Blockchain-Based Credentialing for Teachers: A Systematic Literature Review on Transparency and Trust in Educational Management

Marnita[1*], Nanda Safarati[2], Iswadi Bensaadi [3], M. Taufiq[4]

[1]Faculty of Teacher Training and Education, PPG Study Program, Universitas Almuslim, Aceh, Indonesia
[2]Faculty of Teacher Training and Education, Physics Education Study Program, Universitas Almuslim, Aceh, Indonesia
[3]Faculty of Economics and Business, Accounting Study Program, Universitas Malikussaleh, Aceh, Indonesia
[4] Faculty of Teacher Training and Education, Physics Education Study Program, Universitas Almuslim, Aceh, Indonesia
E-mail: [1*]marnita@umuslim.ac.id, [2]safaratinanda@gmail.com, [3]iswadi@unimal.ac.id, [4]taufiqtp69@gmail.com
*E-mail Corresponding Author: marnita@umuslim.ac.id

Abstract

This study presents a systematic literature review (SLR) of blockchain applications in educational credentialing, with a particular emphasis on teacher professional development and governance. While most existing research focuses on higher education credentials, this review highlights the limited exploration of blockchain in teacher credentialing, despite its significant potential to address persistent challenges such as credential fraud, data fragmentation, and slow verification processes. Guided by the PRISMA 2020 framework, the review synthesizes 27 peer-reviewed studies published between 2019 and 2025. The findings reveal that blockchain's core features —immutability, verifiability, and decentralization —can transform credential governance from a "trust-by-institution" model to a "trust-by-design" system. This paradigm shift enables tamper-resistant records, cross-institutional verification, and transparent audit trails, thereby enhancing accountability. The study makes three key contributions. Theoretically, it extends the literature by systematically consolidating knowledge on the role of blockchain in teacher credentialing, offering a novel perspective on its governance implications. Practically, it provides concrete recommendations for policymakers, institutions, teachers, and technology developers, with relevance for developing countries. In the Indonesian context, blockchain integration with systems such as SIMPKB, SISTER, and PDDikti is proposed as a pathway toward more transparent, accountable, and competency-based teacher management. Finally, the review identifies future research directions, including empirical pilot studies, cross-country comparisons, ethical frameworks for data privacy, and cost-benefit analyses of adoption in resource-constrained settings. Overall, this study highlights blockchain not only as a technological innovation but also as a governance strategy that can strengthen trust, accountability, and transparency in teacher credentialing systems.

Keywords: *Blockchain Education; Educational Management**;** Teachers Credentialing; Transparency; Trust.*

I. INTRODUCTION

In the era of digital transformation, educational institutions are increasingly required to adopt innovative technologies to enhance transparency, accountability, and efficiency in governance. One of the most pressing challenges in this domain is the verification and management of teacher credentials. In many education systems, records of teachers' professional qualifications, certifications, and continuing professional development (CPD) remain fragmented, paper-based, and vulnerable to manipulation. Such inefficiencies not only undermine institutional trust but also hinder the effective management of human resources in the education sector. Blockchain technology, with its decentralized, immutable, and transparent architecture, offers a groundbreaking alternative for credentialing processes. Beyond its well-documented applications in the financial sector, blockchain has been widely discussed in higher education, particularly for diploma verification, transcript management, and certificate authentication.

However, its potential role in strengthening teacher governance and ensuring the integrity of professional development records has not yet been systematically examined. This gap highlights the need for focused exploration of blockchain-based credentialing in education, particularly within the context of teacher management. As emphasized by (Chen et al., 2023)Much of the existing blockchain research has been concentrated in China, primarily presented at computer science conferences, with relatively limited publications in education journals. Blockchain has emerged as a cutting-edge technology that delivers innovative solutions across sectors. Over time, it has not only attracted significant scholarly and institutional attention but has also evolved into a foundational element of organizational operations, while simultaneously becoming a dominant topic in contemporary academic research (Haleem et al., 2021; Lakkis & Issa, 2022).

As a distributed ledger technology, blockchain is characterized by decentralization, immutability, and cryptographic security. Unlike traditional centralized

databases, blockchain stores data in interconnected blocks that cannot be retrospectively altered, thereby ensuring reliability and traceability (Meenakshi & Sashi Rekha, 2023). These features render blockchain particularly suitable for applications requiring integrity, transparency, and fraud resistance. Within the academic domain, Kurniawan & Duwita oktaviani, (2022) argue that blockchain represents a revolutionary solution for academic systems, as it provides security, transparency, and decentralization in data management.

Educational credentials refer to the processes of verifying and certifying teachers' academic qualifications, professional licenses, and training achievements obtained through both formal and non-formal pathways. An effective credentialing system is essential to ensuring teacher quality, reinforcing institutional accountability, and supporting evidence-based recruitment and promotion practices. However, conventional systems frequently face challenges such as data redundancy, lack of interoperability, and vulnerability to forgery (Varadarajan et al., 2023; Wang et al., 2019). Credentials in education not only serve as administrative proof of individual achievement but also function as a critical instrument for safeguarding teaching standards, strengthening institutional accountability, and ensuring that teacher recruitment and promotion are based on valid and verifiable records.

Within today's increasingly complex educational ecosystem, credentials play a strategic role in building public trust in teachers' competencies while promoting transparent educational governance (Ahmat et al., 2021). Yet conventional credentialing systems continue to encounter fundamental obstacles. One recurring issue is data redundancy caused by the absence of integrated systems linking various educational and training institutions. Limited interoperability across digital platforms also hampers cross-institutional recognition, generating inefficiencies and bureaucratic burdens that disadvantage educators. Furthermore, the susceptibility of conventional systems to document forgery and data manipulation poses serious risks to credibility, ultimately compromising certification integrity and eroding public confidence in educational quality.

Hence, innovative breakthroughs are required to deliver safer, more efficient, and sustainable credentialing mechanisms aligned with the demands of the digital era and global educational transformation. Arenas & Fernandez, (2018) highlight that blockchain-based credentials can prevent forgery by enabling stakeholders such as employers or partner institutions to easily verify records using blockchain data, without depending on third parties or requiring direct access to original documents. The integration of blockchain into educational credentialing promises to transform governance practices. By providing tamper-resistant and verifiable digital records, blockchain can streamline teacher recruitment, reduce administrative burdens, and enhance trust among stakeholders. Moreover, blockchain supports lifelong learning by enabling teachers to securely maintain and carry their professional records in a portable format. As Steiu, (2020) notes, blockchain technology facilitates the digital recording of lifelong academic journeys, including informal learning and micro-credentials, thereby encouraging continuous professional growth. Nonetheless, its adoption also raises important ethical questions concerning privacy, data ownership, and digital inequality. To address these concerns, Guo et al., (2020 and Zhao et al., (2022) propose blockchain-based digital rights management systems to mitigate issues such as copyright infringement of multimedia learning resources and the insecurity of digital educational certificates.

Blockchain in Education: Emerging Trends

The application of blockchain in education has gained significant attention in recent years, particularly in areas such as diploma verification, transcript management, and certificate authentication (Arenas & Fernandez, 2018; Kurniawan & Duwita oktaviani, 2022). Blockchain is regarded as a solution to enhance security, transparency, and efficiency in educational evaluation management. As a distributed ledger, blockchain is used to permanently record evaluation results, certifications, and credentials (Ouyang & Huang, 2022). It has the potential to become a new foundation for educational management by ensuring validity, safeguarding security, and strengthening accountability. Nevertheless, its implementation still requires robust infrastructure, regulatory frameworks, and cross-stakeholder collaboration (Ouyang & Huang, 2022; Saadati et al., 2023).

Given its relative novelty, blockchain technology in education remains immature, and many projects have not advanced beyond the pilot stage. Educational administrative systems often adopt a cautious stance, showing skepticism or waiting for concrete evidence before making substantial investments (Steiu, 2020). In higher education, however, several blockchain initiatives have begun to emerge. For instance, (Asamoah et al., 2023) demonstrated that blockchain-based educational loan platforms are both feasible and promising in expanding access to higher education in developing countries, although implementation still faces technical, regulatory, and trust-related challenges. Similarly, pilot projects on blockchain-based platforms for issuing academic certificates have been undertaken in various countries. Leka & Selimi, (2021), for example, investigated the development of a blockchain application for academic certificate validation at Southeast European University, finding the system to be effective, secure, and efficient in addressing document

forgery. Nonetheless, issues related to scalability, cost, and widespread adoption remain significant challenges.

A key advantage of blockchain-based platforms is their resistance to manipulation, which reduces the risk of fraud and administrative inefficiency (Delgado-von-Eitzen et al., 2024). In addition, such platforms accelerate the verification process of certificates compared to traditional methods and lessen reliance on manual bureaucratic procedures. In Asia, similar initiatives are being explored to simplify cross-border credential recognition, reflecting blockchain's potential in facilitating global student and professional mobility (Ghonim & Corpuz, 2021). These initiatives also highlight blockchain's promise in reducing educational access gaps and supporting the achievement of sustainable development goals, particularly in education.

Credentialing Challenges in Teacher Professional Development

While research on blockchain in higher education has been steadily expanding, its application to teacher credentialing remains underexplored. Teacher professional development programs often generate multiple certificates and records from diverse providers, resulting in fragmented databases and reduced accountability (Kelchen, 2022). Furthermore, credential fraud and the misuse of professional achievements continue to pose risks in recruitment and promotion processes. Current centralized systems lack both interoperability and resilience against manipulation, reinforcing the need for more trustworthy solutions. Howard & Mayes, (2020) observe that schools in regions with teacher shortages tend to be more flexible regarding credentials, as long as candidates demonstrate potential and readiness to teach. In contrast, schools with stronger reputations often enforce stricter requirements for academic and professional credentials. Globally, the demand for formal credentials including certifications, licenses, and educational degrees is increasing. However, it remains unclear to what extent these credentials actually influence hiring decisions or contribute to teachers' professional growth.

This condition is further illustrated in a case study discussed by Dungey & Ansell, (2022), which examines the challenges of credentialing in teacher professional development. Teachers in rural areas frequently lack access to nationally recognized formal credentials, thereby limiting the professional legitimacy of their efforts to teach entrepreneurial skills. Moreover, existing formal credentials often fail to align with community expectations, which tend to favor more prestigious professions such as nursing or civil service, rendering entrepreneurship education undervalued. A gap also emerges when traditional curricula the foundation of teacher credentials do not adequately equip teachers with competencies to teach entrepreneurial practices. Furthermore, efforts to broaden the scope of credentials by emphasizing pedagogical innovation, including entrepreneurship education, often encounter resistance from both educational systems and societies that remain deeply attached to conventional formal credential symbols.

Research by Davis et al., (2023) and White, (2021) reveals that the development of micro-credentials for the teaching profession faces challenges related to standardization, accreditation, and credibility, as not all institutions have established robust validation mechanisms. In addition, limited digital infrastructure and high implementation costs create access gaps for teachers, while institutional resistance remains strong due to the perception that traditional credentials carry greater prestige. Tensions also arise in balancing the flexibility of micro-credentials with the need to align them with national professional teaching standards. Similarly, Childers et al., (2023) and Mugayitoglu et al., (2021) highlight unique credentialing challenges in the development of micro-credentials in cybersecurity for K-12 teachers.

One significant barrier is the lack of standardization and accreditation, as no widely recognized formal framework currently integrates micro-credentials into teachers' professional qualifications. Issues of credibility also emerge, with some stakeholders continuing to question the value of micro-credentials compared to traditional credentials. Furthermore, disparities in digital readiness and variations in teachers' technological literacy contribute to unequal access and inconsistent program outcomes. These conditions underscore the necessity for regulatory legitimacy, infrastructural support, and institutional acceptance for micro-credentials to function effectively as instruments of teacher professional development.

Blockchain for Teacher Governance

Several conceptual studies suggest that blockchain can be effectively adapted to manage teachers' qualifications and professional development (Sakhipov et al., 2023). The immutable nature of blockchain ensures that once a credential is recorded, it cannot be altered, thereby safeguarding the integrity of teachers' professional profiles. Unlike centralized systems, blockchain distributes the management of teacher data across multiple stakeholders including educational institutions, training providers, and government agencies supporting a more open and collaborative governance model while reducing the risk of information monopolies. Teachers gain greater confidence in the authenticity of their professional records, while educational institutions benefit from a reliable foundation for evaluation, promotion, and recognition.

The use of blockchain in professional development platforms for teachers creates a more

transparent governance system, as every certification and training record is stored permanently and is resistant to manipulation. With blockchain-based credentialing, teacher governance becomes more accountable and decentralized, thereby strengthening trust among educational institutions, government authorities, and teachers themselves (Altinay et al., 2020; Sakhipov et al., 2023). Furthermore, blockchain can be integrated into school management, particularly in areas such as record keeping, identity verification, information security, lifelong learning, and content ownership and protection (Altinay et al., 2020). This enables instant, cross-institutional validation of teacher credentials, reducing reliance on a single authority and fostering a more equitable, collaborative mechanism. Thus, the integration of blockchain into teacher professional development is not merely a technological innovation, but also an effective and transparent governance strategy capable of strengthening the overall education management system. Findings by (Sakhipov et al., 2023) further demonstrate that implementing blockchain in teacher professional development platforms enhances governance by increasing transparency, efficiency, accountability, and enabling greater validation and mobility of teacher credentials across institutions.

While blockchain offers promising solutions, the literature also highlights critical ethical and technical challenges. Data privacy remains a primary concern, particularly regarding the ownership of teachers' sensitive information. Moreover, blockchain implementation requires substantial financial investment, digital infrastructure, and stakeholder readiness, especially in developing countries where the digital divide persists as a major obstacle (Steiu, 2020). Widespread adoption of blockchain in education necessitates robust data protection, scalability, transaction speed, and solutions for technological limitations, as well as improved collaboration and infrastructure. These challenges, however, should not serve as excuses to hinder educational development. The broader literature consistently agrees that blockchain in teacher professionalism and education management represents a viable pathway, and recommends further development and adoption within education systems (Kurniawan & Duwita oktaviani, 2022).

Several prior studies have explored the application of blockchain in education more broadly; however, systematic analyses of its potential for teacher credentialing remain limited. For instance, (He et al., 2021) highlighted that while the integration of the Internet of Things (IoT) into education such as in smart classrooms offers many benefits, it also poses risks in terms of inadequate protection of access control, thereby potentially compromising the privacy of both students and teachers. Unauthorized actors may gain access to, or even delete, sensitive educational data. Consequently, blockchain-based access control schemes are needed to secure policies and traceability of data access. Overall, the existing literature demonstrates that most studies have concentrated on university students and higher education credentials, leaving a research gap in understanding how blockchain could transform teacher governance at the primary and secondary levels. Furthermore, few empirical studies propose concrete implementation models tailored to the contexts of developing countries, where challenges in credential verification are often most pressing.

To address this gap, the present systematic literature review synthesizes and critically evaluates current knowledge while also highlighting promising future directions for both research and practical implementation. Specifically, this review places its primary focus on the application of blockchain in educational credentialing, with particular emphasis on its broader implications for enhancing teacher professionalism and ensuring the credibility of qualifications. The study aims not only to consolidate recent findings but also to identify persistent research gaps, articulate emerging challenges, and propose innovative pathways for leveraging blockchain as a strategic tool to foster greater trust, accountability, and transparency within educational management systems.

II. RESEARCH METHODOLOGY

This study employed a Systematic Literature Review (SLR) approach to synthesize existing research on the application of blockchain in educational credentialing, with a specific focus on teacher professional development and governance. The review followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigor in the selection and reporting process (Page et al., 2021). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline, originally introduced in 2009, was developed to support researchers in clearly presenting the rationale, processes, and outcomes of their systematic reviews. Over the years, developments in both methodology and terminology have created the need for a revision of this framework. Consequently, the PRISMA 2020 statement was introduced to replace the earlier version, offering updated recommendations that incorporate recent advances in the identification, selection, evaluation, and synthesis of studies (Page et al., 2021; Yepes-Nuñez et al., 2021).

Relevant and up-to-date literature was searched across major academic databases, including Scopus, Web of Science (WoS), SpringerLink, IEEE Xplore, ScienceDirect, and SAGE Journals, along with other reputable articles. The review focused on English-language publications accessible through these databases, covering the period from 2019 to 2025 to capture the most recent developments in blockchain

adoption. The search strategy employed keywords such as *Blockchain AND (Education OR School OR Teacher) AND (Credential OR Certification OR Qualification OR Professional Development)*, as well as *"educational credentialing"*, *"teacher certification"*,*"blockchain in education"*, and *"digital credential"*. The study selection process (PRISMA Flow) involved four main stages:

- Identification: The initial search across multiple databases using the specified keywords yielded approximately 30 studies.
- Screening: Titles and abstracts were screened to remove irrelevant studies and duplicates.
- Eligibility: Full-text articles were assessed against the inclusion and exclusion criteria.
- Inclusion: A final set of 30 studies was selected for the review.

III.RESULTS AND DISCUSSION

Blockchain is highly relevant to the governance of teacher credentialing, as evidenced by the literature synthesis highlighting three major challenges: fragmented data, risks of credential fraud, and slow verification processes largely stemming from centralized data architectures and manual procedures. The key attributes of blockchain immutability, verifiability, and decentralization offer the potential to address these problems simultaneously: (1) tamper-resistant credential records, (2) rapid cross-institutional verification, and (3) transparent audit trails to ensure accountability. Importantly, the value of blockchain does not lie in replacing institutional roles, but rather in shifting governance from "trust-by-institution" to "trust-by-design."

Based on current trends in the literature and the practical needs of educational management, the most realistic architecture is a permissioned (consortium) blockchain that fosters collaboration among stakeholders such as the Ministry of Education and Culture/ accreditation authorities, teacher training institutions (LPTK/universities), provincial and district education offices, official training providers, teacher certification programs (PPG), professional associations, schools, recruitment agencies, and even the public (with limited access rights) who can serve as verifiers.

This practice is already evident in higher education through applications such as SISTER and PDDikti, which act as academic sources of truth and can be categorized as blockchain-like systems that store verified claims (hashes, metadata, and status). Extending these mechanisms to secondary and upper-secondary education would enable portable teacher credentials, thereby facilitating the mobility of educators across schools and regions while supporting competency-based recruitment and placement. In addition, a blockchain-enabled ecosystem could connect local schools with national and even international standards, enabling Indonesian teachers to have credentials recognized across borders, thus expanding opportunities for professional exchange and collaboration. Future research could therefore focus not only on technical pilots but also on assessing the socio-cultural readiness of teachers and institutions, as well as exploring how blockchain-enabled credentialing intersects with global frameworks for teacher quality.

Taken together, the integration of blockchain into teacher credentialing must be understood as more than a technological advancement; it represents a structural innovation in the governance of education. By embedding trust into decentralized, immutable systems, blockchain offers the potential to overcome long-standing inefficiencies that have undermined the credibility of teacher certification and professional development (Kurniawan & Duwita oktaviani, 2022; Varadarajan et al., 2023; Wang et al., 2019). Its adoption signifies a move from a reliance on procedural bureaucracy toward an accountability system grounded in transparency, equity, and sustainability.

The Indonesian case demonstrates the urgency of this transformation. Persistent challenges ranging from bureaucratic delays to credential fraud highlight the inadequacy of conventional mechanisms to guarantee fairness and legitimacy in teacher governance. Blockchain provides a viable pathway for addressing these issues by ensuring that professional records are accurate, accessible, and secure (Lizcano et al., 2020). As emphasized by (Saja & Stecyk, 2023), blockchain-based certification enhances transparency and strengthens trust by ensuring that credentials are securely stored, universally verifiable, and resistant to manipulation. Beyond reducing administrative inefficiencies, such systems also provide a structural response to long-standing issues of fraud and bureaucratic opacity in educational credentialing. These findings reinforce the argument that blockchain adoption is not merely a technological upgrade but a governance innovation that addresses both the ethical and practical dimensions of credential management.However, successful adoption requires the alignment of technical design with regulatory frameworks, ethical safeguards, and institutional capacity-building. Without these supporting structures, blockchain risks becoming another layer of technological complexity rather than a genuine solution to systemic problems

However, successful adoption requires the alignment of technical design with regulatory frameworks, ethical safeguards, and institutional capacity-building. Without these supporting structures, blockchain risks becoming another layer of technological complexity rather than a genuine solution to systemic problems.

Conceptually, blockchain can be positioned as a *strategic enabler* of educational reform. It does not

operate in isolation but interacts with broader initiatives such as digital literacy, competency-based education, and evidence-based policymaking. By connecting teacher credentialing to these larger agendas, blockchain has the potential to redefine the very foundation of governance in the education sector. Importantly, its role extends beyond efficiency gains: it is an ethical and social instrument that can rebuild public trust, elevate professional standards, and align Indonesia's education system with global best practices in the digital era.

Future scholarship and practice should therefore approach blockchain not simply as a technical artifact but as an integrated governance framework that balances innovation with inclusivity. Such a perspective opens space for comparative studies across national contexts, interdisciplinary research on ethical and legal implications, and pilot projects that test blockchain's adaptability at different levels of the education system. Through these efforts, blockchain can evolve from an experimental technology into a cornerstone of sustainable educational governance, ensuring that teacher professionalism and accountability are secured for generations to come.

IV. CONCLUSION

This systematic literature review highlights the emerging role of blockchain technology in educational credentialing, with particular relevance to teacher governance and professional development. While most existing studies emphasize diploma verification and student credential management, the findings underscore that the application of blockchain to teacher credentialing remains underexplored in scholarly literature. Yet, blockchain holds significant potential to address chronic issues such as credential fraud, fragmented records, and slow verification processes by providing immutable, transparent, and portable digital records across institutions.

At the same time, the literature also identifies several barriers to implementation, ranging from data privacy concerns and limited interoperability with existing systems to substantial financial costs and varying levels of institutional readiness. These challenges necessitate the development of frameworks that are locally contextualized, balancing technological innovation with ethical responsibility.

In the Indonesian context, blockchain represents not merely a technological innovation but also a paradigm shift in governance from institution-based trust to system-embedded trust. This transformation carries profound implications for modernizing educational management, particularly where teacher quality and accountability are central to educational reform. Blockchain is therefore not only relevant for teacher credential management but also crucial to be cultivated within the broader educational governance ecosystem, especially at the secondary school level. Its integration can enhance transparency, reduce manipulative practices in teacher certification or recruitment, and strengthen public trust in the quality of the teaching workforce. Thus, the adoption of blockchain goes beyond delivering technical efficiency; it also serves as a strategic instrument for building a more equitable, accountable, and sustainable system of educational governance in Indonesia.

V. RECOMMENDATIONS

This review suggests several directions for future research, including:

- Empirical studies examining pilot implementations of blockchain-based credentialing in teacher education.
  - ✓ For Policymakers, formulate comprehensive national standards and establish robust regulatory frameworks to guide the adoption and governance of blockchain-based credentialing systems, ensuring consistency, security, and alignment with broader educational policies.
  - ✓ For Educational Institutions, Initiate pilot projects that implement blockchain technologies for the issuance and verification of academic and professional credentials, with an initial emphasis on teacher training programs as a foundational step toward broader institutional integration.
- Cross-national comparative studies exploring how blockchain supports credential portability in a global context.
- Investigations into ethical frameworks that safeguard teacher data privacy while ensuring accountability.
- Cost benefit analysis assessing blockchain adoption in resource-constrained developing countries

VI. REFERENCES

Ahmat, N. H. C., Bashir, M. A. A., Razali, A. R., & Kasolang, S. (2021). Micro-Credentials in Higher Education Institutions: Challenges and Opportunities. *Asian Journal of University Education*, *17*(3). https://doi.org/10.24191/ajue.v17i3.14505

Altinay, F., Beyatli, Ö., Dagli, G., & Altinay, Z. (2020). The role of Edmodo model for professional development: The uses of blockchain in school management. *International Journal of Emerging Technologies in Learning*, *15*(12). https://doi.org/10.3991/ijet.v15i12.13571

Arenas, R., & Fernandez, P. (2018). CredenceLedger: A

Permissioned Blockchain for Verifiable Academic Credentials. *2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings*. https://doi.org/10.1109/ICE.2018.8436324

Asamoah, K. O., Darko, A. P., Antwi, C. O., Kodjiku, S. L., Aggrey, E. S. E. B., Wang, Q., & Zhu, J. (2023). A Blockchain-Based Crowdsourcing Loan Platform for Funding Higher Education in Developing Countries. *IEEE Access*, *11*. https://doi.org/10.1109/ACCESS.2023.3252917

Chen, X., Zou, D., Cheng, G., Xie, H., & Jong, M. (2023). Blockchain in smart education: Contributors, collaborations, applications and research topics. *Education and Information Technologies*, *28*(4). https://doi.org/10.1007/s10639-022-11399-5

Childers, G., Linsky, C. L., Payne, B., Byers, J., & Baker, D. (2023). K-12 educators' self-confidence in designing and implementing cybersecurity lessons. *Computers and Education Open*, *4*. https://doi.org/10.1016/j.caeo.2022.100119

Davis, M., De Bari, J., & Maschi, S. (2023). Credentialling: Educational Pathways in Design. *She Ji*, *9*(2). https://doi.org/10.1016/j.sheji.2023.03.001

Delgado-von-Eitzen, C., Anido-Rifón, L., & Fernández-Iglesias, M. J. (2024). NFTs for the Issuance and Validation of Academic Information That Complies with the GDPR. *Applied Sciences (Switzerland)*, *14*(2). https://doi.org/10.3390/app14020706

Dungey, C., & Ansell, N. (2022). 'Not All of Us Can Be Nurses': Proposing and Resisting Entrepreneurship Education in Rural Lesotho. *Sociological Research Online*, *27*(4). https://doi.org/10.1177/1360780420944967

Ghonim, A., & Corpuz, I. (2021). Moving Toward A Digital Competency-based Approach in Applied Education: Developing a System Supported by Blockchain to Enhance Competency-Based Credentials. *International Journal of Higher Education*, *10*(5). https://doi.org/10.5430/ijhe.v10n5p33

Guo, J., Li, C., Zhang, G., Sun, Y., & Bie, R. (2020). Blockchain-enabled digital rights management for multimedia resources of online education. *Multimedia Tools and Applications*, *79*(15–16). https://doi.org/10.1007/s11042-019-08059-1

Haleem, A., Javaid, M., Singh, R. P., Suman, R., & Rab, S. (2021). Blockchain technology applications in healthcare: An overview. In *International Journal of Intelligent Networks* (Vol. 2). https://doi.org/10.1016/j.ijin.2021.09.005

He, X., Guo, H., & Cheng, X. (2021). Blockchain-Based Privacy Protection Scheme for IoT-Assisted Educational Big Data Management. *Wireless Communications and Mobile Computing*, *2021*. https://doi.org/10.1155/2021/3558972

Howard, J. E., & Mayes, E. L. (2020). Do teaching credentials matter? School leaders' preferences when screening and selecting teacher candidates. *International Journal of Educational Research*, *103*. https://doi.org/10.1016/j.ijer.2020.101637

Kelchen, R. (2022). The Lasting Effects of the Pandemic on Graduate and Professional Education. *Journal of Student Financial Aid*, *51*(1). https://doi.org/10.55504/0884-9153.1783

Kurniawan, R., & Duwita oktaviani. (2022). Characteristics of Blockchain Technology In Educational Development. *Blockchain Frontier Technology*, *1*(2). https://doi.org/10.34306/bfront.v1i2.41

Lakkis, H., & Issa, H. (2022). Understanding Blockchain Technology. *International Journal of Technology and Human Interaction*, *18*(1). https://doi.org/10.4018/ijthi.297617

Leka, E., & Selimi, B. (2021). Development and evaluation of blockchain based secure application for verification and validation of academic certificates. *Annals of Emerging Technologies in Computing*, *5*(2). https://doi.org/10.33166/AETiC.2021.02.003

Meenakshi, K., & Sashi Rekha, K. (2023). An Enhanced Security System Using Blockchain Technology for Strong FMC Relationship. *Intelligent Automation and Soft Computing*, *35*(1). https://doi.org/10.32604/iasc.2023.025032

Mugayitoglu, B., Borowczak, M., & Burrows, A. C. (2021). Designing a Creative Cybersecurity Microcredential for Educators: Challenges and Successes of K-12 Teacher Professional Development. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://doi.org/10.18260/1-2--36927

Ouyang, S., & Huang, X. (2022). Education Evaluation Management Based on Blockchain Technology. *Mobile Information Systems*, *2022*. https://doi.org/10.1155/2022/7513365

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *BMJ* (Vol. 372). https://doi.org/10.1136/bmj.n71

Saadati, Z., Zeki, C. P., & Vatankhah Barenji, R. (2023).

On the development of blockchain-based learning management system as a metacognitive tool to support self-regulation learning in online higher education. *Interactive Learning Environments*, *31*(5). https://doi.org/10.1080/10494820.2021.1920429

Sakhipov, A., Baidildinov, T., Yermaganbetova, M., & Ualiyev, N. (2023). Design of an Educational Platform for Professional Development of Teachers with Elements of Blockchain Technology. *International Journal of Advanced Computer Science and Applications*, *14*(7). https://doi.org/10.14569/IJACSA.2023.0140757

Steiu, M. F. (2020). Blockchain in education: Opportunities, applications, and challenges. *First Monday*, *25*(9). https://doi.org/10.5210/FM.V25I9.10654

Varadarajan, S., Koh, J. H. L., & Daniel, B. K. (2023). A systematic review of the opportunities and challenges of micro-credentials for multiple stakeholders: learners, employers, higher education institutions and government. In *International Journal of Educational Technology in Higher Education* (Vol. 20, Issue 1). https://doi.org/10.1186/s41239-023-00381-x

Wang, L., Quota, M. B. N., Demas, A., & Prouty, B. (2019). Strengthening Accountability for Better Learning Outcomes. In *Expectations and Aspirations: A New Framework for Education in the Middle East and North Africa*. https://doi.org/10.1596/978-1-4648-1234-7_ch14

White, S. (2021). Developing credit based micro-credentials for the teaching profession: An Australian descriptive case study. *Teachers and Teaching: Theory and Practice*, *27*(7). https://doi.org/10.1080/13540602.2021.2003324

Yepes-Nuñez, J. J., Urrútia, G., Romero-García, M., & Alonso-Fernández, S. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Revista Espanola de Cardiologia*, *74*(9). https://doi.org/10.1016/j.recesp.2021.06.016

Zhao, L., Zhang, J., & Jing, H. (2022). Blockchain-Enabled Digital Rights Management for Museum-Digital Property Rights. *Intelligent Automation and Soft Computing*, *34*(3). https://doi.org/10.32604/iasc.2022.029693

.