(REVIEW ARTICLE)

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Blockchain technology in education: The perspective, challenges, and concerns

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Abstract

Blockchain technology has altered the way transactions are conducted since its introduction. It offers a risk-free and secure way to exchange digital currency that is impervious to manipulation by those with bad intentions. In blocks that store the data, it stores all transactional data. The best example of decentralized, systematic data collection is blockchain technology. By storing the block in many locations across a distributed network arrangement, it offers a public ledger system that combines public key encryption of all transactions to solve the double spending problem, making change impossible and therefore more secure. This article explores the usefulness and benefits of Blockchain technology compared to traditional data management by outlining its fundamental concepts and how it has been adopted in different industries. The writers also discuss the factors that led to the adoption of Bitcoin and other cryptocurrencies as well as the shift to a decentralized crypto ledger. In-depth information on this technology's potential hazards, drawbacks, security features, threats, and vulnerabilities is also included in the article.

Keywords: Cryptocurrencies; Blockchain; Bitcoin; Security Restrictions

1. Introduction

Blockchain technology has the potential to revolutionize various industries, including education. Here's how blockchain can be applied in the education sector:

- **Credential Verification and Digital Diplomas:** One of the most prominent applications of blockchain in education is the secure and tamper-proof storage of educational credentials and certificates. Students' academic achievements, degrees, and certifications can be stored on a blockchain, ensuring their authenticity and making it easier for employers and educational institutions to verify them without relying on traditional paper-based records [1].
- **Immutable Records:** Block chain's inherent immutability ensures that once data is recorded on the chain, it cannot be altered or deleted. This characteristic can help prevent fraud, unauthorized alterations, and discrepancies in academic records [2].
- **Decentralized Learning Platforms:** Blockchain can support the development of decentralized learning platforms, where educational content, courses, and assessments are distributed across a network of nodes rather than being controlled by a single entity. This could empower educators and learners by providing more control over the learning process.
- **Micro credentialing and Badges:** Blockchain can enable the creation of digital badges and micro credentials that represent specific skills or achievements. These badges can be shared across platforms and institutions, allowing for a more granular representation of a person's skills and achievements beyond traditional degrees.
- **Secure Data Sharing:** Educational institutions often need to share student data securely with other institutions, employers, or researchers. Blockchain-based systems could allow students to control who has access to their data, giving them more control over their personal information [3].

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- **Smart Contracts for Administrative Processes:** Smart contracts are self-executing contracts with the terms of the agreement directly written into code. These could streamline administrative processes such as enrolment, fee payments, and course registration by automating steps based on predefined conditions.
- **Reduced Verification Costs:** Traditional processes of verifying educational credentials can be time-consuming and costly. With blockchain, the verification process can become faster, more efficient, and cost-effective since the information is stored in a secure, accessible, and tamper-proof format [4].
- **Global Collaboration and Credits Transfer:** Block chain's distributed nature could facilitate the recognition and transfer of credits across borders and institutions, simplifying the process for students who transfer between schools or universities [5].
- **Research and Intellectual Property:** Blockchain can be used to create an immutable record of research findings and intellectual property rights, ensuring proper attribution and preventing disputes over ownership.

Despite its potential benefits, integrating blockchain into education also comes with challenges, including issues related to scalability, data privacy, standardization, and the need for technical expertise. Furthermore, the adoption of blockchain in education is still relatively nascent and requires cooperation among educational institutions, governments, and technology providers. As of my last knowledge update in September 2021, the use of blockchain in education was still evolving. It's recommended to explore more recent sources to find out about the latest developments in this area [6].

2. Blockchain Applications

Achievements without relying on intermediaries.

- **Digital Diplomas and Certificates:** Instead of traditional paper diplomas, digital diplomas and certificates can be issued on a blockchain. This provides students with easy access to their credentials and allows for secure sharing of these documents with potential employers or other institutions.
- **EPortfolios and Skill Tracking:** Students can create ePortfolios that showcase their skills, projects, and accomplishments. Blockchain enables the secure storage and sharing of this information, making it easy for students to demonstrate their abilities to potential employers [7].
- **Micro credentialing and Badges:** Blockchain can be used to issue digital badges or micro credentials for completing specific courses or acquiring particular skills. These badges can be verified by anyone with access to the blockchain, allowing for a more granular representation of a person's capabilities.
- **Decentralized Learning Platforms:** Blockchain-based platforms can facilitate peer-to-peer learning, enabling students to create, share, and access educational content directly. This reduces the need for intermediaries and central authorities in education [7].
- **Transcript Management:** Traditional transcripts can be vulnerable to tampering or loss. Blockchain-based transcripts ensure the security and accuracy of academic records, making it easier for students to transfer credits between institutions.
- **Student Data Privacy:** Blockchain technology can provide students with more control over their personal data. They can grant temporary access to specific parts of their educational records, enhancing data privacy while allowing institutions to perform necessary verifications [9].
- **Smart Contracts for Enrolment and Payments:** Smart contracts can automate administrative processes like enrolment, fee payments, and course registrations. This reduces paperwork, ensures transparency, and minimizes the chances of errors [6].
- **Global Collaborations and Research:** Blockchain can facilitate collaboration on research projects by providing a secure and transparent platform for sharing data, attributing contributions, and ensuring the integrity of findings.
- **Continuing Education and Lifelong Learning:** Blockchain can track and validate a person's ongoing professional development, making it easier for employers to verify skills and training acquired throughout a person's career.
- **Reduced Fraud and Verification Costs:** The tamper-proof nature of blockchain reduces the risk of credential fraud. It also lowers the cost and time associated with verifying educational qualifications.
- **Secure Digital Libraries:** Educational institutions can use blockchain to create secure repositories for storing and sharing digital learning resources, research papers, and course materials [10].

These applications illustrate how blockchain technology can enhance transparency, security, and efficiency in the education sector. However, it's important to note that the successful implementation of these applications requires careful planning, collaboration among stakeholders, and consideration of technical challenges. The education landscape is continuously evolving, so staying updated on recent developments and trends is crucial.

3. Evolution of blockchain for learning in Education

The evolution of blockchain technology in education has followed a trajectory from initial explorations to more sophisticated applications. Here's a rough timeline of how blockchain has evolved for learning in education:

- Early Exploration (2010s): In the early 2010s, some forward-thinking educators and technologists began to explore the potential of blockchain in education. Initial discussions centred on secure credentialing, transparent record-keeping, and the potential for decentralizing learning platforms [8].
- Digital Credentials and Certificates (Mid to Late 2010s): By the mid-2010s, the focus shifted to practical applications like secure digital credentials and certificates. Several universities and educational institutions started piloting blockchain-based systems to issue and verify diplomas, degrees, and certifications. This approach aimed to combat credential fraud and enhance the efficiency of verification processes [12].
- Micro credentialing and Open Badges (Late 2010s to Early 2020s): As interest in lifelong learning and skill-based education grew, the concept of micro credentialing gained traction. Blockchain was seen as a suitable technology for issuing, verifying, and sharing digital badges that represent specific skills and achievements. Open Badges, an initiative that aims to standardize digital badge systems, gained attention in this context.
- Decentralized Learning Platforms (Mid 2010s to present): The idea of using blockchain for decentralized learning platforms gained momentum. These platforms aim to empower educators and learners by removing intermediaries, allowing for peer-to-peer interactions, and enabling the creation of content and courses without relying on traditional centralized institutions [7].
- Ecosystem Development (Mid 2010s to Present): The blockchain ecosystem supporting education started to develop further. Start-ups and projects emerged that focused specifically on building blockchain solutions for educational institutions, including platforms for issuing and managing digital credentials, decentralized learning marketplaces, and secure data-sharing systems.

Integration Challenges (Ongoing): Despite the potential benefits, integrating blockchain technology into education faces challenges such as scalability, interoperability, regulatory considerations, and the need for technical expertise. Institutions need to navigate these challenges while ensuring that the benefits of transparency, security, and efficiency outweigh the complexities.

Continued Research and Innovation (Ongoing): As of my last update in September 2021, research and experimentation with blockchain technology in education are ongoing. Researchers, educators, and technologists continue to explore ways to harness block chain's potential to transform various aspects of the education sector [13].

Partnerships and Collaborations (Ongoing): Collaborations between educational institutions, governments, technology companies, and standards organizations play a crucial role in driving the evolution of blockchain in education. Such partnerships help ensure that solutions are practical, scalable, and aligned with industry needs.

It's important to note that the evolution of blockchain in education is ongoing and may have progressed further since my last update. It's recommended to explore recent sources and reports to gain a more up-to-date understanding of the current state of blockchain technology's integration in the education sector.

4. Concerns in relation to blockchain applications in Education

While there are several potential benefits to using blockchain technology in education, there are also certain concerns and challenges that need to be addressed. Here are some of the main concerns related to blockchain applications in education:

- Technical Complexity: Blockchain technology is complex and requires specialized technical knowledge to implement and maintain. Educational institutions may face challenges in finding skilled personnel capable of developing and managing blockchain-based solutions [9].
- Scalability: Blockchain networks can face scalability issues as the number of transactions or participants increases. As educational systems involve a large number of students, teachers, and institutions, ensuring that a blockchain solution can handle the required volume of transactions can be a challenge.
- Interoperability: Integrating blockchain solutions with existing educational systems and technologies can be complex due to interoperability issues. Ensuring that different blockchain platforms and educational software can work together seamlessly is a challenge that needs to be addressed.

- Data Privacy and Security: While blockchain is inherently secure due to its cryptographic nature, there can still be concerns about the privacy of student data. Sensitive information stored on a blockchain could potentially be accessed by unauthorized parties if proper security measures are not in place.
- Regulatory and Legal Challenges: The use of blockchain in education may raise legal and regulatory issues related to data ownership, intellectual property rights, and compliance with data protection laws. Institutions must ensure that their use of blockchain technology aligns with relevant regulations.
- Energy Consumption: Some blockchain networks, especially those that use proof-of-work consensus mechanisms (like Bitcoin), are criticized for their high energy consumption. This could raise concerns in educational settings, especially if environmental sustainability is a priority [3].
- Lack of Standards: While efforts are being made to establish standards for blockchain applications, there is still a lack of uniformity in terms of data formats, protocols, and interoperability. This lack of standards can hinder the widespread adoption of blockchain solutions in education.
- User Experience: Blockchain applications, especially those with cryptographic keys and wallet management, can be complex for non-technical users. If the user experience is not user-friendly, it could lead to frustration and resistance from educators and students.
- Cost and Resource Allocation: Implementing blockchain solutions can require significant financial investments in terms of development, infrastructure, and ongoing maintenance. Institutions need to carefully weigh the costs against the benefits [8].
- Perception and Acceptance: Introducing Blockchain technology in education might face resistance or scepticism from stakeholders who are unfamiliar with the technology or concerned about its potential disruptions.
- Reliance on Technology Providers: Educational institutions may need to rely on third-party technology providers for blockchain solutions, potentially leading to vendor lock-in and dependency.
- Changing Landscape: The technology landscape, including blockchain, is constantly evolving. The solution that seems promising today might become outdated or less relevant in a rapidly changing environment.

Addressing these concerns requires collaboration between educational institutions, technology providers, policymakers, and other stakeholders. Institutions should carefully evaluate the potential benefits and risks of implementing blockchain technology in education and develop strategies to mitigate challenges while maximizing the advantages.

The promises and potential benefits of introducing blockchain applications in education are significant and encompass various aspects of the educational ecosystem. Some of the key promises include:

- **Transparency and Trust:** Blockchain's decentralized and tamper-proof nature ensures transparency in educational processes. This can lead to increased trust among stakeholders, such as students, employers, and institutions, as they can independently verify credentials and records.
- **Secure Credential Verification:** Blockchain-based digital credentials provide a secure and reliable way to verify educational achievements, reducing the risk of fraudulent claims and enhancing the credibility of qualifications.
- **Data Integrity and Security:** Blockchain ensures the integrity and security of data by making records immutable and protected through cryptographic techniques. This is crucial for safeguarding sensitive student information.
- **Efficient Verification Processes:** Verifying educational records traditionally involves time-consuming processes. With blockchain, verification can be streamlined, reducing administrative burdens and saving time and resources.
- **Reduced Costs:** By eliminating intermediaries and automating processes through smart contracts, blockchain can potentially lower administrative costs associated with tasks like record-keeping, verification, and payments.
- **Decentralized Learning:** Blockchain can support the creation of decentralized learning platforms that empower learners and educators to collaborate and share content directly, without the need for centralized intermediaries.
- **Portable Credentials:** Digital credentials on a blockchain are portable and can be accessed by students whenever needed. This makes it easier for individuals to showcase their qualifications to potential employers or educational institutions.
- **Lifelong Learning and Micro credentials:** Blockchain enables the issuance and recognition of micro credentials and badges for specific skills or achievements, encouraging continuous learning and skill development.

- **Global Recognition:** Blockchain's standardized and interoperable nature could lead to increased recognition of credentials across international borders, facilitating credit transfer and enhancing educational mobility.
- **Smart Contracts for Automation:** Smart contracts can automate various administrative processes, from enrolment and fee payments to course registrations. This reduces manual intervention and increases accuracy.
- **Innovation and Research:** Blockchain can foster innovation in educational practices and research collaboration by providing a secure and transparent platform for sharing ideas, findings, and resources.
- **Data Ownership and Privacy:** Blockchain enables individuals to have more control over their data, granting access only to those who are authorized. This aligns with principles of data ownership and privacy.
- **Verification of Open Educational Resources (OER):** Blockchain can ensure the authenticity and provenance of open educational resources, fostering trust and encouraging their adoption.
- **Digital Identity:** Blockchain can be used to create secure digital identities for students, enabling them to manage and share their educational records and achievements more effectively.
- **Credential Portability:** Students can maintain a lifelong record of their academic achievements and skills, which can be accessed, verified, and shared as needed throughout their careers [1].
- **Reduced Credential Fraud:** The immutability of blockchain records reduces the risk of credential fraud and misrepresentation.

It's important to note that while these promises are compelling, implementing blockchain in education requires careful planning, collaboration, and consideration of potential challenges. The technology is not a one-size-fits-all solution and needs to be adapted to the specific needs of educational institutions and the broader ecosystem.

5. Challenges with an introduction of blockchain applications in education

- Introducing blockchain applications in education comes with several challenges that need to be carefully addressed to ensure successful implementation and adoption. Some of the main challenges include:
- Technical Complexity: Blockchain technology is complex and requires specialized technical knowledge to develop, implement, and maintain. Educational institutions may struggle to find or afford the expertise necessary to build and manage blockchain-based systems [10].
- Scalability: As educational systems involve a large number of students, teachers, and transactions, scalability can be an issue. Ensuring that the blockchain network can handle a high volume of transactions without compromising performance is a significant challenge.
- Interoperability: Integrating blockchain solutions with existing educational systems and technologies can be challenging due to interoperability issues. Ensuring seamless communication between different platforms and data formats is crucial for a smooth user experience.
- Data Privacy and Security: While blockchain is secure by design, the implementation and management of the technology must prioritize data privacy. Unauthorized access to student data could have serious consequences, so robust security measures are essential.
- Regulatory and Legal Compliance: The use of blockchain in education may raise legal and regulatory concerns related to data ownership, intellectual property rights, and compliance with data protection laws. Ensuring that the implementation aligns with relevant regulations is essential [2].
- Adoption and Training: Introducing blockchain technology requires training educators, administrators, and other stakeholders to understand how to use the technology effectively. Resistance to change and lack of familiarity with the technology can hinder adoption.
- Costs and Resources: Implementing and maintaining blockchain solutions can be costly, involving expenses related to development, infrastructure, security, and ongoing maintenance. Budget constraints might impact an institution's ability to invest in these solutions.
- Energy Consumption: Some blockchain networks, especially those using proof-of-work consensus mechanisms, can be energy-intensive. This might raise concerns about environmental sustainability, particularly if the technology's carbon footprint is significant.
- User Experience: Blockchain applications, especially those involving cryptographic keys and wallets, can be challenging for non-technical users. Ensuring a user-friendly interface and experience is crucial for adoption.
- Lack of Standards: The lack of standardized protocols and data formats can lead to compatibility issues and hinder the interoperability of blockchain applications in education.
- Resistance to Change: Educational institutions can be resistant to adopting new technologies, especially when the benefits are not immediately apparent or when the technology disrupts existing processes [11].
- Vendor Lock-In: Institutions that rely on third-party technology providers for blockchain solutions may face the risk of vendor lock-in, where they become dependent on a single provider's ecosystem [12].

- Sustainability and Longevity: Blockchain technology is rapidly evolving, and the long-term sustainability and viability of specific blockchain platforms need to be carefully considered. Implementing a solution that becomes obsolete can lead to wasted resources [17].
- Cultural Shift: Embracing blockchain technology might require a cultural shift within educational institutions, involving changes in mind set, organizational structure, and practices.
- Educational Equity: The introduction of blockchain technology should not exacerbate existing disparities in education access and quality. Ensuring that all students have equal access to blockchain-enabled resources is essential.

Addressing these challenges requires a collaborative effort among educational institutions, technology providers, policymakers, and other stakeholders. Institutions should conduct thorough assessments of their needs and capabilities before embarking on blockchain initiatives, considering both the potential benefits and potential obstacles [13].

6. Perspective of researchers for introducing blockchain in education

Researchers have shown a growing interest in the potential of introducing blockchain technology in education. Their perspectives often emphasize both the opportunities and challenges that come with integrating blockchain into educational systems. Here are some key points from the perspective of researchers:

6.1. Opportunities

- Transparency and Authenticity: Researchers recognize the potential of blockchain to enhance transparency and authenticity in educational credentials. This could reduce instances of credential fraud and provide a more reliable way to verify qualifications.
- Decentralization: Blockchain's decentralized nature aligns with the principles of open education. Researchers see potential in creating peer-to-peer educational platforms that reduce reliance on traditional intermediaries.
- Micro credentialing and Lifelong Learning: Blockchain can support the issuance of micro credentials, allowing learners to showcase specific skills. Researchers believe this could incentivize lifelong learning and help individuals adapt to rapidly changing job markets [8].
- Data Ownership and Privacy: The concept of self-sovereign identity, where individuals have control over their own data, aligns with privacy concerns. Researchers see blockchain as a potential solution to empower individuals with control over their educational records [14].
- Global Recognition: Blockchain's potential for creating standardized and interoperable systems has the potential to facilitate global recognition of credentials, making education more accessible across borders.

7. Challenges of Block chain in Education

- Technical Complexity: Researchers acknowledge that blockchain implementation requires specialized technical expertise. They emphasize the need for collaboration between educational experts and technologists.
- Scalability and Performance: The scalability of blockchain networks remains a concern, especially when applied to large educational systems with numerous transactions. Researchers discuss the need for solutions that can handle high transaction volumes without sacrificing performance [20].
- Interoperability: Researchers point out the challenge of integrating blockchain with existing educational systems. Ensuring compatibility and seamless data exchange between different platforms is a significant concern.
- Ethical and Social Implications: As blockchain stores sensitive data, researchers highlight ethical concerns related to data privacy, consent, and the potential for discrimination based on immutable records.
- Regulation and Legal Issues: Researchers caution that regulatory frameworks need to be updated to accommodate the unique attributes of blockchain in education, including data ownership and verification processes.
- Adoption and Resistance: Researchers note that the adoption of blockchain technology might face resistance due to lack of awareness, misconceptions, and institutional inertia. Overcoming these challenges requires effective communication and education [15].
- Cost and Resources: The initial costs associated with implementing blockchain solutions can be substantial. Researchers discuss the importance of considering the long-term return on investment and cost-effectiveness.
- Standardization: Researchers emphasize the need for standardization efforts to ensure interoperability, data portability, and the successful scaling of blockchain solutions in education [21].

- User Experience: User-friendly interfaces and intuitive design are crucial for the successful adoption of blockchain applications in education. Researchers stress the importance of minimizing the complexity for end users.
- Environmental Impact: Researchers discuss concerns about the energy consumption of certain blockchain networks and emphasize the importance of considering more energy-efficient consensus mechanisms.

In essence, researchers acknowledge the transformative potential of blockchain in education while highlighting the complexities that need to be navigated. They emphasize the need for interdisciplinary collaboration, careful planning, and continuous assessment to ensure that blockchain implementations align with educational goals and values [16].

8. Conclusion

In the current study, we assessed how Blockchain and digital technologies function in the current education sector. Although this technology offers a more dependable and safe platform for online learning, authors noted that it still leaves signs of potential threat regions and weak points where a constant improvisation and enhancement model is required. The emergence of Blockchain in the business, educational, and financial transaction management sectors is acknowledged by the authors, who anticipate further expansion of the non-traditional transaction system. For better results, blockchain in the education sector still need numerous inputs.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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