BLOCKCHAIN TECHNOLOGY'S POTENTIAL IN SPECIAL EDUCATION RECORDS MANAGEMENT: A THEMATIC ANALYSIS

by

KALEIGH M. KENDRICK

B.A, Reinhardt College, 2008
M.S., University of West Georgia, 2016

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Blockchain technology's potential in special education records management: a thematic analysis

Kaleigh Kendrick, *Middle Georgia State University, kaleigh.kendrick@mga.edu*

Abstract

In the years since its introduction, blockchain technology has been explored as a potential solution to a variety of problems across numerous industries; however, none of the existing literature specifically examines the potential of blockchain for special education records management. This paper is a systematic literature review of blockchain applications for records management in education and healthcare. A thematic analysis was conducted on the relevant literature with the goal of identifying common challenges in both fields. Areas for future research are suggested.

Keywords: blockchain, special education, education, academic records, healthcare, electronic medical records, electronic health records, Individualized Education Plans

Introduction

According to the National Center for Education Statistics, approximately 15 percent of all students enrolled in public schools in the United States—7.3 million students between the ages of 3 and 21—received services via an Individualized Education Plan (IEP) during the 2021 – 2022 academic year (National Center for Education Statistics, 2023). Students with disabilities and their caregivers face challenges related to both educational and medical records when securing and receiving services via an IEP. The records collected to secure a child's eligibility and establish, implement, and maintain services include extensive personal identifying information (PII), sensitive records related to mental and physical health, and a variety of educational records that pose concerns for privacy, data protection, and compliance. This research was inspired by my experience securing, establishing, and implementing services for my kindergartener. The ongoing maintenance of their IEP is a daily reminder of the need for a better way to manage special education records. It is my dearest hope that this paper contributes to improving this process for the millions of students and their adults who navigate it as a part of their educational journey.

Individualized Education Plans are governed by the Individuals with Disabilities Education Act (IDEA). This federal law, originally known as the Education for All Handicapped Children Act, was established in 1975 and requires public schools to provide free and appropriate public education (FAPE) in the least restrictive environment (LRE) to children with disabilities who qualify under one or more of several eligibility categories (US Department of Education, n.d.). One of the most unique aspects of IEPs is that "while the law tells us what information must be included in the IEP, it does not specify what the IEP should look like. No one form or approach or appearance is required or even suggested" (Office of Special Education and Rehabilitative Services, 2000).

In the field of education, blockchain technology offers exciting opportunities "to address the challenging data sharing and transparency issues faced by institutions, schools, and students" (US Department of Education, 2019). The Department of Education and the American Council on Education both recognize the potential for blockchain to revolutionize education and have established a partnership known as the Education Blockchain Initiative (EBI). Through EBI, both organizations hope to learn "how blockchain technology can facilitate the secure, traceable, and verifiable exchange of…data among institutions" (US Department of Education, 2022). Individualized Education Plans are noticeably absent from their proposed use cases and stand apart as a unique opportunity to address challenges related to record keeping for both educational and healthcare records.

Blockchain technology is a type of digital ledger technology (DLT) comprised of blocks, distributed across a network, and popularized by the development of Bitcoin and subsequent cryptocurrencies in the early 2000s. Transactions on a blockchain are shared and synchronized across the network, eliminating the need for central authority, and providing unprecedented transparency. Each block contains a header comprised of metadata—except in the instance of the initial block in the chain, called a genesis block—and a cryptographic hash to the previous block. Each block's body contains zero to many transactions validated by consensus protocol. Users digitally sign their transactions by utilizing public and private keys. Blockchain technology is inherently fault-tolerant—if one block fails, the other blocks contain a complete copy of the data. Data in the blockchain is also immutable (append-only), "which allows for modifications to working data while providing a full history of changes" (Yaga, Mell, Roby, & Scarfone, 2018, p. 64).

Problem statement

With the current model of records collection, schools serve as the central authority and repository for records related to Individualized Education Plans. This creates problems with transparency, trust, and security concerns. Data breaches of centralized digital records systems are quite common. The US Government Accountability Office reported ninety-nine data breaches for K12 student data between July 2016 and May 2020. Special education records were involved in 58% of these breaches (US Government Accountability Office, 2020).

Purpose of the study

While extensive research on blockchain technology's usability in education and healthcare exists, research related to the use of blockchain to manage records and transactions for Individualized Education Plans is absent from the current literature. Therefore, the purpose of this study is to examine existing literature related to blockchain technology in education and healthcare records management and find key themes and issues to identify opportunities for future research.

Consistent with the purpose of this study, the following research question is posed:

Research question

RQ: What themes can be identified in existing literature related to the potential of blockchain technology for use in special education records management?

Research objective

The objective of this paper is to identify obstacles and challenges to blockchain adoption for use in special education services. Overall, this paper will add to the existing literature by identifying gaps and areas for future research in blockchain technology's application to IEPs, education, and healthcare records management. By addressing these challenges and leveraging the potential benefits, future research can be conducted to further explore blockchain's potential to provide secure, transparent, and efficient services for students with disabilities and improve data management practices across multiple industries.

Review of the Literature

A preliminary review of the literature was conducted in 2023 with the goal of exploring the existing knowledge relating to blockchain and records management in the fields of education and healthcare. The key findings from this initial research are summarized below.

Benefits of implementing blockchain

The potential benefits of blockchain technology in the education sector are vast. It promotes accountability and transparency by ensuring the immutability of student data, including grades, degrees, and certifications. Through verifying and sharing proofs, blockchain preserves the validity and permanence of these credentials (Loukil, Abed, & Boukadi, 2021), even in the face of institutional closures or disruptions (Chinnasamy, et al., 2023). Moreover, blockchain streamlines the certification process by eliminating intermediaries and enabling direct verification, leading to cost reduction (Chinnasamy, et al., 2023). Importantly, blockchain technology enhances access control over education records while empowering students to maintain control over their own data (Loukil, Abed, & Boukadi, 2021).

Similarly, in the healthcare sector, blockchain technology has the potential to revolutionize the industry. It offers benefits such as enhanced information accessibility, increased patient privacy, and accelerated innovation (Javed, Tahir, Aabid, Danish, & Zanib, Rida, 2021). Healthcare organizations leveraging blockchain can establish transparency, reinforce privacy measures, and ensure data integrity (Alzahrani, Diam, & Choo, 2023). By enabling the efficient sharing of medical information, blockchain contributes to cost reduction and improved operational efficiency. Furthermore, giving patients greater control over their personal healthcare information (PHI) empowers them to make informed decisions regarding their health (Alzahrani, Diam, & Choo, 2023). The immutability inherent in blockchain technology guarantees data integrity and traceability, facilitating error detection without labor-intensive manual processes. Additionally, the adoption of blockchain technology eliminates the need for backup services and optimizes the utilization of advanced technologies like big data analytics and artificial intelligence (Alzahrani, Diam, & Choo, 2023).

Researchers have made significant advancements to address the limitations of existing blockchain systems. These advancements focus on improving processing speed, developing lightweight consensus mechanisms, reducing storage costs, and minimizing communication bandwidth requirements (Li & Wu, 2022). These efforts contribute to the continuous evolution of blockchain technology and its potential applications in various sectors.

Challenges for blockchain implementation

The implementation of blockchain technology in the education sector entails multiple challenges that must be addressed. These challenges include the need for organizational process changes, seamless integration with existing systems, compliance with regulatory requirements, limitations regarding immutability, and concerns regarding scalability. These obstacles emphasize the importance of careful planning, coordination, and adaptation within educational institutions when adopting blockchain technology.

Although the potential advantages of incorporating blockchain technology are significant in healthcare, the adoption rate remains low, and many blockchain projects face failures or fall short of expectations (Alzahrani, Diam, & Choo, 2023). These shortcomings can be attributed to several factors, including the immaturity of the technology, scalability concerns, inherent business challenges, and a general lack of understanding about blockchain. Barriers to implementing blockchain in the healthcare sector also include skill gaps, regulatory limitations, lack of support from key executives, uncertainty regarding return on

investment (ROI), and challenges related to interoperability (Javed, Tahir, Aabid, Danish, & Zanib, Rida, 2021).

Despite recent advancements in blockchain technologies, several key challenges hinder the widespread adoption of blockchain technology across sectors. These challenges include technological limitations, concerns about data privacy, constraints associated with consensus mechanisms, and the need to strike a balance between decentralization, security, and scalability (Li & Wu, 2022).

Additionally, regulatory compliance poses challenges, particularly regarding the General Data Protection Regulation (GDPR). Bahalul Haque et al. (2021) highlight the insufficient discussion surrounding the integration of blockchain and data protection regulations. They emphasize the need for technical solutions that can meet GDPR requirements. The authors identify several challenges that these solutions face, such as the potential conflict between the immutability of blockchain and the right to be forgotten, identifying data controllers and processors in a decentralized blockchain network, compliance issues related to privacy and protection by design, managing user content without fixed controllers or processors, the automatic data processing nature of blockchain, and the challenges associated with controlling data storage outside the European Union (EU) in public blockchains.

Research frameworks for blockchain case studies

The need for structured and comprehensive blockchain case studies is emphasized by Treiblmaier (2019), who argues that the existing literature primarily consists of anecdotal accounts lacking a defined structure. The objective of his research is to provide recommendations for transforming anecdotal evidence into systematic knowledge by following the principles of academic case study research. Through a review of current blockchain case studies, Treiblmaier exposes the fragmented nature of the literature, with only a few studies adhering to recommended case study procedures, and exploratory case studies outnumbering descriptive ones.

Treiblmaier (2019) identifies numerous challenges that hinder the adoption of blockchain technology. These challenges include throughput, latency, size and bandwidth constraints, resource wastage, usability versioning, hard forks, multiple chains, evidentiary quality, trustworthiness of records, lack of standards, regulatory concerns (including the General Data Privacy Regulation, GDPR), shared governance, building a viable ecosystem, and addressing potential attack surfaces.

To address the limitations of existing literature and facilitate the development of more rigorous future case studies, Treiblmaier (2019) proposes a comprehensive case study checklist. This checklist encompasses key sections, including an abstract, introduction, methodology, results, discussion, and funding disclosure. The implementation of Treiblmaier's proposed framework will empower researchers to elevate the quality, coherence, and replicability of future case studies. It establishes a robust foundation for further research and industry recommendations.

Methodology

Systematic literature review

I conducted a systematic literature review using the methodology outlined by Loukil, Abed, & Boukadi (2021). Papers from relevant scientific databases and search engines, specifically IEEE Xplore and ACM Digital Library, were gathered. The search was conducted in February 2024.

To begin, I searched for articles with abstracts that included the keywords “blockchain” AND “education” OR “healthcare”. This initial search yielded 1,670 results in IEEE Xplore and 208 results in ACM Digital Library—a total of 1,878 results. I decided to split my search into two different searches: one specific to

healthcare and the other specific to education. Splitting the search enabled me to review the results more quickly. In IEEE Xplore, these searches yielded 1,351 results for healthcare and 378 results for education. In ACM Digital Library, these search queries yielded 105 results for healthcare and 113 for education.

By adding additional terms to my query strings ("electronic medical records", "electronic health records", and "personal health records" for healthcare and "academic records" for education), I was able to yield results that pertained specifically to records management—the object of my inquiry. This quickly reduced the results to 63 for healthcare and seven for education in IEEE Xplore and 66 for healthcare and one for education in ACM Digital Library—129 total results for healthcare and eight for education. Table 1 outlines the query strings used for each scientific database.

Table 1: Search in Databases

Scientific database	Query strings
IEEE Xplore	("Abstract":blockchain) AND ("Abstract":healthcare AND "Abstract":"electronic medical records")
	("Abstract":blockchain) AND ("Abstract":healthcare AND "Abstract":"electronic health records")
	("Abstract":blockchain) AND ("Abstract":healthcare AND "Abstract":"personal health record")
	("Abstract":blockchain) AND ("Abstract":education AND "Abstract":"academic records")
ACM Digital Library	[Abstract: blockchain] AND [Abstract: healthcare] AND [Abstract: "electronic medical records"]
	[Abstract: blockchain] AND [Abstract: healthcare] AND [Abstract: "electronic health records"]
	[Abstract: blockchain] AND [Abstract: healthcare] AND [Abstract: "personal health record"]
	[Abstract: blockchain] AND [Abstract: education] AND [Abstract: "academic records"]

After completing the initial search, I added the criteria, "Journal only" in IEEE Xplore and "Research article" in ACM Digital Library. This reduced healthcare results in IEEE Xplore to 14 and education results to just one. In ACM Digital Library, the criteria did not further reduce results. I also identified eight duplicate articles. Altogether, I excluded 1,714 publications for review from IEEE Xplore and 151 from ACM Digital Library; 74 publications were selected for further screening.

At this stage, inclusion and exclusion criteria were applied. Because blockchain is an emerging technology and the research related to it is current there was no need to exclude results based on publication date. First, I reviewed the article abstracts to ensure that the article specifically related to either academic or medical records. This eliminated nine additional records which only mentioned healthcare or education in the context of listing various industries which currently leverage blockchain in some capacity. One article was excluded because it included a statement of concern from the publisher asking that the article be excluded from research while an investigation is conducted about the validity of the paper's peer review process. Finally, I excluded papers that consisted solely of proposed solutions to specific use cases—conceptual frameworks, proposed systems, etc. After applying this exclusion criteria, fourteen articles were selected as relevant papers for inclusion in this study.

Table 2: Relevant Papers

Title	Authors (Year)	Database
Understanding the Use of Blockchain in Medical Data Security: A Systematic Literature Review	(Gunawan, Putra, Susant, Saputr, & Rizal, 2022)	ACM Digital Library
Blockchain: a panacea for electronic health records?	(Kassab, DeFranco, Malas, Neto, & Destefanis, 2019)	ACM Digital Library
A Survey on Healthcare Data: A Security Perspective	(Singh, Anand, Lv, & Mohan, 2021)	ACM Digital Library
Investigating quality requirements for blockchain-based healthcare systems	(Kassab, DeFranco, Malas, Destefanis, & Neto, 2019)	ACM Digital Library
Blockchain and its dimensions: Future Security	(Lavania & Sharma, 2023)	ACM Digital Library
A survey on the opportunities and challenges of Blockchain technology adoption for revolutionary innovation	(Duy, Hien, Hien, & Pham, 2018)	ACM Digital Library
Measuring the impact of blockchain on healthcare applications	(Loizou, Karastoyanova, & Schizas, 2019)	ACM Digital Library
Healthcare Applications Using Blockchain Technology: Motivations and Challenges	(Ramzan, Aqdus, Ravi, Koundal, & Al Ghamdi, 2023)	IEEE Xplore
Overcoming Challenges for Improved Patient-Centric Care: A Scoping Review of Platform Ecosystems in Healthcare	(Chibuike, Grobbelaar, & Botha, 2024)	IEEE Xplore
Blockchain in Education: A Systematic Review and Practical Case Studies	(Ocheja, Agbo, Oyelere, Flanagan, & Ogata, 2022)	IEEE Xplore
A Framework for the Adoption of Blockchain Technology in Healthcare Information Management Systems: A Case Study of Nigeria	(Azogu, Norta, Papper, Longo, & Draheim, 2019)	ACM Digital Library
Improving Healthcare Record Management System in Indonesia by using Blockchain Technology	(Munassar, Arsyad, & Richard, 2023)	ACM Digital Library
First approach to Digitalize Academic Records in Viet Nam using Blockchain Technology: Provide concepts to apply Blockchain to decentralized academic record management in Viet Nam	(Quach, et al., 2023)	ACM Digital Library
Can blockchains and data privacy laws be reconciled?: a fundamental study of how privacy-aware blockchains are feasible	(Stach, Gritti, Przytarski, & Mitschang, 2022)	ACM Digital Library

Thematic analysis

Rather than create a systematic map of my results, I chose to conduct a thematic analysis utilizing the methodology outlined by Braun & Clarke (2006). Thematic analysis allows me to identify themes across education and healthcare sectors, both of which are critical to the IEP process. Further, these themes can be used to identify gaps and patterns in the existing literature and propose focused areas for future research specific to this use case.

Initial codes generated during the preliminary and systematic literature reviews were used to search the abstracts of the selected papers. The most referenced code was Secure/Security, appearing in 78% of all relevant paper abstracts. The other four codes, Implement/Implementation, Comply/Compliance, Interoperable/Interoperability, and Regulate/Regulatory/Regulation(s) were equally represented in the relevant papers with each keyword appearing in 18% of all abstracts. After additional review and repeated readings of the relevant papers, all but one of the codes identified (Implement/Implementation) evolved into themes. Comply/Compliance and Regulate/Regulatory/Regulation(s) merged into a single theme, and

additional themes (Cost and Usability) were identified. To meet the defined research objective, these themes were evaluated in the context of the challenges they represent to blockchain adoption in records management for healthcare and education. Ultimately, five themes emerged: Security Concerns, Interoperability, Regulatory Constraints, Cost, and Usability.

Results

Security concerns

Concerns related to security risks for blockchain implementation were raised in 21% of relevant articles. Specific challenges include the presence of malicious actors, network vulnerabilities, and the use of private keys for data access. Blockchain systems can be compromised by malicious code, which may be used to alter the data stored on the blockchain and can ultimately lead to access and subsequent data theft by unauthorized parties. Network attacks could be used to overwhelm the blockchain system, resulting in loss of access and providing attackers with opportunities to cause harm to the blockchain and its data (Gunawan, Putra, Susant, Saputr, & Rizal, 2022). The potential for Majority Attack is also cause for concern—"If the computing power of any node is more than 51%, then it can control the blockchain, which can cause major security issues" (Singh, Anand, Lv, & Mohan, 2021). Reliance on private keys also poses security risks. Data fraud can occur if keys are stolen (Gunawan, Putra, Susant, Saputr, & Rizal, 2022). Self-governance adds additional complications as people could lose their personal keys or be prevented from sharing these personal keys for a variety of reasons, preventing access to the data stored on the blockchain (Kassab, DeFranco, Malas, Neto, & Destefanis, 2019).

Interoperability

Another key concern for blockchain's use in records management is the challenge of interoperability, which was identified in 21% of relevant papers. Lack of adequate infrastructure is a common concern, particularly in relevant case studies. The lack of universal standards for blockchain development (Gunawan, Putra, Susant, Saputr, & Rizal, 2022) is also an obstacle. Ocheja, Agbo, Oyelere, Flanagan, & Ogata (2022) observed that in educational settings currently leveraging blockchain, each institution tends to deploy its own blockchain network—which defeats the purpose of a decentralized technology. The lack of universal standards related to blockchain's use in both education and healthcare is noted in the existing literature.

Regulatory constraints

Significant challenges related to regulatory constraints exist and were raised in 29% of relevant papers. Clashes with existing privacy legislation, especially related to the European General Data Protection Rule (GDPR), were discussed at length. Blockchain's immutability characteristic, in particular, conflicts with "the right for every citizen to request an institution to delete his/her personal data" (Kassab, DeFranco, Malas, Neto, & Destefanis, 2019). Additionally, blockchain is an emerging technology and legal acceptance remains a hurdle until precedence for the technology's use is established (Duy, Hien, Hien, & Pham, 2018). The lack of clarity regarding the ownership of blockchain data due to the lack of a centralized authority also poses concerns and potential obstacles (Ramzan, Aqdus, Ravi, Koundal, & Al Ghamdi, 2023). Until rules and regulations are established for blockchain, and conflicts related to existing privacy regulations such as GDPR, HIPPA, and FERPA are addressed, the use of blockchain for records management in education and healthcare is not possible.

Cost

Another challenge for blockchain adoption in records management is cost, which was discussed in 29% of relevant papers. Concerns related to cost include a lack of funding and need for infrastructure spending

(Azogu, Norta, Papper, Longo, & Draheim, 2019), (Munassar, Arsyad, & Richard, 2023), (Quach, et al., 2023), the ongoing expenses related to maintaining a blockchain system (Kassab, DeFranco, Malas, Destefanis, & Neto, 2019), time consumption (Singh, Anand, Lv, & Mohan, 2021), and the expense of securing/training qualified individuals to develop, deploy, and provide ongoing support for the technology.

Usability

As with any new technology, blockchain's usability is a significant barrier to adoption and is cited in 50% of relevant articles as a primary challenge to overcome. Duy, Hien, Hien, & Pham (2018) note that the popularity of blockchain has outpaced the number of individuals trained to develop the technology. To further complicate matters, members of the general public are unfamiliar with blockchain technology (Munassar, Arsyad, & Richard, 2023). Blockchain's technical complexity poses additional concerns for adoption by education and healthcare workers and the populations they serve (Ramzan, Aqdus, Ravi, Koundal, & Al Ghamdi, 2023). Institutions may also be hesitant to relinquish control of the records management process due to the profitability of serving as the custodial records holder (Kassab, DeFranco, Malas, Destefanis, & Neto, 2019). To overcome these usability challenges, a "cultural shift" is needed (Ramzan, Aqdus, Ravi, Koundal, & Al Ghamdi, 2023). Education and healthcare sectors will need to alleviate apprehension related to the technology through education and detailed communication to the populations they serve, and the internal stakeholders involved (Chibuike, Grobbelaar, & Botha, 2024).

Discussion

In this research, I conducted a systematic literature review and thematic analysis of records management in healthcare and education to identify shared challenges. Extensive literature related to blockchain in healthcare and education exists, but only a small portion of that research relates to records management, and most of the existing literature relates to the technical obstacles for blockchain. Research focused on the usability of the technology is non-existent. An industry-first approach to records management is pervasive across literature in both sectors. Five common thematic challenges—security, interoperability, regulatory constraints, cost, and usability—were identified.

Connecting these five themes is the human element. Researchers need to give as much consideration to those who will ultimately utilize this technology—students and their guardians, educators, and healthcare providers—as the industries that serve them. Unless the humans at the center of this use case are considered, solving the technical, operational, and financial problems with blockchain is moot. Technologists can build the best system in the world, but it will not survive if the people it was created for refuse to adopt it. With this caveat in mind, the following areas are suggested for future research.

Recommendations for future research

Interdisciplinary research is needed to explore literature across multiple domains and identify cross-industry use cases. By fostering collaboration and facilitating the exchange of knowledge among different sectors, researchers can contribute to the development of a robust blockchain ecosystem that extends beyond the confines of individual industries (Li & Wu, 2022). Because Individualized Education Plans (IEPs) involve education and healthcare records, it is crucial to evaluate the shared challenges encountered when adopting blockchain technology in these sectors. Through an extensive examination of the existing literature, notable similarities have emerged in the challenges associated with blockchain adoption in these sectors including:

- **Interoperability.** Educational and healthcare institutions face significant challenges in achieving interoperability due to their utilization of diverse systems and centralized databases. Adopting blockchain technology offers a potential solution by providing a decentralized framework for

secure and transparent data exchange. However, achieving interoperability requires collaborative efforts, standardized protocols, and technical solutions to ensure compatibility and seamless integration of blockchain across different platforms.

- **Regulatory constraints.** Educators and healthcare providers operate within a complex regulatory landscape encompassing a multitude of state, federal, and international regulations focused on safeguarding data privacy, ensuring security, and maintaining compliance. Both sectors must navigate these extensive regulatory frameworks to protect sensitive information and meet the stringent requirements imposed upon them. Literature dedicated to education and healthcare consistently emphasizes the challenges and concerns associated with these regulatory requirements, highlighting the need for blockchain solutions that can effectively address privacy, security, and compliance concerns in a transparent and auditable manner. The current literature proposes expanding research efforts in the education and healthcare sectors to devise solutions within private blockchains that comply with the General Data Protection Regulation (GDPR). This entails exploring how blockchain applications can adhere to data protection regulations while effectively addressing the unique requirements and challenges inherent in these sectors (Bahalul Haque, Najmul Islam, Hyrynsalmi, Naqvi, & Smolander, 2021).
- **Usability.** Both the education and healthcare sectors face the challenge of implementing blockchain within their existing frameworks and processes. Education institutions must navigate established systems and procedures to seamlessly integrate blockchain technology, while healthcare organizations must adapt their complex systems to accommodate the decentralized nature of blockchain. Addressing these challenges requires careful planning, stakeholder involvement, and comprehensive assessments to leverage the transformative potential of blockchain in enhancing operations and data management in both sectors.

By acknowledging these common obstacles, future research investigations can delve into the consequences and prospective remedies for harnessing blockchain technology in the education and healthcare domains with greater precision, especially in the context of Individualized Education Plans (IEPs).

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