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A Review: Blockchain Technology Applications in the Field of Higher Education

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Abstract: Education is undergoing a continuous digital change. The administrative departments must be able to handle grading, admissions, enrollments, and certificate recognition efficiently and securely. Course administrators should have confidence in both e-learning and e-assessment. Lastly, students should be able to access course materials from anywhere and take tests outside their institutions. With the advancement of education governing systems and governance abilities, technology has broader applicability in the education sector, as it is the ideal technology for securing data. This article aims to determine the state of blockchain applications in education, their benefits, and concerns, as well as to show that the blockchain is becoming a vital technology in future education. In conjunction with digital signatures for identification and verification, blockchain may be the best approach to digital transformation in education. This article cites papers evaluating and detailing the applications and challenges of blockchain technology in the higher education sector. An extensive literature review was conducted, and 63 papers that contributed significantly to the discussion of blockchain's potential in education were chosen for the review. The analysis of these papers provided important information and answered the research questions about how blockchains are currently being used in education, which features can help this field, and what problems need to be solved. Analysis shows that blockchain could become important in the field of education. However, some important technological, regulatory, and academic issues must be resolved before adoption.

Keywords: blockchain technology, blockchain applications, higher education, data security, data privacy, certification management.

回顧：區塊鏈技術在高等教育領域的應用

摘要：教育正在經歷持續的數字化變革。行政部門必須能夠高效、安全地處理分級、錄取、註冊和證書識別。課程管理員應該對電子學習和電子評估都有信心。最後，學生應該能夠從任何地方訪問課程材料並在他們的機構之外參加考試。隨著教育治理體系和治理能力的提升，技術在教育領域的應用越來越廣泛，是保護數據安全的理想技術。本文旨在確定區塊鏈在教育中的應用現狀、它們的好處和關注點，並表明區塊鏈正在成為未來教育中的一項重要技術。結合用於識別和驗證的數字簽名，區塊鏈可能是教育數字化轉型的最佳途徑。本文引用了評估和詳細介紹區塊鏈技術在高等教育領域的應用和挑戰的論文。進行了廣泛的文獻審查，並選擇了63篇對討論區塊鏈在教育方面的潛力做出重大貢獻的論文進行審查。這些論文的分析提供了重要信息，並回答了關於區塊鏈目前如何用於教育、哪些特性可以幫助該領域以及需要解決哪些問題的研究問題。分析表明，區塊鏈可能在教育領域變得重要。然而，一些重要的技術、監管和學術問題必須在採用之前得到解決。

关键词：区块链技术、区块链应用、高等教育、数据安全、数据隐私、认证管理。

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1. Introduction

Because today's society is home to the generation that has the broadest access to educational opportunities of any in history, educational standards are of the utmost significance in this era of information and knowledge. This has led to the establishment of brand-new educational institutions that are in the business of conferring certificates, which has in turn increased the production of brand-new undergraduate and graduate degrees [1]. In spite of this, educational institutions continue to give prospective employers only the information that pertains to a student's degree and transcripts, ignoring the extent to which a student has internalized a set of skills and competencies during their academic career [2, 3, and 63]. This is a problem when considering the quality of education provided. In point of fact, the prestige of the educational establishment that confers the diploma remains one of the most important signals that unmistakably influence a student's future in the workplace [4].

The process of issuing and verifying academic data is one of the most important aspects of education, especially in higher education [56]. Currently, this process is conducted mainly independently of other organizations' record-keeping practices within every proprietary system of an educational institution. Because, often, the human authentication of a certificate or transcript may be very timely and resource-intensive; this issue directly affects the verification of educational data for students [5]. Due to the increasing need to demonstrate acquired abilities and skills in a world that is becoming more competitive, this circumstance supports the emergence of fraudulent academic diplomas, which originate from five distinct sources [6]:

1. "Degree mills" that produce phony credentials and sell them to people who pay for them;
2. Fake academic documents that come from universities and colleges that don't exist [57];
3. Modified documents that change authentic documents that altered to include fake dates, courses, specialties, and so on;
4. "In-house" certificates are forgeries of actual academic records prepared by a legitimate institution and printed and sealed as if they were genuine, but sometimes dishonest staff makes them;
5. Erroneous translations of real papers intended to meet specific standards in some other country with a different language.

One way to resolve previous problems is to promote interoperability. This will level the playing field for vendors of digital certification management and issuance solutions and create the prerequisites for giving learners further control over their certificates since portability between systems will be possible. Increase the effectiveness of the verification processes. Currently, the issuing institutions slow down the verification procedure. By dissolving this centralized gatekeeper system and replacing it with a distributed one that gives certificate holders more power, blockchain technologies offer an opportunity to reconsider their roles and responsibilities [7].

Blockchain Technology is a new technology that operates on the distribution and decentralization concepts. It draws on knowledge from various fields of wisdom. Blockchain uses a distinct database that is built with the help of information blocks that are linked together in the form of chains. When new information is added, a new block is produced and continuously attached to the chain. It is a distributed system that eventually produces a ledger of transactions controlled collaboratively by all users. Because this is a decentralized system, data put to a block is irreversible and visible to all users [8].

In this work, we investigated in deep the Blockchain technology to serve higher education with many important aspects covered these technique and main related works that have been achieved [58, 59].

2. Overview of Blockchain Technology

Bitcoin and cryptocurrencies were adopted due to the absolute distributed ledgers in multiple nodes, which were proposed in 2008 by Satoshi Nakamoto. It drew attention and so became a draw in the Blockchain [9]. This technology is a system that may be set up and decentralized [10] and create open records of digital events or all transactions that will be shared among participating parties [11]. Each transaction on the Blockchain will be validated with a digital signature to demonstrate its legitimacy. Because of the use of digital signatures and encryption, information recorded on the blockchain can be sealed and unchangeable [12].

Blockchain is a data block chain. Every block can correspond to a page in a shared ledger. Single blocks are made up of various components, which are usually divided into block header and block body [13, 14], as seen in Fig. 1.

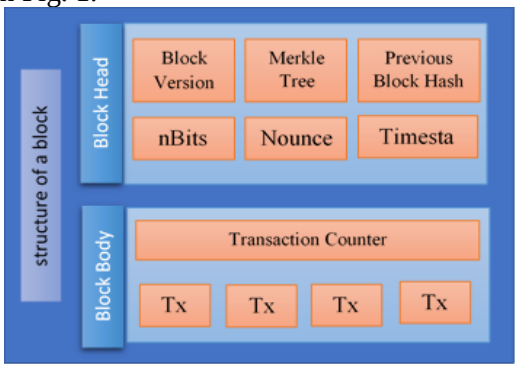

Fig. 1 Structure of blockchain

The block header is broken into six components, such as the block's version number, Timestamp, nBits, Nounce, preceding block hash, and Merkle tree root hash (MTRH). In most circumstances, the version number of blocks is irrelevant; nevertheless, a miner with a certain version number can indicate which protocol decisions it mostly supports. Since the hash of the previous block is included in the hash of the new block, the chain of blockchain is the hash of the previous block. Without this component, there would be no connectivity between the blocks of the blockchain [14].

The MTRH encrypts blockchain data rapidly and securely. In a peer-to-peer blockchain network, it enables the rapid verification of blockchain data and the rapid transport of enormous amounts of data between one computer node to the next. The data are hashed before the hashes are hashed one more and merged. The Merkle tree is finally merged into a single hash, called the root hash. It represents all the data from its leaves, i.e. are single transactions, and its branches, that are hashes of the leaves, in a relatively short stream. Every transaction on a certain blockchain network is associated with a hash; even so, these hashes are not stored in sequential order on the block, but rather in a tree-like architecture, with each hash related to its parent through a parent-child tree-like linkage [15]. nBits is the encoded form of a block header. Nounce is the variable that the Proof-of-Concept has raised. This is how a miner predicts a valid hash. In addition to providing diversity for the block hash, each block has a unique timestamp, making it harder for an adversary to alter the blockchain. A timestamp is valid if it is greater than the median of the previous eleven blocks' timestamps or the network-modified time, that is the median of timestamps provided by all nodes connected to the blockchain [13].

Also, blockchain has three features, which are [16]:

1. *Open-source and transparent:* This concept of open source and transparency is the blockchain's code accessible. By verifying the code that is available on the blockchain, one can have access to the code, but cannot modify the data.

2. *Not centralized (decentralized):* It is in the system's performance that no one has any control. Since the blockchain code isn't stored on the servers that run the system, and the computers store blocks containing transactions in records within a system that spans hundreds of machines.

3. *Eternal:* Its description of blockchain technology is that the entering data validated on blockchain technology will continue to exist remaining the same. Since the technology has partnered with the hash pointer data to block and construct a chain, the data is limitless and will not be lost.

3. Types of Blockchains

There are three main types of blockchains [17].

3.1. Permissioned Blockchain

It is additionally known as private blockchain. It is a closed ecosystem were joining the blockchain network is difficult. They require authorization to do network-based functions whether the permissions belong to a single individual or an organization, a central authority handles them all. The consensus mechanism may be identical to a public blockchain or it may be different, e.g., Ripple or Quorum platforms [18].

3.2. Permissionless Blockchain

One example of this form of blockchain is Bitcoin. Anyone can use and operate a node with this mining program. This is possible so long as the laws of the blockchain are followed. These blockchains are accessible and transparent. It is accessible to everyone at any time. It is also referred to as public blockchains. Most digital currencies on the market belong to this category. e.g., bitcoin and light coin [19].

3.3. Consortium or Federated Blockchain

In this form, wasted power on a single entity is eliminated. Instead of granting authority to a single company, power is handed to a group of people or individuals who establish consortiums or federations, such as Quorum, Hyperledger, or Corda platforms [20].

4. Blockchain Technology in and for Education

Blockchain is a mechanism for storing transactions on computers using a decentralized peer-to-peer network in a linked environment without influencing third parties; it represents a technological advance in terms of accuracy, data management, security, and convenience [21]. The blockchain technology has affected the teaching system as well as the educational system [22]. Ted Mitchell published a report that there is an associated influence in the education world and the workforce to develop efficiency and effectiveness of technologies in that field. This statement was written as a direct result of the (ACE Report). It found that a system using digital-based rights management that is incorporated in blockchain technology could be a solution in managing to record, store, and digitally verify certificates with guaranteed safety [23].

Many ways exist that blockchain technology can be used in higher education. Even though several colleges and universities have not fully adopted blockchain technology, professionals, technologists, futurists, as well as some professionals in higher education (such as faculty) have predicted that it will be widely used in the future [24]. The Holburton School, Massachusetts Institute of Technology (MIT), and the Nicosia

University are all ahead of the curve regarding blockchain in higher education [25].

Blockchain can help colleges and universities in the following ways:

- Management of academic degrees [26].
- Summative assessment of the learning results [26].
- Degree records and certification storage and access [27].
- Less fraud with credentials and diplomas [25, 28].
- The commercialization of academic abilities and the provision of incentives for scholastic performance [28].
- Making processes like admissions, registration, and time-to-degree reporting more efficient to cut down on administrative waste and costs [28].

Blockchain makes a permanent record of the existence of a degree or certificate, but they do prove that the degree or certificate is real. Authenticating documents requires a person to make a subjective decision [29]. Therefore, any blockchain-based system for managing degrees must include peer review and reputation management to avoid academic fraud and wrong use of official records. Assessing the results of learning also requires human help. Any evaluation of educational achievement must consider the fact that people are different [30]. Earning money while learning (so-called "earn while you learn") [31] could give students more motivation to study more and do better by, for example, linking grades to cryptocurrency earnings. But it could also make academic institutions, which are already criticized for being like businesses and copying their structures, little more than extensions of capitalist businesses. Blockchain technology promises to make it easier to run schools, but being more efficient also has its downsides. For example, if functions like admissions, registration, and keeping track of degrees were automated, admissions officers, registrars, and academic advisors would have less to do and, eventually, their jobs would be eliminated. Widespread use of blockchains could also reduce universities' economic impact on the communities around them, where they are often the best place to work and help the economy grow [29].

As Blockchain technology enables the quick and simple validation of individual learning achievements and the monetization skills of employment and credentials, it facilitates the repurposing of schools and universities for vocational (and hence less scholarly) purposes. Whilst the efficiency advantages of blockchain lead to the Blockchain-for-higher-education narrative, which is mainly driven by predictions of the technology's positive impact on higher education. The following are predictions regarding how Blockchain will significantly impact higher education [32]:

1. Blockchain will make it easier for entrepreneurs and public higher education research institutions to work together and coordinate their research [33].

2. The implementation of blockchain technology will result in a shift in the curriculum of institutions of higher learning, leading to an expansion of degree programs and professional certifications at the intersection of business and technology. This will be the case, for example, in the fields of financial technology (Fin-tech), cryptocurrency, and blockchain itself [34].

3. Blockchain will replace the time-consuming and labor-intensive processes of Learning Management Systems (LMSs) and Student Information Systems (SISs) that track graduation, admissions, degree progress, and registration and make use of blockchain templates as well as smart contracts [35].

4. Blockchain technology will creates proof of digital rights protection, intellectual property and work and thereby streamlining copyright for scholars and artists at higher education institutions [29, 36].

5. Blockchain will transform colleges and universities into supply chains for education certifications (professional, continuing, and online), offering learning and training chances throughout a person's entire lifetime as opposed to degree-centric, two-levels (graduate and undergraduate) institutions that prepare young adults for the workplace [37].

With this newly discovered urgency to redefine the purpose of higher education institutions, the rush to use Blockchain technology has coincided. Based on the Blockchain-for-Higher-Education concept, colleges and universities are currently shifting from administrators of undergraduate and graduate degrees to supply chain providers of training and certificates from conservators of civilization's information. Blockchain must successfully disrupt higher education to effectively promote and offer learning possibilities to workers who feel inherently inadequate despite sweeping technological change if the shift is to be successful. Their sense of inadequateness is a reaction to the quickly growing complexity of industrial and digital technology. The success of the shift hinges on outsiders perceiving universities and colleges as failing to meet their original objective, thus in need of repurposing, in addition to employees' feelings of the availability and inadequacy of Blockchain technology [38].

5. Challenges of the Blockchain in Education

The application of blockchain technology in education faces significant technological challenges. The first, and possibly most difficult, is proof-of-work, which is the consensus process for the confirmation of new blocks. The larger the blockchain size, the larger and more expensive its proof of work becomes. The volume and intensity of proof of work (mining) is absolutely mind-boggling; for example, Bitcoin miners computed over 450,000 trillion solutions through a second in 2015 at a total cost in energy, apparatus, and

maintenance labor of approximately USD six hundred million. Blockchain mining offers issues to climate change due to its high electricity usage, and China becomes the first state to ban it outright. Mining a worldwide blockchain in education can provide challenges such as "the solving of complicated mathematical problems during the approval process, with no what type of fraudulent block might be put in to the chain." As a result, including mining into the framework of Blockchain Learning will necessitate a specific study." The issue doesn't end with the recognition of miners' proof-of-work [39].

A blockchain for education using students as Nodes, the lawful owners of their own blocks, has extra qualia difficulties, that is, those factors of learning that are difficult to quantify Additionally, the technological mechanics of distributing assessments, soliciting participation, collecting results, and giving prizes. A blockchain is designed, used, and mined within a single educational institution or a small consortium is more likely to be sustainable. A larger education blockchain at the global and national level, on the other hand, may be a fruitless effort because it will almost certainly fail to exchange knowledge in a decentralized online community without going through numerous third parties. For example, through a blockchain with student nodes, the state or university, who are third parties nearly often award university degrees [40]. A blockchain for education would produce a permanent record where a particular piece of information would stay unchangeable and unalterable to all Nodes concerned. Furthermore, it has been challenged whether this is truly desirable for the students themselves and whether a permanent record violates the fundamental premise of education for growth, transformation, and, if not that, at least for self-repair/reinvention with a second or third chance [41].

The second primary reason that there are so few actual blockchain technology applications in education is that it is not aligned with a genuine concept of the sustainable growth of educational institutions. This is a difficult problem with several facets to consider. Educators who are interested in leveraging the strength of this latest technology should first pose a few teleological questions rather than just speculate on potentials alone. These questions should center on the following topic: "What problems might blockchain answer in education?" What technological and ideological challenges might arise from the widespread adoption of blockchain technology in education? For one thing, the worldwide experience with cryptocurrencies has shown that although a piece of information stored in a blockchain might be immutable, the value of that information is not. The value of the same piece of knowledge can shift drastically depending on the levels of need and greed in the human population. It is imperative that do not lose sight of the fact that the implementation and usage of innovative pedagogies and technology in the field of education have frequently resulted in unexpected consequences. As an illustration, the path that the theory of giftedness and higher ability would take was determined a century ago by way of Binet's intelligence measurement. Despite this, it unintentionally brought about a new type of social stratification, that comprised fitting people to a normal curve, determining scores to their information, figuring out social circles, and ability-based on institutional streaming.

A blockchain-based education system that maintains permanent records of students' skills and accomplishments may also produce a new form of social stratification, which is probably more pervasive and severe than the current method for classifying individuals according to their intelligence quotient. It's possible that, in the end, the nature and degree of the arbitrariness of institutional confidence and value will be a barrier to progress to a more sustainable future for the entire world. Even though blockchains have a great potential and are very efficient, we won't be able to answer the question "What issues can blockchains solve in the education field?" even though blockchains have a great potential and are very efficient. This is because we don't have obvious philosophy of what the objective of education is and where there is a need to be. It is possible that a blockchain will empower students by obtaining them ownership and managing their credentials; however, it also can derail the objective of education by creating a novel form of social inequity and inequality or by worsening the outdated forms that already exist [60]. The use of blockchain technology could transform educational institutions and other social organizations into a forum for social interaction control and maintenance of power, such as maintaining a permanent record in a manner analogous to a Social Credit System and engaging in widespread monitoring, could result in significant breaches of privacy and the exercise of oppression [40].

Blockchain technology should, ideally, serve education in a way that places a priority on peer-to-peer co-operation and durability. Instead of serving authoritarian social control or hypercapitalism of education and improvement, blockchain technology should serve education in this way. It isn't the methods for the sake of technological novelty for every se that is the end aim of education; rather, it is education's main goals of social rights and sustainable development [41]. Communication between peers, autonomous organization, and contributions to globally dispersed "education commons" with contributed modern knowledge, pedagogic sources, and open supportive education systems are made possible thanks to this model. Blockchain would have be placed to a more suitable use if it had been combined with an obvious philosophy of a decentralized and sustainable development of education, in which the main goal is

situated beyond the frontiers of academic credentials, bureaucratic efficacy, and the kind of monetary enticements that goes to the motto "learning is earning." This would have cumulated in greater social control, as part of what might be considered the most recent developments in the blockchain industry [42].

6. Most Recent Related Works for Blockchains in Education

This investigation comprises illuminating study papers that were supposedly taken from journals, gatherings, and books, all of which include the most recent articles.

The authors of [43] have provided an overview of the fundamental technological concepts as well as the application-based characteristics of the blockchain technology. The provision of a solution to the challenges faced by online educational environments was the primary objective of this research. The blockchain technology enables the storage of learning records in a trustworthy distributed way, the realization of smart contract-based learning resource sharing, the provision of reliable digital certificates, and the usage of data encryption to safeguard intellectual property. According to the findings of this study, the expansion of opportunities for online learning can be supported by using blockchain technology.

[44] provided consensus algorithms and cryptography methodologies for generating features such as traceability, decentralization, immutability, and monetary characteristics. As an incentive for learning, blockchain technology inspires students. Additionally, it retains a set of records containing educational acts and outcomes in formal and informal learning situations. Additionally, the faculty's instructional practices and performance records provide a basis for teaching evaluation. Blockchain provides numerous potential educational designs, analysis, evaluation, recording, and behavior and uses for students and teachers [61].

[45] presented a method using advanced blockchain technologies that will enable education providers to issue certified certificates that provide proof of completion or achievement. Consumers can obtain these certificates and share them with anyone who requires official documents. Furthermore, education is a long-term undertaking rather than a one-time occurrence. People continue on learning because of their experiences in life, employment, and professional training. Keeping a note of those learning events is just as important as is keeping track of formal education. Our resolution can also provide the necessary features for post-secondary education.

[46] suggested a blockchain model that used the well-known technique Technology Acceptability Model (TAM) for forecasting the acceptance of Blockchain deployment in education in the Kingdom of Saudi Arabia KSA. This research was conducted in Saudi Arabia. The primary objective is to evaluate the potential applications of blockchain technology inside the Saudi Arabian higher education system. The TAM model is extended in this study, and its validity and application in the setting of higher education are put to the test to better explain and predict students' behavioral intentions. To verify the findings of the study, he proposed certain hypotheses and recommended some independent external factors.

[47] developed a novel method called PIRATE that they used to build a secure computing system. The value of the suggested method for dispersed learning is demonstrated through a case study. The salient learning framework foresees several difficulties and unanswered questions posed by the large number of devices made possible by 5G technologies and is eager to take part in distributed-learning assignments that require a large amount of available data transfer.

The system developed in [48] records the outcomes of activities using Blockchain in a way that permits the student to pursue a customized learning path while enabling the subject's teacher-tutor to perform formative and summative assessments of the student's performance. The evaluation phase of the project's implementation is well under way. They have been able to get crucial insights into the practicality and relevance of Blockchain's usage in education thanks to their experience with some aspects of the design and the experimental implementation in a formal university context throughout the current academic course. This article will provide a broad overview of them, along with an explanation and justification of the context in which they are applicable.

[49] developed a system based on Blockchain technology and smart contracts that would automate the production of test-type assessment exams and record the results in a Blockchain ledger. The responses are recorded in chronological order, ensuring that the answers and grades will not be altered, as well as providing the student with access to this information (with previous consent). Additionally, they propose that the test's questions be drawn from a "question pool" that has been previously populated by subject matter experts and categorized by level of difficulty, allowing assessors or students to choose the test's level of difficulty. This will enable the development of a richer curriculum for every student, the student budget, a budget storing exam scores and the extent to which pupils have mastered the acquired competencies and skills.

To address the issue of education transaction object authentication across institutions, [50] presented a unique blockchain-based authentication service for digital education transaction objects. To ensure security and transparency, they built information models for both types of objects and recorded the model's metadata in a distributed ledger. Additionally, educational institutions can now conduct their own

automated authentication of transaction objects including education thanks to smart contracts. An enhanced consensus mechanism for blockchain networks is presented and implemented in our prototype system to enhance the efficiency of blockchain-based authentication services. Using both theoretical analysis and experimental findings, we show that our blockchain-based authentication service is both feasible and effective.

[51] discusses the implementation of blockchain technique in the education area for the benefit of students and to enhance the learning process. The origin, immutability, security, and peer-executed smart contracts of a blockchain could add a new level of security, trust, and transparency to e-learning. In this article, we will examine what blockchain is, the many types of blockchains, what a block is and its structure, blockchain-related algorithms, and how this technology will affect the education industry in the coming years.

[52] developed a model that can be used for teaching purposes. They investigate the implementation of blockchain technologies and related issues to issue and verify educational data in their studies, and provide an innovative approach to address them. The suggested approach facilitates the issuance, storage, and verification of many types of academic information, both formal and informal, and complies with applicable requirements while maintaining users' personal data privacy. This plan also addresses scalability issues and lays the groundwork for a global academic certification system [62].

[53] created a model that suggests that integrating blockchain technology with the Smart Program Education platform, which is based on the Massive Open Online Course (MOOC), is a trend that is expected to emerge on the Internet in relation to the expansion of online education. The conclusion may include a critique of the technical features and fundamental uses of blockchain, as well as the provision of solutions to problems that are encountered in online education that are based on blockchain technology. Assistance, discussion on blockchain, and discussion on how blockchain technology must approve the work of educational institutions to be considered a digital technology are relevant. This is necessary so that more can be expected in terms of prototypes, and so that a more suitable replacement can be developed.

[54] proposed a model for managing online education data that is based on a blockchain. This model solves the problems of online education resource data write-into-chain authentication and online learning data storage in blockchain. On the basis of the temporary verification code and the third-public party's key, a smart contract-based system for sharing online education data is proposed, and its effectiveness is checked by a security analysis.

The study [55] used a multi-method approach to investigate Blockchain-based education design, Blockchain features that were implemented, and Blockchain-based educational services as a direct result of the study. The effectiveness of the implementation depends on each of these aspects significantly.

7. Conclusion

In this survey, 63 recent publications are reviewed to determine the state of blockchain applications in the field of education, their prospective benefits, and the concerns that must be answered for their outline. From analysis, Blockchain can benefit education, as shown by recent research and publications. Its features strengthen the security, trust, and efficient usage of academic information, enable its issuance, sharing, exploitation, and verification, and establish new use cases. As shown in this paper, research and the quantity of blockchain projects directed at education continue to rise, although the underlying technology and applications are not yet mature, but are evolving rapidly. Smart contracts must be modeled from a scientific, normative and legislative, and academic viewpoint (such as, security, scalability, privacy, quality, etc.).

Earlier studies have already recommended Blockchain technology as an educational aid and benefit. In addition to the concerns related to the forgery of paper certificates and degrees and the sites that offer them, students may encounter additional issues after graduation due to paper certificates. This research intends to identify specific issues associated with paper certificates and to assess the potential of alternative Blockchain-based solutions for paper certificates and diplomas. When issuing, storing, and certifying certificates and diplomas, the Blockchain technology is helpful for combating counterfeit. Presently, only models, prototypes, and demonstrations of concept use blockchains in the field of education. From deep analyzing we can conclude that the Blockchain is becoming a vital technology in future education, as shown by ongoing initiatives.

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