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Challenges of Blockchain Technology and its Relationships to Sustainable Education: An Analysis using AI-Based Literature Review

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ABSTRACT

Blockchain technology is known for its features like immutability, transparency, decentralisation and security, which can enhance trust, create transparency and promote accountability in educational systems. This study explores the relationship between blockchain technology and sustainable education, focusing on the challenges and benefits of integrating blockchain into educational systems. The research employs an AI-based literature review using Scite.AI to gather and analyse relevant articles, ensuring the selected literature directly addresses blockchain technology within the context of sustainable education. The study identifies significant challenges, such as organisational, technological and environmental factors, that must be addressed to leverage blockchain for sustainable educational advancements. The research highlights that integrating blockchain in education can support sustainable practices by ensuring secure credentialing, efficient resource allocation and fostering trust in digital learning environments. Additionally, blockchain technology can ease worldwide accreditation systems for teaching, learning, practice and business communication, ensuring data protection and transmission of student projects and evaluations. The study also points out the need for robust frameworks to address blockchain technology's technical, ethical and policy challenges in education. It proposes a new Relationship model between Blockchain technology and Sustainable Education. The findings suggest that while blockchain technology has the potential to revolutionise education by providing creative and environmentally responsible educational tools, its implementation faces several technological organisational and environmental challenges. Future research directions are suggested to address these gaps and challenges, aiming to develop effective strategies for integrating blockchain technology into sustainable education systems.

1. Introduction

Blockchain technology is a novel and disruptive innovation with the potential to revolutionise various industries. It is characterised by several desirable functional characteristics, including

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immutability, transparency, decentralisation and security [1]. Technology is heralded for improving trust, creating transparency and promoting accountability in various domains, including government activities [2].

Blockchain technology is a decentralised and encrypted digital ledger initially developed for Bitcoin cryptocurrency [3]. It is characterised by immutability, transparency and security [4]. Blockchain technology provides transparency, robustness, suitability and security, all inherent to the system [5]. It is an emerging, disruptive technology that solves centralised transaction system problems [6]. The technology inextricably binds elements such as immutability, transparency and anonymity, providing the blockchain with unique features that distinguish it from other distributed ledger technologies [7]. Blockchain technology changes the lifestyle of people and business views in many fields through its privacy and security [8]. It can act as a form of normative ordering expressing public or private objectives [9]. Additionally, when used appropriately, blockchain technology can reduce cybersecurity risks [10]. Overall, blockchain technology is a transformative innovation with the potential to revolutionise various industries and domains.

There has been a growing concern regarding the educational approach to sustainability for over twenty years. This method aims to develop values and motives for students to engage in sustainable activities for the present and the future [11]. Integrating sustainability education into higher business education is critical for developing sustainable firms because it gives students the knowledge and skills to comprehend and manage challenging sustainability issues in their future jobs. According to Bjelobaba *et al.,* [12], it assists students in developing a comprehensive grasp of sustainable development and its three pillars, which are economic, environmental and social perspectives. In addition, this education strongly emphasises the significance of research-based learning, technology-driven pedagogy and collaborative learning, which are very important for learning that continues throughout one's life and offers seamless chances for personal and professional development.

This study examines the problems and implications of implementing blockchain technology in higher education to make learning more sustainable and trustworthy. Based on the research question, "What is the relationship between blockchain technology and sustainable education? It proposes a model for how blockchain might be used to develop safe and decentralised educational platforms that improve collaboration among learners, educators and institutions. The study also identifies the primary barriers to implementing blockchains in education, such as a lack of understanding and faith in the technology, insufficient training and the complexity of establishing and adhering to new regulations and standards.

The methodology used for this study is an Artificial Intelligence (AI) based Literature Review using Scite.AI as a tool. AI-based literature review research methods involve machine learning and natural language processing (NLP) techniques to automate and enhance the process of analysing vast amounts of scholarly articles. AI tools can identify patterns, trends and significant findings across numerous studies, enabling researchers to perform systematic reviews more efficiently. These methods include text mining, sentiment analysis and topic modelling, which help categorise and summarise the content. Additionally, AI algorithms can assist in detecting research gaps and predicting future research directions, significantly improving the depth and scope of literature reviews

AI-based literature reviews on the challenges of blockchain technology and its relationship to sustainable education highlight several key insights. Blockchain technology, while promising to enhance transparency, security and decentralisation in educational systems, faces significant challenges such as scalability, high energy consumption and regulatory hurdles. AI-based literature reviews systematically identify and synthesise research findings, revealing that integrating blockchain in education can support sustainable practices by ensuring secure credentialing, efficient resource

allocation and fostering trust in digital learning environments. However, the literature also points out the need for robust frameworks to fully address the technical, ethical and policy challenges to leverage blockchain for sustainable educational advancements.

The paper opens with an introduction that outlines the central thesis and objectives of the research, setting the stage for a detailed exploration of the topic. It then progresses into a literature review, examining fundamental theories and previous studies to frame the research questions. The research background provides a deeper theoretical foundation, enhancing the understanding of the context and significance of the study. Results and findings are then detailed, thoroughly analysing the data and its implications. A proposed relationship model between Blockchain technology and Sustainable Education is presented. The paper concludes with a summary of the insights gained, their practical and theoretical contributions and suggestions for future research in the field.

2. Methodology

This study uses an AI based literature review. Conducting an AI-based literature review on the relationship between blockchain technology and sustainable education using Scite.AI involves several structured steps. Below is a detailed step-by-step guide illustrated in Figure 1.

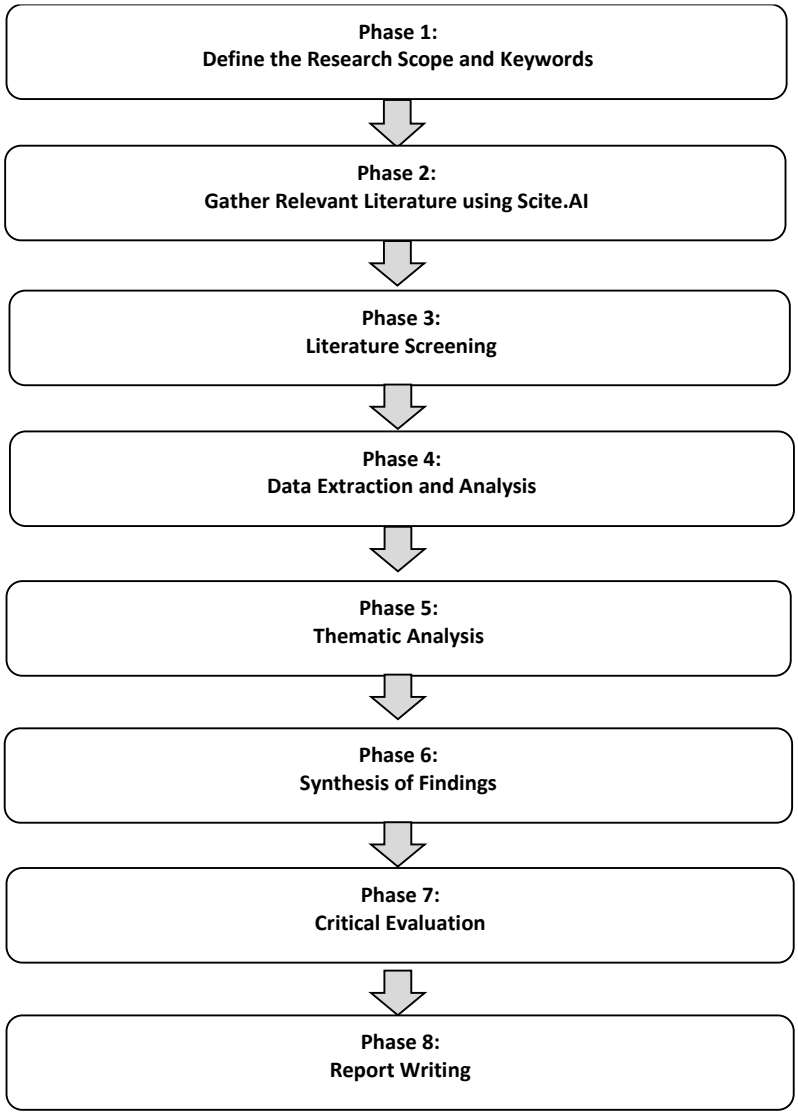

Fig. 1. AI-based literature review

2.1 Step 1: Define the Research Scope and Keywords

This study aims to explore the research question, "What is the relationship between blockchain technology and sustainable education?" Key terms and phrases central to this investigation include "blockchain technology," "sustainable education," "challenges," "decentralisation in education," "secure credentialing," and "digital learning environments."

2.2 Step 2: Gather Relevant Literature using Scite.AI

This study employs Scite.AI's search functionality to locate relevant articles and papers using the specified keywords. Then, leverage Scite.AI's innovative citations to evaluate how other studies support or challenge these articles, aiding in assessing their reliability and significance.

2.3 Step 3: Literature Screening

This study filters the search results to ensure the selected literature directly addresses blockchain technology within the context of sustainable education. Then, it analyses Scite.AI's innovative citations to swiftly grasp the context in which these articles have been cited, emphasizing those that are highly supported and pertinent to our research question.

2.4 Step 4: Data Extraction and Analysis

This study utilises Scite.AI to extract essential findings, methodologies and conclusions from the chosen articles, with particular attention to those discussing the challenges of blockchain technology and its applications in education. Subsequently, the context of citations provided by Scite.AI is analysed to comprehend how blockchain technology is perceived in sustainable education.

2.5 Step 5: Thematic Analysis

This study uses Scite.AI's citation context analysis to pinpoint recurring themes and patterns within the literature. Subsequently, the information is grouped into key areas, such as the challenges of blockchain technology, its benefits for sustainable education and implementation strategies.

2.6 Step 6: Synthesis of Findings

This study uses the extracted data to organise insights into a structured format, highlighting the relationship between blockchain technology and sustainable education. Subsequently, it compares findings from different studies to identify common challenges and proposed solutions for integrating blockchain in education.

2.7 Step 7: Critical Evaluation

This study assesses the credibility of the research using Scite.AI's citation analysis to determine the reliability of the findings. It then uses the citation context to identify gaps in the current study that require further investigation.

2.8 Step 8: Report Writing

This study utilises Scite.AI to draft a comprehensive literature review, ensuring all relevant themes and insights are well-documented. It then incorporates visual aids such as citation graphs and context maps provided by Scite.AI to illustrate critical findings and relationships.

The draft was submitted for peer review to obtain feedback and validation. Based on the input, necessary revisions and refinements were made to ensure clarity, coherence and completeness.

Lastly, the researcher summarises the key findings on the relationship between blockchain technology and sustainable education. Directions for future research are then suggested based on the identified gaps and challenges.

3. Results and Discussion

Below is the discussion of findings from the methodology chosen for this study. It is divided into three categories: challenges and critical success factors in applying Blockchain, Blockchain's relationship with sustainability education and recommendations for blockchain technology in education.

3.1 Challenges and Critical Success Factors in Applying Blockchain

The implementation of blockchain technology in the real world faces several challenges. One of the primary challenges is the limitation of technology access, which hinders the real-time information flow in supply chains [13]. Financial investment poses a significant challenge for organisations implementing blockchain technology [14]. Furthermore, market-based risk and external environmental factors, such as government regulations, hinder the adoption of blockchain technology [15]. Moreover, the lack of technological maturity and the stakeholders' opposing incentive mechanisms hinder blockchain technology implementation [16]. Privacy, data security and the need for transparency influence the adoption of blockchain technology [17]. The complexity of technology and the difficulty of understanding and implementing it in real-world settings are also significant challenges [18].

Furthermore, the unpredictability associated with time-sensitive and perishable items in supply chains creates further challenges to blockchain implementation [19]. Interoperability, ongoing market surveillance for safety and effectiveness and scalability and adaptability are barriers to blockchain adoption [20]. Finally, a comprehensive assessment of the risks and obstacles associated with blockchain deployment is critical for long-term success [21]. As a result, Table 1 summarises the three primary essential factors of success in deploying blockchain.

Table 1
Challenges in implementing blockchain technology

No.	Critical Success Factors	Issues Of Challenges	Authors
1	Organisational Factors	Lack of knowledge Lack of skills Lack of training Lack of technical expertise Lack of management vision	[3,13,17,19]
2	Technological Factors	Security and privacy vulnerabilities Data Transparency Interoperability Compatibility Cost-effectiveness Technology's complexity Resource constraints Scalability	[7,10,41,42,45]
3	Environmental Factors	Government regulations Regulatory issues Protocols Norms Sustainability Supply chain management	[13,17,20,24,25,36]

The table lists factors and issues that can pose challenges when implementing blockchain technology. Here is an explanation of the different factors and problems mentioned in the table:

i. Organisational Factors

- Lack of knowledge: Organisations may lack understanding or awareness of blockchain technology and its potential applications.
- Lack of skills: Organisations may not have the necessary skills or expertise to implement and manage blockchain systems.
- Lack of training: Organisations may not provide sufficient training opportunities for employees to learn about blockchain technology.
- Lack of technical expertise: Organisations may not have the technical knowledge required to develop and maintain blockchain systems.
- Lack of management vision: Organisations may lack a clear vision or strategy for implementing blockchain technology.

ii. Technological Factors

- Vulnerabilities regarding security and privacy: Blockchain systems may be vulnerable to security breaches or privacy problems.
- Data Transparency: Blockchain systems' transparency may present difficulties when preserving sensitive or confidential information.
- Interoperability: Integrating blockchain systems with pre-existing technologies or platforms may be challenging due to the interoperability of blockchain technology.
- Compatibility: It is possible that blockchain systems will not work with specific hardware and software combinations.
- Cost Effectiveness: Implementing and maintaining blockchain systems may incur significant costs.

- The intricacy of the technology: Blockchain technology can be challenging and requires specialised knowledge to implement and manage.
- Resource Constraints: Resource constraints can limit organisations' financial, human or infrastructure resources. Blockchain systems may experience difficulties scaling up to manage massive data or transactions.

iii. Environmental Factors

- Government regulations: Government regulations or policies may impact the implementation and use of blockchain technology.
- Regulatory issues: Regulatory frameworks or legal considerations may challenge the implementation of blockchain technology.
- Protocols: The protocols or standards used in blockchain systems may need to be aligned with industry or regulatory requirements.
- Norms: Existing norms or practices in the education sector may need to be adapted to accommodate blockchain technology.
- Sustainability: Ensuring blockchain systems' long-term sustainability and viability may be challenging.
- Supply chain management: Blockchain technology can be used to improve supply chain management, but implementing it may face challenges related to coordination and collaboration among different stakeholders.

The table highlights various factors and issues organisations may encounter when implementing blockchain technology in education. These challenges must be addressed to fully leverage blockchain's potential educational benefits.

3.2 Blockchain Relationship with Sustainability Education

Implementing blockchain technology in education can improve many educational system components [22]. Blockchain technology is a decentralised and secure database system. It can revolutionise higher education by boosting security, transparency and efficiency in procedures such as student records, credentials verification, payment processing and resource sharing [23]. These characteristics might completely change the way higher education is delivered. According to Altamimi *et al.,* [24], systems built on blockchain technology can offer new opportunities for collaboration and certification, thereby improving the educational experience for students.

Additionally, technology has the potential to handle concerns such as the preservation of copyright, the prevention of fraud and secure evaluations. Through blockchain technology, educational institutions can guarantee the genuineness of credentials, streamline the process of transferring academic records and allow individuals to possess verifiable records of their accomplishments in lifelong learning. In addition, educational ecosystems that are built on blockchain technology have the potential to encourage the sharing of academic resources, collaborative research and peer-to-peer learning, thereby creating an educational setting that is more inclusive and engages in student participation. However, obstacles need to be conquered, such as concerns regarding privacy, interoperability, technological implementation, scalability, cost-effectiveness and regulatory constraints [25].

According to a summary, blockchain technology promises to alter numerous parts of the education industry. These aspects include the authentication of credentials and the maintenance of educational records, intellectual property rights and collaborative educational platforms. Given its

more significant disruptive potential across various industries, its possible educational uses align with that promise. It is important to note that the relationship between blockchain technology and education about sustainability is complex and has the potential to advance the aims of sustainable development significantly. According to Kouhizadeh *et al.,* [26], the democratic nature of blockchain systems can contribute to promoting social sustainability by empowering individuals and regions with lower incomes. Furthermore, blockchain technology has the potential to play a crucial role in fostering sustainability in various industries, such as manufacturing, supply chain management and maritime transportation. This potential, in turn, can impact educational curricula and practices [27].

Incorporating blockchain technology into sustainability reporting and assurance gives a growing number of opportunities for educational programs and professionals, contributing to a more profound comprehension of the fundamentals of sustainability [28]. Furthermore, the potential of blockchain technology to shape sustainable global value chains is in line with the broader goals of sustainability education, which emphasises the significance of ethical and responsible corporate practices [29].

Blockchain technology can potentially create a revolutionary change in sustainable education by promoting openness, traceability and accountability within educational institutions and practices [30]. Personalised learning, secure credentialing and decentralised learning networks are examples of the creative and sustainable teaching and learning tools this technology can provide. Solutions based on blockchain technology can digitise the process of issuing and verifying certificates, which helps avoid the proliferation of bogus signatures and certificates. Furthermore, blockchain technology can ease working together, boost students' motivation and improve learning outcomes in higher learning institutions. The utilisation of blockchain technology by educational institutions has the potential to improve both the quality and accessibility of education, thereby contributing to the achievement of Goal 4 of the Sustainable Development Goals (SDGs), which is titled "Quality Education" [31]. In addition, the potential of blockchain technology to accomplish the Sustainable Development Goals (SDGs) in the field of education and to provide assistance to underserved areas is yet largely unexplored, which presents prospects for additional research and implementation [21].

In general, blockchain technology has the potential to revolutionise education by delivering safe and transparent systems and supporting teaching and learning methods that are environmentally responsible. As a result, the connection between blockchain technology and teaching sustainability holds the potential to cultivate environmental stewardship, social equality and economic resilience within educational systems and beyond. The hypothetical relationship model between blockchain technology and sustainable education is depicted in Figure 2.

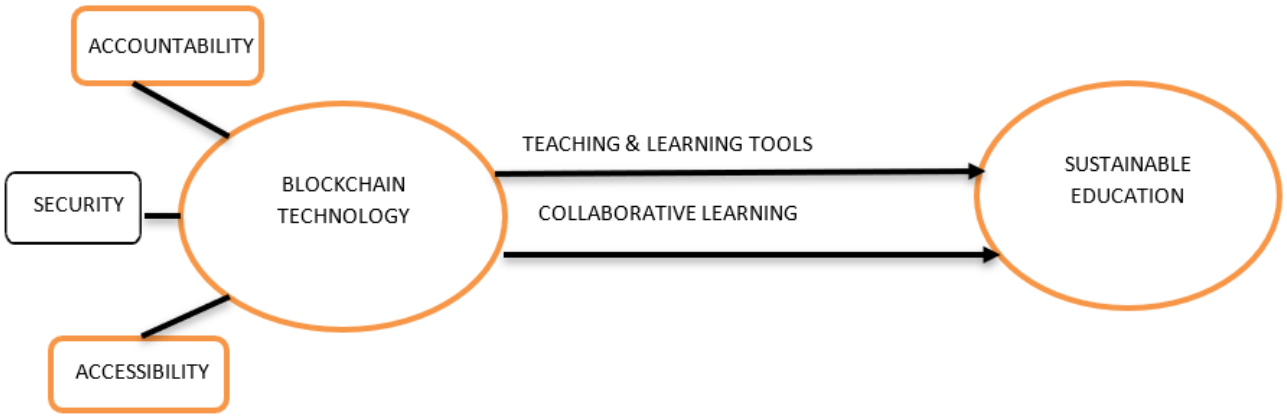

Fig. 2. Relationship model between blockchain technology and sustainable education

Figure 2 is a conceptual model illustrating the relationship between blockchain technology and sustainable education. It highlights how blockchain can enhance various aspects of education through its inherent features and influences to contribute to Sustainable Education. Blockchain Technology is connected to three attributes: Accountability, Security and Accessibility. Moreover, Blockchain Technology influences Teaching and Learning Tools and Collaborative Learning. Essential results and conclusions that can be drawn from the figure:

i. Blockchain's accountability, security and accessibility can improve educational tools and collaboration.
ii. Enhancements in these areas are likely to support the sustainability of educational practices.

The education sector can benefit from blockchain technology's many teaching and learning opportunities. Personalised learning experiences, secure credentialing and decentralised learning networks can be accomplished using artificial intelligence and blockchain technologies [23]. The creation of gamification teaching applications that imitate blockchain activities is another example. These applications allow students to experiment with blockchain concepts and operations [32]. Students can gain a better knowledge of blockchain principles and practical experience through the use of modular learning tools that are already accessible. These tools incorporate blockchain components into computer science courses, thereby allowing students to gain hands-on experience.

Additionally, the use of blockchain technology has the potential to ease worldwide accreditation systems for teaching, learning, practice and business communication. This utilisation guarantees data protection and transmission of student projects and evaluations [12]. Through the provision of creative and environmentally responsible educational tools, these examples illustrate how blockchain technology can potentially improve individuals' teaching and learning experiences.

Blockchain technology can facilitate collaborative learning initiatives by implementing decentralised networks, protecting data privacy and guaranteeing honest computation. Consequently, this indicates that blockchain technology has the potential to encourage students to participate actively in their learning and to allow cooperation among students, which ultimately results in improved learning outcomes. Blockchain-based Collaborative Learning and Student Work Evaluation (CLSW) models are one way that can be used. These models use blockchain technology to safeguard the storage and transmission of data about student projects and assessments [12]. Another approach is implementing a decentralised collaborative learning network built on blockchain technology. This approach overcomes trust and security concerns associated with Federated Learning [33]. In addition, the Swarm Learning (SL) architecture, founded on blockchain technology, allows authenticated training nodes to share gradients, hence protecting data privacy and minimising gradient leakage [34]. In addition, the TrusCL framework combines homomorphic encryption and differential privacy to protect individual privacy and provide trusted computations in collaborative learning [35]. By utilising blockchain technology, these best practices make it possible to engage in cooperative learning that is both secure and efficient. The specifics of the components that make up the proposed model are shown in Figure 1. By taking Blockchain technology as an example, there are three characteristics that this technology possesses: accountability, security and accessibility.

3.2.1 Accountability

Lai *et al.,* [36] highlighted that blockchain technology can facilitate accountability by its fundamental characteristics, which include decentralisation, traceability and transparency. Tyma *et al.,* [37] on the other hand discussed that these characteristics make it possible to establish a reliable

and tamper-resistant system where participants can work honestly and enhance the quality of services. The fact that blockchain is decentralised makes it impossible for a single entity to influence the system. It makes the system less likely to be manipulated or fraudulently used. According to Graf *et al.,* [38] research from 2020, the traceability of blockchain technology enables the recording and tracking of all transactions, making it feasible to identify responsible parties and maintain accountability for them. Furthermore, the openness of blockchain technology guarantees that all participants have access to the same information, which in turn promotes fairness and trust in the system [39]. Considering everything, these characteristics of blockchain technology offer a solid basis for accountability in various applications and industries.

3.2.2 Security

Sehar *et al.,* [40] further emphasize that blockchain technology creates the possibility of security by its essential characteristics, which include non-repudiation, authenticity, immutability, integrity and confidentiality. It offers a decentralised framework that uses encryption to protect data and guarantee the authenticity of transactions [41]. A blockchain is immutable because it is composed of a chain of blocks. Any change made to a single block would require changes to be made to all blocks that follow it. It makes it difficult to manipulate the data contained inside the blockchain. Based on Preethi *et al.,* [42] findings, blockchain technology also provides decentralisation, dependability, efficiency and anonymity, which are essential for safe communication in various industries, including healthcare. Furthermore, blockchain technology can utilise biometric systems and authentication methods to improve security and access management. Because of these characteristics, blockchain technology is a promising option for securing data against intrusion by malicious actors, maintaining privacy and assuring secure transactions across various businesses.

3.2.3 Accessibility

Blockchain technology enables accessibility through its key features, such as decentralisation, immutability, audibility and trustlessness. The decentralised nature of blockchain eliminates the need for a central authority, allowing for a distributed network where transactions can be recorded and verified by multiple participants [43]. The immutability of blockchain ensures that once a transaction is recorded, it cannot be altered or tampered with, providing high data integrity and security [44]. The audibility of blockchain allows for transparent and traceable transactions, making it easier to verify and track the flow of information. Lastly, the trustlessness of blockchain eliminates the need for trust between parties, as the technology ensures the validity and accuracy of transactions, reducing the risk of fraud or manipulation [45]. These features make blockchain technology accessible and reliable for various applications, including healthcare, data management and access control systems.

3.3 Recommendation for Blockchain Technology in Education

Regarding the education sector, blockchain technology involves various domains, each of which has the potential to alter educational procedures and systems in its unique way. The following are some of the applications that are suggested for use in educational settings by this study:

3.3.1 Credential verification and issuance

Using blockchain technology to issue and validate academic credentials safely is possible. These credentials include degrees, diplomas and certificates. By storing these credentials on a blockchain, educational institutions can verify their legitimacy and prevent fraudulent acts from occurring. Furthermore, using blockchain technology for credentialing can streamline the verification process, enhancing its efficiency and reliability [46-48].

3.3.2 Academic research and intellectual property

Blockchain technology can manage intellectual property rights, copyrights and patents related to academic research. Through blockchain-based systems, educational institutions can build transparent and traceable procedures for recording and preserving intellectual property [49]. It will contribute to the promotion of innovation and collaboration in academic research. Additional empirical research is needed to investigate the influence and effectiveness of blockchain systems in the educational sector. In the context of educational and academic research forums, it is essential to bring attention to the limited number of publications and discussions that have been conducted on this topic [50].

3.3.3 Financial transactions and scholarships

Blockchain technology can potentially simplify various financial transactions within the education sector. These transactions include the payment of tuition, the distribution of scholarships and the distribution of financial aid. According to Alsaadi *et al.,* [51], implementing financial systems based on blockchain technology can improve transparency, save money on transaction costs and lower the risk of fraud in educational institutions' financial operations. Additionally, the properties of blockchain technology improve the system's integrity, security and fairness, which in turn results in an increase in the confidence of donors and an improvement in the management practices of scholarship programs [52].

3.3.4 Collaborative educational platforms

Blockchain technology has the potential to serve as the foundation for the construction of decentralised and secure educational platforms. It would make it possible for students, educators and institutions to collaborate transparently and trustless. Consistent with Guustaaf *et al.,* [53] and Iyer *et al.,* [54], educational ecosystems based on blockchain technology can encourage sharing academic resources, collaborative research and peer-to-peer learning, creating an academic environment that promotes participation and inclusion. Additionally, blockchain technology has applications that extend beyond the purview of the educational sector. Blockchain technology has the potential to facilitate the incorporation of student work evaluations into the process of professional development, which would be of great benefit to students. Ensuring assessments and projects are easily accessible to prospective employers provides them with valuable insights into the students' practical skills and the feedback they have gotten from other individuals [55].

3.3.5 Lifelong learning records

The technology behind blockchain makes it possible to create digital portfolios that accurately capture the accomplishments of an individual throughout their lifetime, whether they are formal or informal lifelong learners. This technique makes it easier to continue learning throughout one's life and to develop in one's career by guaranteeing that educational records can be easily transferred, verified and accessed. The problem of cold-start, encountered by learning data analytic systems, can be solved using blockchain technology. According to Ocheja *et al.,* [56], this challenge emerges when the system tries to give individualised experiences to new learners. Following Huang *et al.,* [57], blockchain technology would end the absence of privacy protection and the ease with which single-point attacks might occur. The development of the continuing education sector would be significantly slowed down due to this.

These sectors offer a multitude of opportunities for the implementation of blockchain technology in the educational sector, which has the potential to enhance the efficiency, transparency and safety of educational processes and systems. There is a lack of understanding and faith in the technology because Blockchain is still in its infancy in education [58-60]. There are various modifications in the implementation of blockchain technology in education, as listed below:

i. Defining standardised rules and protocols for utilising blockchain technology in education poses challenges due to its nascent state of development.
ii. Encouraging educational institutions and businesses to embrace blockchain technology to verify credentials poses a significant challenge.
iii. Many educational institutions may be reluctant to use blockchain technology due to their lack of understanding and faith in it, stemming from limited knowledge and skillset in managing data inside a blockchain network.
iv. Stakeholders in the education sector lack awareness, training and understanding of blockchain technology's benefits and use.
v. Senior management's lack of awareness and active participation can impede an organisation's readiness to use blockchain technology.

4. Conclusion

The technology known as blockchain can completely transform the educational system by making it more accessible, effective and secure. Personalised learning, secure credentialing and decentralised learning networks are some benefits they provide. Through the utilisation of blockchain technology, educational institutions can deliver education that is both accessible and inexpensive on a worldwide scale, thereby conforming to the principles of public blockchains. Blockchain-based solutions can potentially digitise issuing and verifying certificates, prohibiting the creation of fraudulent signatures and certificates. A further benefit of blockchain technology is that it can enhance collaborative work and students' motivation, resulting in improved learning outcomes. The application of blockchain technology in education is still in its infancy and additional empirical research is required to understand its full potential better. Nevertheless, blockchain technology can potentially contribute to sustainable education development in the Fourth Industrial Revolution era.

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