Volume 2. Nomor 3. Halaman 196-202. Tahun 2025
ISSN: 3031-5824
https://naluriedukasi.com/index.php/eticjournal/index
Email: educationandsocialsciencejourn@gmail.com

Utilizing Blockchain Technology to Increase Transparency in Education in Indonesia

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ARTICLE INFO

Article history:
Received January 02, 2025
Accepted January 31, 2025
Published March 31, 2025

Keywords: *Utilizing, Blockchain Technology, Increase Transparency, Education in Indonesia*

Abstract
This study aims to analyze the potential, challenges, and opportunities for implementing blockchain technology to improve educational transparency in Indonesia. The method used is a qualitative approach with a literature review, involving searching scientific articles, books, and research reports through the Google Scholar database. Data analysis was conducted using thematic analysis techniques to identify patterns and meanings relevant to the Indonesian educational context. The results show that blockchain has significant potential to prevent academic document forgery, increase education budget transparency, and facilitate the implementation of digital credentials. However, significant challenges remain, including the lack of a clear legal framework, limited technological infrastructure in certain regions, and issues regarding student data privacy. The opportunity for blockchain implementation is wide open thanks to national policy support and the readiness of some educational institutions that have experimented with blockchain application prototypes. This study recommends that blockchain implementation be carried out in stages, accompanied by human resource training and strengthening regulations on personal data protection. These findings are expected to serve as a reference for policymakers and education practitioners in adopting blockchain technology to improve educational transparency and accountability in Indonesia.

1. Introduction

Public education in Indonesia faces serious challenges related to accountability and budget utilization; several studies indicate that budget allocations do not always translate into improved quality due to efficiency issues and potential corruption at the implementation level (Kastawi, 2018). Lack of transparency in administrative practices, from fund management to diploma and transcript verification, results in leaks, diminished public trust, and hinders academic and employment mobility (Kastawi, 2018). Diploma forgery and the complexities of academic qualification verification are global issues, notably affecting Indonesia. Manual verification of diplomas is time-consuming and prone to error and manipulation, necessitating technological solutions to ensure the authenticity of academic documents (Castro & Au-Yong-Oliveira, 2021).

Blockchain offers technical features such as decentralization, immutability, and publicly verifiable audit trails, which are conceptually well-suited to increasing the transparency and

integrity of educational data, such as academic records, budget allocations, and administrative transaction histories (Loukil, Abed & Boukadi, 2021).

A systematic review shows that blockchain in education has been intensively studied since the late 2010s and offers potential solutions for applications such as digital certificates, verified transcripts, micro-credentials, and resource tracking mechanisms. However, adoption remains sporadic and is often a proof-of-concept rather than a nationwide implementation (Prity Rani et al., 2023). Beyond its technical potential, the benefits of blockchain in the educational context extend to governance. More transparent expenditure recording, tamper-evident audit evidence, and data-sharing mechanisms that minimize intermediaries are relevant for preventing budget leakage and increasing accountability in educational institutions (Castro & Au-Yong-Oliveira, 2021).

However, the literature also highlights significant barriers such as legal and regulatory issues, technical scalability, student data privacy, and integration challenges with heterogeneous school or college infrastructures. These factors often hinder the transformation from prototype to operational implementation (Loukil et al., 2021; Prity Rani et al., 2023). The Indonesian context demonstrates research interest and several proposed frameworks for implementing blockchain in higher education systems, but adoption in the field remains limited. Framework design studies and local studies recommend technical and policy adjustments to make blockchain solutions nationally relevant (Rahardja et al., 2019).

Against the backdrop of national programs to improve the quality and accountability of education, as well as the practical need to address document forgery and administrative inefficiencies, research on utilizing blockchain as a tool to increase transparency in education in Indonesia has become a research priority with the potential to directly impact education governance (Rahardja et al., 2019; Kastawi, 2018). Several systematic reviews and empirical studies have mapped the blockchain landscape in education. Loukil, Abed, & Boukadi (2021) categorize blockchain educational applications and highlight benefits such as security, reliability, and transparency, as well as barriers such as legality, privacy, and scalability. Prity Rani et al. (2023) present a more recent study that classifies initiatives, products, benefits, and challenges based on a literature review up to 2023. Both studies indicate that evidence of technical benefits is strong but evidence of large-scale adoption is still limited.

In practical applications, studies such as Castro & Au-Yong-Oliveira (2021) highlight the use of blockchain to digitize and verify certificates or diplomas as an anti-fraud solution with tangible benefits for student mobility and employer verification. Local research in Indonesia, such as that conducted by Sudaryono et al. (2020) and Rahardja et al. (2019), has proposed frameworks and application examples, such as iLearning assessment and higher education frameworks, but these remain prototypes or conceptual studies, rather than large-scale field evaluations.

While international literature demonstrates strong proof of concept for certificate verification and academic data recording, there is a research gap regarding end-to-end implementation in the context of the Indonesian public education system, including integration with budgeting mechanisms, regional regulations, and the unique public audit process in Indonesia. Few studies empirically examine sustainability, costs, and impacts on local bureaucratic practices (Prity Rani et al., 2023; Rahardja et al., 2019). Furthermore, there is a knowledge gap regarding how blockchain solutions can be designed to comply with regulations on student personal data protection in Indonesia, address infrastructure limitations such as connectivity and school IT capabilities, and incentivize stakeholders to transition from legacy systems to distributed systems. These aspects are rarely tested through field case studies or quantifiable pilots (Loukil et al., 2021; Sudaryono et al., 2020).

This research can provide novelty by designing and evaluating an integrative blockchain model for educational transparency that focuses not only on diploma verification but also connects the recording of education budget allocation and realization, evidence of expenditure, and an audit trail accessible to the public and the inspectorate. This cross-functional approach is relatively rare in the literature and would fill the gap in end-to-end implementation in a developing country like Indonesia (Castro & Au-Yong-Oliveira, 2021; Rahardja et al., 2019). Another novelty is the testing of a technical design that combines privacy-preserving mechanisms such as off-chain storage for sensitive data and on-chain hash proofs, smart contract rules for budget reporting automation, and an empirical study of local stakeholder acceptance. This combination of engineering, policy, and socio-organizational evaluations adds scientific and practical value beyond previous conceptual studies (Loukil et al., 2021; Prity Rani et al., 2023).

In practice, the transition to blockchain solutions faces real obstacles in Indonesia. Variations in IT human resource capacity across regions, the need to harmonize regulations such as the Public Information and Communications Information (KIP) and the Personal Data Protection Law, and the initial budget for pilot infrastructure development present challenges. Therefore, any design must consider a phased strategy, capacity building, and a clear financing model such as central-regional co-funding or public-private partnerships (Kastawi, 2018; Rahardja et al., 2019).

However, there is local policy and research momentum supporting experimentation. Several educational institutions in Indonesia have researched or prototyped blockchain applications for assessments and digital certificates, and there is academic support for developing frameworks appropriate to Indonesian bureaucratic culture. This suggests that well-designed, measurable, and stakeholder-inclusive pilots have the potential to be accepted and scaled if the results clearly demonstrate increased transparency and efficiency (Sudaryono et al., 2020; Rahardja et al., 2019).

2. Methods

This research employed a qualitative approach using a literature review method. A qualitative approach was chosen because it allows researchers to deeply understand the concepts, processes, and context of blockchain technology implementation in education. According to Creswell (2018), a qualitative approach provides a comprehensive understanding of social phenomena by considering the perspectives, experiences, and meanings constructed by stakeholders. In this context, a literature review was conducted to identify, analyze, and synthesize previous research relevant to the topic of educational transparency through blockchain.

The literature review procedure was conducted by collecting secondary data from scientific articles, books, research reports, and academic publications obtained through the Google Scholar database. The search technique used keywords such as "blockchain in education," "transparency in education," and "educational data management with blockchain." According to Snyder (2019), a systematic literature review allows researchers to identify research gaps and develop a strong theoretical foundation for new research.

Data analysis in this literature review was conducted using thematic analysis techniques. The first stage was selecting sources that met inclusion criteria such as topic relevance, publication within the last ten years, and a good academic reputation. The second stage is data extraction to identify key themes, while the third stage is interpretation of the findings in the context of Indonesian education. Braun and Clarke (2006) explain that thematic analysis is a flexible method that can be used to discover patterns or meaning from qualitative data.

To maintain the validity of the findings, this study employed source triangulation

techniques. Triangulation was conducted by comparing data from various publications, such as journal articles, conference proceedings, and institutional research reports. Flick (2018) stated that triangulation helps reduce researcher bias and increase the credibility of findings, particularly in literature studies involving data from multiple sources.

The results of the analysis are then presented in the form of a descriptive narrative that outlines the development of blockchain implementation in education, the potential and challenges faced, and opportunities for implementation in Indonesia. This method allows researchers to build arguments based on existing scientific evidence, while also offering new perspectives that can serve as a reference for further research (Snyder, 2019; Creswell, 2018).

3. Results and Discussion

a. Result

1) Blockchain's Potential to Increase Transparency in Education

Blockchain technology has significant potential to increase transparency in education through its decentralization and immutability. According to Loukil, Abed, and Boukadi (2021), any transaction or data stored in a blockchain cannot be unilaterally altered, thus minimizing the risk of manipulation of academic and administrative data. This is crucial for maintaining the integrity of educational documents such as diplomas, transcripts, and certificates. Furthermore, blockchain can be used to manage and publish education budget data in real time. Castro and Au-Yong-Oliveira (2021) demonstrated that integrating blockchain with the education finance system can provide public access to information on budget allocation and use, which in turn increases accountability. In the Indonesian context, this is relevant to the need to prevent corruption in the education sector.

The use of blockchain in education also supports the concept of micro-credentials and digital certificates that can be verified instantly. Prity Rani et al. (2023) found that this model facilitates academic mobility across institutions and countries and reduces bureaucracy in document verification processes. Thus, blockchain benefits not only institutions but also students and employers.

The implementation of blockchain can create a more transparent and efficient education ecosystem if supported by adequate policies and infrastructure. Rahardja et al. (2019) emphasize the importance of involving all stakeholders, from the government and educational institutions to the private sector, to ensure the successful adoption of this technology.

2) Challenges of Blockchain Implementation in Education

Despite its significant potential, blockchain implementation in the education sector faces various challenges. One major obstacle is regulatory and legal issues. Loukil et al. (2021) identified that the lack of a clear legal framework can hinder blockchain adoption, particularly regarding the protection of students' personal data. Another challenge is limited technological infrastructure in some regions. According to Sudaryono et al. (2020), not all educational institutions in Indonesia have adequate internet connectivity or human resources trained in blockchain technology. This requires a phased implementation strategy based on local capacity.

Data privacy and security issues are also concerns. Although blockchain is known to be secure, storing sensitive data on-chain can pose risks if not equipped with additional security mechanisms. Castro and Au-Yong-Oliveira (2021) recommend a hybrid model that separates sensitive data off-chain and stores only hashes on the blockchain. Furthermore, adoption challenges also relate to resistance to change within educational institutions. Prity Rani et al.

(2023) noted that without adequate training and understanding, educators and administrative staff may be reluctant to switch from legacy systems to blockchain-based ones.

3) Opportunities for Blockchain Implementation in Indonesian Education

Current conditions indicate significant opportunities for blockchain implementation in Indonesian education. Rahardja et al. (2019) noted that several universities have experimented with blockchain-based digital certificates, indicating initial readiness at the institutional level. National programs for the digitalization of education can be a catalyst for blockchain adoption. Loukil et al. (2021) suggest that clear government policy support can accelerate the integration of this technology into the education system. With programs like Merdeka Belajar (Freedom to Learn), the opportunity for integration is even greater.

Furthermore, blockchain can be utilized to strengthen accreditation and quality assurance systems in education. Castro and Au-Yong-Oliveira (2021) emphasized that transparent recording of accreditation processes can increase public trust in educational institutions. Developing a collaborative ecosystem between the government, educational institutions, and the private sector also presents a strategic opportunity. Prity Rani et al. (2023) emphasized that this collaboration can reduce the burden of implementation costs and accelerate the spread of technology to various regions.

b. Discussion

1) Blockchain's Potential to Increase Educational Transparency

Research results show that blockchain technology has the ability to provide a transparent and immutable record-keeping system, which is relevant to Hood's (2006) theory of public transparency, which emphasizes information disclosure as a mechanism for preventing corruption. Loukil, Abed, and Boukadi (2021) demonstrated that blockchain can serve as a permanent storage medium for educational documents such as diplomas and transcripts, thereby preventing forgery.

The implementation of blockchain in education budget transparency aligns with Bovens' (2007) theory of public accountability, which states that all management of public resources must be accountable to the public. Castro and Au-Yong-Oliveira (2021) found that blockchain-based record-keeping minimizes human intervention, thereby reducing the opportunity for financial data manipulation.

The use of blockchain for micro-credentials also supports the concept of decentralized credentials discussed by Grech and Camilleri (2017), where learners have full control over their evidence of learning achievement. This strengthens the link between transparency, efficiency, and learner empowerment.

2) Challenges of Blockchain Implementation in Education

The implementation of blockchain in education faces regulatory challenges, which aligns with Lessig's (2006) view that technology is shaped by the legal framework that governs its use. Loukil et al. (2021) suggest that the absence of specific policies related to blockchain in education may hinder the widespread adoption of this technology.

Infrastructure barriers are also a significant issue. According to Rogers' (2003) diffusion of innovation theory, the rate of adoption of new technologies depends on the readiness of infrastructure and human resources. Sudaryono et al. (2020) emphasize the need for technical training and infrastructure investment to support blockchain implementation in schools and universities.

The issue of student data privacy cannot be ignored. The principles of personal data protection as stipulated in the Indonesian Personal Data Protection Law must be a reference in blockchain system design. Castro and Au-Yong-Oliveira (2021) suggest a combination of on-chain and off-chain storage to maintain a balance between transparency and privacy.

3) Opportunities for Blockchain Implementation in Indonesian Education

The opportunities for blockchain implementation in Indonesian education can be analyzed using Parasuraman's (2000) technological readiness theory framework, which measures readiness for technology adoption based on optimism, innovation, discomfort, and insecurity. Rahardja et al. (2019) showed that most universities in Indonesia are highly optimistic about certificate digitization.

Government policies promoting digital transformation in education, such as the Merdeka Belajar program, create a conducive environment for blockchain adoption. Loukil et al. (2021) emphasize that top-down policy support can accelerate the process of integrating this technology into the education system.

Furthermore, opportunities for collaboration between the government, educational institutions, and the private sector pave the way for joint financing schemes. According to Grech and Camilleri (2017), public-private partnerships can be a key factor in overcoming the cost barriers to implementing new technologies, including blockchain.

4. Conclusion

This research reveals that blockchain has significant potential to improve transparency and accountability in education in Indonesia through secure, permanent, and publicly verifiable data recording. This potential includes preventing academic document forgery, transparency in education budgets, and the development of digital credentials that facilitate academic mobility.

However, blockchain implementation faces challenges including regulation, infrastructure readiness, and personal data protection. On the other hand, the support of national policies and the readiness of some educational institutions open up opportunities for broader implementation, especially if carried out collaboratively and in stages, involving various stakeholders.

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