher education institutions to focus on technical expertise and creativity (Lam and Dongol, 2020). Universities should work together more effectively to share educational resources, conduct experiments, and come up with new innovative solutions. For all stakeholders, including higher education institutions and students, it is an innovative technology that may enhance information management while preserving privacy and authenticity for all parties, particularly HEIs and students. As for HEIs, Blockchain may help secure and share legitimate digital credentials.

In addition, students can take advantage of the use of blockchain technology for certification and knowledge management processes related to the acquisition of technical expertise through experimental methods in order to ensure secure communication of essential academic data between them and key stakeholders such as sponsors, publishers, and loan providers. There is a wide range of stakeholders interested in this technology, besides higher education institutions and students themselves. Blockchain technology is a major benefit to all stakeholders since it facilitates knowledge organization, for example, in the case of providing certifications, to prevent counterfeit or faked papers and to ensure confidentiality (Arndt, 2019). Students' records may be transferred from one university to another and from one sponsor to another and from one student's job to another using a decentralized network that is secure. The exchange of writing between writers and editors is made easier as a result of this technology, as are student mobility programs. In the end, the educational ecosystem will benefit from the multiple alliances and collaborative customer interactions that are possible as a result of these apps. Another finding in the literature is that the use of e-learning and digital platforms to educate students about blockchain technology has increased the quality of academic curricula, spurred organizational innovation, and encouraged students to do new things in their studies. Finally, creative education contributes to the total value of stakeholders by enhancing the learning experience. Using distributed ledgers and other educational agents, blockchain technologies establish and store transactions that improve e-learning applications and confidence in online higher education processes.

A final reason for the importance of this technology is that it may be used in environments with limited resources, where the process of gathering documents and providing assistance to students is still in its infancy. There are a variety of players and processes/structures involved in implementing Blockchain applications in higher education that cannot be analyzed apart from the context in which they are implemented. Instead, it should be a part of the organization's overall learning and procedure processes. Furthermore, these protocols, which are based on safe platforms of digital hashes and enable corrective actions without affecting the current data, are achieved through a chain of decentralized verified records. The ability to process and manage documentation in a new manner is also enabled by this technology, which enables the material to be transmitted across many companies while being unmodified and able to be checked, tracked, and validated. This is where smart contracts come in handy, as they allow for the exchange of data and the organizing of paperwork, all while maintaining the secrecy of the certification process. By eliminating the need for a middleman, these various contracts represent a significant increase in the number of people who may benefit from e-learning protocols since they establish confidence and transparency for all parties involved.

Indeed, the literature on Blockchain technology in higher education suggests that it has significant potential for improving the delivery and quality of education. Blockchain offers benefits such as flexibility, security, and immutability that can address many of the challenges faced by traditional educational methods. It can enable students to access education from anywhere, at any time, and from any device, making it easier for them to balance their studies with work and personal commitments. Additionally, Blockchain can provide a secure and transparent platform for storing and sharing educational records, certificates, and credentials, thereby reducing fraud and increasing trust in the educational system.

Moreover, Blockchain can facilitate the development of new educational models that leverage emerging technologies such as artificial intelligence, virtual and augmented reality, and gamification. These models can enhance student engagement and learning outcomes, and better prepare students for the demands of the digital workforce. Overall, the literature suggests that Blockchain technology is a timely and feasible solution for many of the challenges facing higher education today. It offers numerous benefits for students, educators, and institutions alike, and can enable the development of innovative educational models that better align with the needs and expectations of today's learners and the demands of the digital age.

12. CHALLENGES AND FUTURE DIRECTIONS

Lastly, immutability is a key characteristic of Blockchain technology, but it can also be a disadvantage in certain circumstances. Once data is recorded on the Blockchain, it cannot be altered or deleted, which may be problematic in situations where mistakes are made. For instance, if an error is made in recording a student's academic record, it may be difficult or even impossible to correct it. Additionally, the immutability of Blockchain may conflict with privacy regulations, as it may be difficult to delete sensitive information that was recorded in error. Thus, further research is needed to determine the best approach to balancing the benefits of immutability with the need for flexibility and privacy protection.

In conclusion, while Blockchain technology has the potential to revolutionize higher education, there are several technical limitations that need to be addressed before widespread adoption can occur. These limitations include usability, scalability, platform and algorithm appropriateness, social limits, cost, privacy, and immutability. Further research is needed to overcome these constraints and to design a Blockchain-based higher education ecosystem that is user-friendly, scalable, cost-effective, and privacy-protective, while also ensuring the flexibility and accuracy of academic records.

In summary, the use of Blockchain technology in higher education is still hindered by a number of technological limitations. Usability, scalability, platform and algorithm appropriateness, social limits, cost, privacy, and immutability are all areas where further research and development are needed. It is important to develop user-friendly interfaces and provide training for faculty and students to increase adoption. Scalability is also a concern, as the system must be able to handle a larger volume of data as it grows in size and complexity. The use of multiple shared algorithms and the lack of a Blockchain-based higher education ecosystem also limit adoption. Legal frameworks around Blockchain transactions and the cost of implementing the system are additional challenges. Finally, immutability is a key characteristic of Blockchain technology but also poses challenges in certain areas of higher education, such as the need for the right to erase. Future research should focus on addressing these limitations and developing standardized forms of permission based on Blockchain to ensure the authenticity and security of academic credentials.

Overall, while blockchain technology offers numerous advantages for the educational field, addressing challenges such as scalability, integration, data privacy, standardization, regulatory compliance, and sustainability will be critical to its successful implementation and widespread adoption.

Figure 1. Challenges and limitations

13. APPENDICES

This section will include the survey questions used. For example:

I answer this survey from the perspective of...

1. Educator
2. IT Professional
3. Admin/Staff
4. Student

These statements represent different levels of readiness or interest in implementing Blockchain technology. Statement 1 indicates that the organization is currently implementing Blockchain technology, suggesting that the implementation is already in progress.

Statement 2 suggests that the organization has plans to implement Blockchain technology within the next 12 months, indicating that they have already identified a specific use case for the technology and are actively working towards its implementation.

Statement 3 suggests that the organization is considering implementing Blockchain technology and is conducting a serious investigation to determine its feasibility and potential benefits.

Statement 4 indicates that the organization currently has no plans to use Blockchain technology soon, suggesting that they may not see any immediate benefits or have other priorities that take precedence over this technology.

Statement 5 suggests that the person responding to the question does not have any information regarding the organization's plans to implement Blockchain technology (Figure 1).

It's worth noting that the decision to implement Blockchain technology should be made after careful consideration of the potential benefits and drawbacks, as well as the specific use case and the organization's goals and capabilities.

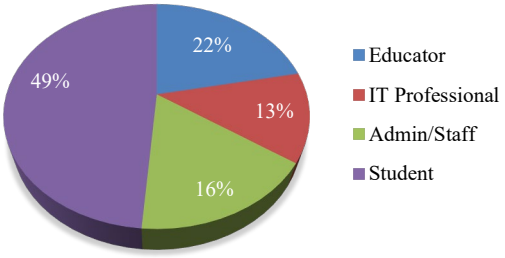

Figure 2. Responses to the question: I answer this survey from the perspective of...

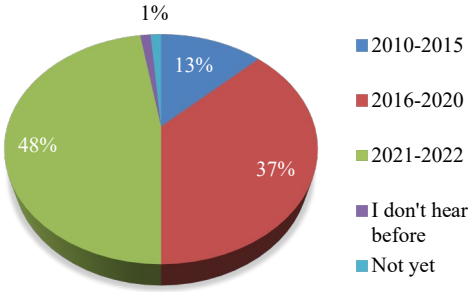

Figure 3. Responses to the question: I first heard of the concept of blockchain technology in the year ...

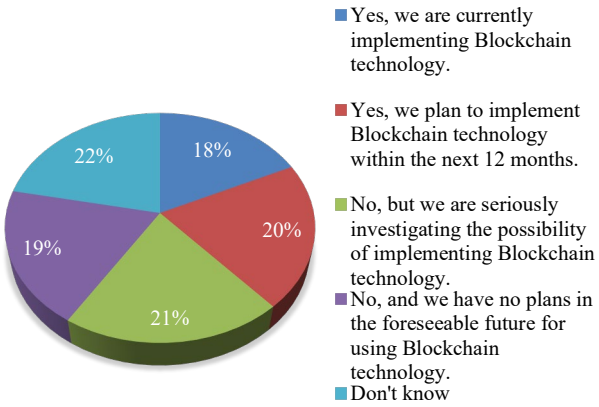

Figure 4. Responses to the question: Is your organization currently implementing - or does it plan to implement - Blockchain technology?

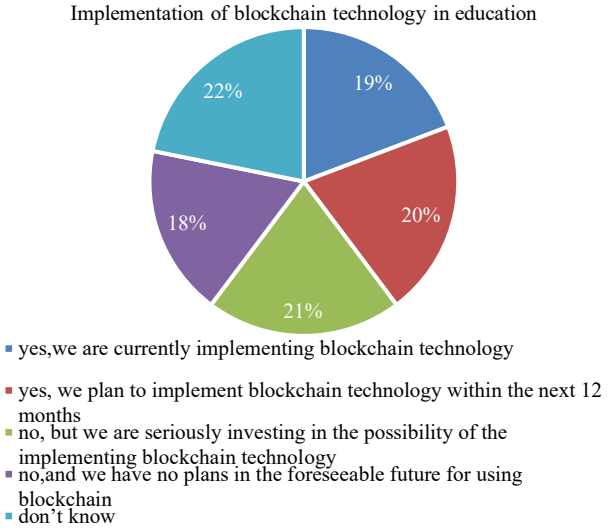

Figure 5. Responses to the question: Implementation of blockchain technology in education

14. RESULTS

This study is centered around research conducted by highly cited authors in the field. To assess their citation impact, we utilized two databases, namely Scholar Google and SpringerLink.

Our Systematic Literature Review is categorized into three main research groups:

1) Research papers investigating trends in blockchain technology development.

2) Review papers focusing on the integration of blockchain in higher education.

3) Specialized papers exploring the application of blockchain in higher education.

The results of our analysis of Research Papers that Determined Tendencies in Blockchain Technology Development are presented in Table 2. This table showcases papers authored by influential researchers who laid the foundation for further specialized studies across various domains, including higher education.

Table 1. Highly cited authors influencing the field of blockchain technology development

Author and Name of Article	Year	Number of Citations	Type of Research Paper	Country
Swan, M. Blockchain: Blueprint for a New Economy	2015	2,504	book	UK
Kosba, A.; Miller, A.; Shi, E.; Wen, Z.; Papamanthou, C. Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts	2016	1,166	Conference Proceedings	USA
Nakamoto, S. Bitcoin: A Peer-to-Peer Electronic Cash System	2008	10,277	Article	Japan
Buterin, V. A Next-Generation Smart Contract and Decentralized Application Platform	2014	1,078	Journal Article	Canada

Satoshi Nakamoto is an eminent and highly influential author in the field of blockchain technology. In 2008, Nakamoto published the seminal article "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008). This article introduced the innovative concept of bitcoin, a decentralized digital cash system based on cryptography, eliminating the need for intermediaries like banks. Nakamoto's proposal addressed the critical issue of "double spending" and laid the foundation for blockchain technology. The blockchain, a distributed ledger developed by Nakamoto, forms the core of this cash system. It comprises a chain of interconnected digital transactions secured through cryptography. This structure ensures that submitted transaction information remains unaltered, safeguarding it against theft or manipulation.

Another crucial aspect introduced by Nakamoto was the cryptographic algorithm for Bitcoin mining. This mechanism incentivized network participants by rewarding them for contributing sufficient resources, such as computational power and electricity, to maintain the blockchain's operational capacity. Over the years, Nakamoto's groundbreaking system has garnered significant attention and undergone extensive promotion and enhancements by programmers. However, research in this area remained relatively overlooked until V. Buterin's contribution in 2014.

V. Buterin's work, "A Next-Generation Smart Contract and Decentralized Application Platform" (Buterin, 2014), presented a new Ethereum blockchain. Unlike Bitcoin's primary focus on digital cash, Ethereum introduced a flexible platform with an embedded programming language that enabled the creation of smart contracts and decentralized applications. Buterin categorized these applications into financial, semi-financial, and nonfinancial types, extending the application of blockchain beyond cryptocurrencies.

The introduction of Ethereum sparked further research and development in the field. However, a critical issue emerged concerning data confidentiality. In 2015, A. Kosba, A. Miller, E. Shi, Z. Wen, and C. Papamanthou proposed the "Hawk" blockchain model in their work "Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts" (Kosba, et al., 2015). The Hawk model addressed the problem of data privacy in smart contracts by employing a software compiler to encode smart contracts with cryptographic protocols. This approach separated the public and private portions of the smart contract, ensuring the confidentiality of transactions and personal data.

Hawk's approach to on-chain privacy and contractual security provided a new level of protection for parties involved in financial contracts, securing their privacy from external entities and even from each other. These groundbreaking contributions by Nakamoto, Buterin, and the team behind the Hawk model have significantly advanced the field of blockchain technology. Their works have laid the groundwork for a wide range of applications, driving interest and innovation among startups, software developers, and businesses alike. The pursuit of cutting-edge solutions in the blockchain space continues to shape the future of this transformative technology. The emergence of Hawk as an intellectual contracts system has opened up diverse applications of blockchain technology in various fields.

In her paper titled "Blockchain: Blueprint for a New Economy" (Swan, 2015), M. Swan views blockchain as a novel organizational paradigm capable of coordinating human activities. She identifies distinct stages of the technological blockchain revolution: Blockchain 1.0, 2.0, 3.0, 4.0, and 5.0. Blockchain 1.0 primarily focused on cryptocurrencies, streamlining common cash transactions. Blockchain 2.0, on the other hand, introduced the concept of smart contracts for property agreements. Subsequently, Blockchain 3.0 witnessed the development of numerous applications across sectors such as government, education, healthcare, and science. Presently, the advancements in Blockchain 4.0 are centered around large-scale industrial applications, enabling simultaneous control, processing, and storage of vast data arrays with logical correlations. Looking ahead, Blockchain 5.0 is expected to formalize over 80% of human life events, spanning logistics, goods transactions, and copyright protection. Swan speculates that blockchain will evolve from decentralized applications to the notion of decentralized autonomous organizations and corporations, functioning independently based on predefined business rules and regulations.

Table 2. Review papers related to the application of blockchain in education

Author and Name of Article	Year	Number of Citations	Type of Research Paper	Country
Grech, A. and Camilleri, A.F. Blockchain in Education	2017	180	Report	EU
Chen, G., Xu, B., Lu, M. et al. Exploring Blockchain Technology and Its Potential Applications for Education	2018	53	Article	China
Yumna H., Murad Khan M., Ikram M., Noreen S. and Sabeen R. Use of Blockchain in Education: A Systematic Literature Review	2019	7	Conference Proceedings	Pakistan
Kamisalic A., Turkanovic M., Mrdovic S., Hericko M. A Preliminary Review of Blockchain-Based Solutions in Higher Education	2019	4	Conference Proceedings	Slovenia
Alammary, A.; Alhazmi, S.; Almasri, M.; Gillani, S. Blockchain-Based Applications in Education: A Systematic Review	2019	10	Article	Saudi Arabia
Hameed B., Murad Khan M., Noman A., et al. A Review of Blockchain-Based Educational Projects	2019	1	Article	Pakistan

In the realm of education, research papers concerning blockchain remain relatively limited, with the number of citations per paper not exceeding 100, as indicated by SpringerLink. For the literature analysis, we categorized blockchain-related research into two groups: review papers and specialized research. Review papers typically rely on secondary data, while specialized research involves primary data analysis. The rapidly expanding field of blockchain research has yielded only seven review papers that analyze its development trends. These findings highlight the dynamic nature of blockchain technology and its potential to transform diverse industries, including education. As the research in this field progresses, more comprehensive insights into its applications and implications are expected to emerge (Table 2).

One of the pioneering review papers on the application of blockchain in education is authored by A. Grech and A. Camilleri titled "Blockchain in Education" (Grech, Camilleri, 2017). This highly influential work, with 64 citations on Semantic Scholar and 181 citations on Scholar Google, is a report by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It highlights real-world use cases of blockchain in universities. The University of Nicosia, Cyprus (UNIC), emerged as a key player in the application of blockchain technology in higher education. In 2014, UNIC officially adopted blockchain to store and verify diplomas, becoming the first university to accept fees in bitcoins. Since then, UNIC has been publishing all graduates' diploma projects (bachelors, masters, and PhDs) on the block.co blockchain platform. This platform is not limited to education but is also used in various sectors, including healthcare, public administration, and transportation.

In 2016, Sony Global Education, in collaboration with IBM, developed a blockchain platform to secure and exchange students' performance and progress-related information. The company sees blockchain as a transformative technology for the future of education. Additionally, the Massachusetts Institute of Technology (MIT) introduced the blockchain-based Blockcerts in 2017, simplifying the issuance of digital diplomas and professional certificates. Grech and Camilleri's review paper suggests eight scenarios for applying blockchain in education, such as permanent certificate protection, verification of multi-stage accreditation, and automatic recognition and transaction of credits. They also propose using blockchain as a lifelong training passport, a means to track intellectual property, and for accepting student payments and providing financing through blockchain-based vouchers.

The review paper identifies some unresolved issues hindering widespread blockchain adoption in education. These include difficulties with data verification in regions with no centralized data management and the lack of a global system of standards. The paper mainly focuses on midterm and short-term development scenarios, with little emphasis on long-term perspectives. Moreover, the paper outlines the unique features of blockchain technology that contribute to its advantages, such as decentralized data storage, unchangeable records, transparent transaction tracking, and cryptocurrency-based reward systems. Smart contracts, self-controlled working programs transmitted through blockchain nodes, enable real-time execution of commitments, reducing costs and enhancing internal audit processes.

Other review papers further explore the potential of blockchain in education. G. Chen (Chen, et al., 2018) identifies four trends for blockchain application in education, including party identification, digital encoding of rights and commitments, student performance assessment, and education as a source of income. A. Kamisalic, M. Turkanovic, S. Mrdovic, and M. Hericko (Kamisalic, et al., 2019) classify blockchain projects into four fields: records storage and application, educational games, digital market assets, and projects disrupting traditional education. These reviews offer valuable insights into the growing landscape of blockchain applications in education, highlighting its potential to revolutionize various aspects of the educational process. As the field continues to evolve, addressing unresolved issues and leveraging blockchain's unique features will be critical for its successful integration in educational settings.

15. DISCUSSION

Our Systematic Literature Review categorized research papers into three groups: those focusing on trends in blockchain technology development, review papers about blockchain in higher education, and specialized papers concerning its development in the education sector. The findings of our research demonstrate that managing blockchain is a complex task at both the ecosystem and platform levels. Developing appropriate policies and regulations faces challenges as blockchain networks operate internationally without attachment to a single jurisdiction. Implementing updates or changes for general-access block networks presents a control problem due to decentralized decision-making involving many participants. However, centralized implementation of updates may pose security threats.

A key issue is the lack of a national blockchain platform and a centralized controlling structure to coordinate the "educational" blockchain as a single digital information space. However, attempting to regulate it contradicts the main advantage of blockchain as a decentralized system. Additionally, there have been fewer blockchain projects realized in the public sector compared to the private sector.

The larger-scale application of blockchain technology may encounter the following factors:

1. The information factor: A significant number of representatives in the academic community are unaware of this technology.
2. The legislation factor: In many countries, the use of blockchain applications or cryptocurrencies has an ambiguous legal status. In Russia, despite the decision to convert paper diplomas to electronic format in 2020, the legal status of such diplomas has not been officially stipulated. Plans to prohibit cryptocurrency emission and circulation further complicate matters.
3. The organizational factor: The technology's potential cost-saving benefits for university administrative staff may lead to resistance from university administrations.

Understanding these factors is crucial for successfully implementing blockchain in educational settings.

16. PROSPECTS AND RESEARCH DIRECTIONS

Here are some prospects and research directions for the application of blockchain technology in education:

- Interoperability and Standardization: One of the key challenges in implementing blockchain in education is achieving interoperability and standardization across different platforms and institutions. Future research can focus on developing common data formats, protocols, and standards to enable seamless exchange, verification, and recognition of educational credentials across diverse blockchain systems.
- Blockchain Integration with Learning Management Systems: Integrating blockchain technology with existing learning management systems (LMS) can enhance the functionality and security of educational platforms. Future research can explore ways to seamlessly integrate blockchain into LMS, enabling the secure storage of educational records, streamlined verification processes, and the issuance of blockchain-based credentials within an existing educational infrastructure.
- Scalability and Performance Enhancements: As blockchain networks grow, scalability becomes crucial to handle increased transaction volumes and ensure efficient processing. Future research can focus on developing scalable blockchain solutions, such as shading, sidechains, or layer-2 protocols, to enhance the performance and throughput of educational blockchain applications.

➢ User Experience and Adoption Strategies: To encourage the widespread adoption of blockchain in education, user experience (UX) plays a crucial role. Future research can focus on improving the usability and accessibility of blockchain-based educational applications, making them intuitive and user-friendly for students, educators, and other stakeholders. Additionally, research can explore strategies and frameworks for the successful adoption and implementation of blockchain technology in educational institutions, considering organizational culture, change management, and user training.

➢ Privacy-Preserving Solutions: While blockchain ensures data integrity, addressing privacy concerns is essential. Future research can explore privacy-preserving techniques, such as zero-knowledge proofs or secure multiparty computation, to protect sensitive student information while still leveraging the benefits of blockchain in education.

➢ Smart Contracts and Automation: Smart contracts, which are self-executing agreements coded on the blockchain, have the potential to automate various educational processes, such as enrollment, grading, and certification. Future research can focus on exploring the use of smart contracts to streamline administrative tasks, enhance transparency, and improve efficiency in educational institutions.

These prospects and research directions aim to address the challenges and expand the potential applications of blockchain technology in the education sector. Continued research and innovation in these areas will contribute to the advancement and widespread adoption of blockchain in education, ultimately transforming the way we learn, verify credentials, and interact with educational systems.

17. CONCLUSIONS

In conclusion, the use of blockchain technology in the educational field offers significant benefits and has the potential to revolutionize various aspects of education. Through its enhanced security, integrity, and transparency, blockchain ensures the immutability of educational records and credentials, reducing the risk of fraud and providing a reliable verification system. It empowers learners by giving them control over their own data and enables lifelong access to their achievements. Moreover, blockchain technology streamlines administrative processes, reduces costs, and fosters trust among stakeholders. Despite the challenges and limitations, ongoing research and development are addressing scalability, privacy, interoperability, and user experience concerns.

• Summary of Findings: The research findings highlight several key points regarding the use of blockchain technology in the educational field. Blockchain enhances security and integrity, streamlines verification processes, and empowers learners by providing them with control over their credentials. It fosters trust and transparency among stakeholders and offers cost and time savings. Blockchain also enables interoperability and standardization of educational credentials, supports lifelong learning, and facilitates global accessibility. However, challenges such as scalability, integration, data privacy, and regulatory compliance need to be addressed for successful implementation.

• Implications and Significance: The implications of using blockchain in education are far-reaching. Blockchain technology can enhance the efficiency, security, and reliability of educational systems, providing a foundation for a more transparent and learner-centric ecosystem. It has the potential to transform the way educational credentials are issued, shared, and verified, promoting lifelong learning, and facilitating global mobility. The increased trust and transparency offered by blockchain also have implications for employer recruitment processes, ensuring the authenticity of job applicants' educational backgrounds.

• Recommendations for Future Implementation: To further implement blockchain technology in the educational field, several recommendations can be considered.

Firstly, there is a need for collaborative efforts among educational institutions, industry stakeholders, and policymakers to establish common standards and frameworks for data exchange and interoperability.

Secondly, research and development should focus on scalability solutions, privacy-preserving mechanisms, and user-friendly interfaces to address current limitations. Furthermore, educational institutions should invest in training and capacity building to ensure the smooth adoption and integration of blockchain systems.

Lastly, continuous monitoring and evaluation should be conducted to assess the impact and effectiveness of blockchain in education and make necessary adjustments to optimize its implementation. By considering these recommendations, educational institutions and policymakers can effectively harness the potential of blockchain technology to drive innovation, enhance educational processes, and ultimately benefit learners, employers, and the entire education ecosystem.

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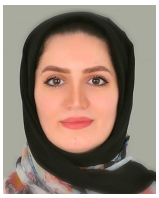
BIOGRAPHY



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