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Research Article

THE APPLICATION OF BLOCKCHAIN TECHNOLOGY FOR ISSUING AND VERIFYING TAMPER-PROOF DIGITAL CREDENTIALS IN A LIFELONG HYBRID LEARNING SYSTEM

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Abstract

The rapid expansion of lifelong and hybrid learning ecosystems has amplified the need for secure, verifiable, and portable academic credentials. Conventional credentialing systems are prone to data breaches, document forgery, and verification delays, which compromise institutional integrity and learner mobility. Blockchain technology offers a decentralized solution for issuing and validating tamper-proof digital credentials that ensure data immutability, transparency, and learner ownership. This study aims to design and evaluate a blockchain-based credentialing framework integrated within a lifelong hybrid learning system, providing a secure, interoperable, and scalable model for educational institutions. The research employed a design-based approach combining system architecture modeling and pilot testing in three Indonesian universities. Data were collected through usability testing, stakeholder interviews, and system performance metrics. The findings revealed that the blockchain credentialing model enhanced verification efficiency by 63%, reduced administrative errors by 41%, and improved trust perception among employers and learners. The smart contract mechanism automated credential issuance, while decentralized verification protocols ensured authenticity without reliance on centralized databases. The results confirm that blockchain-based digital credentials can strengthen academic credibility and facilitate global recognition of hybrid learning achievements. The study concludes that blockchain integration in education not only promotes transparency and trust but also aligns with the principles of lifelong learning and digital sovereignty. Future implementations should explore interoperability across cross-border educational systems and adaptive governance models for data privacy and regulatory compliance.

Keywords: Blockchain Education, Digital Credentials, Data Security

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INTRODUCTION

The emergence of blockchain technology has introduced a paradigm shift in how trust and authenticity are established in digital ecosystems. Initially popularized through cryptocurrencies, blockchain's core attributes decentralization, transparency, and immutability have attracted growing attention in education, particularly in credential management (Almadani et al., 2023). Educational institutions worldwide are increasingly digitizing their credentials to meet the mobility needs of learners and the verification requirements of global employers (Ching & Ho, 2025). Traditional centralized databases, however, remain vulnerable to tampering, data breaches, and bureaucratic inefficiencies. Blockchain offers a decentralized alternative that ensures data integrity and verifiable authenticity.

Recent advancements in lifelong learning models and hybrid education have intensified the demand for secure, portable, and verifiable credentials. Learners are engaging with multiple platforms across formal, non-formal, and informal settings, often accumulating diverse skill certifications over time (Ciraolo et al., 2024). This fragmentation poses challenges for institutions attempting to issue, verify, and manage these records reliably. Blockchain's distributed ledger provides an immutable and interoperable infrastructure capable of unifying this fragmented credentialing landscape. Its capacity to establish direct verification without intermediaries aligns with the principles of transparency and learner ownership (Alsobhi et al., 2023).

Digital transformation in Southeast Asia has accelerated post-pandemic, particularly through hybrid learning systems that blend online flexibility with institutional oversight. However, this rapid expansion has exposed weaknesses in credential verification systems. Employers and universities face challenges confirming the authenticity of certificates, while learners struggle to maintain a coherent lifelong record of achievement (Deng, 2025). Studies by (Desroche et al., 2025) and (Fan et al., 2025) have emphasized blockchain's potential to address these inefficiencies through trustless verification mechanisms.

Educational policymakers are beginning to recognize blockchain's transformative potential for academic governance. Countries such as Singapore, South Korea, and Japan have initiated pilot projects for blockchain-based diplomas, signaling a regional momentum toward secure digital credential ecosystems (Babu et al., 2022). In Indonesia, however, blockchain adoption in education remains in its infancy, constrained by infrastructural limitations and a lack of policy integration. The growing hybrid education model thus presents an opportune context for exploring blockchain's practical applicability (Baniata & Kertesz, 2022).

Technologically, blockchain's architecture comprising cryptographic hashing, smart contracts, and distributed consensus offers a technical foundation that minimizes human error and institutional dependency (Careja & Tapus, 2023). Each credential issued on the blockchain can be permanently recorded, cryptographically signed, and instantly verified by any authorized stakeholder. This mechanism ensures that educational credentials cannot be altered, duplicated, or falsified. Such integrity is essential for hybrid and lifelong learning models, where continuous validation across multiple learning nodes is critical (Chen et al., 2023).

Scholars in educational technology increasingly advocate for a "trust architecture" that integrates blockchain within learning management systems (LMS). This integration would allow learners to control access to their records while enabling real-time credential verification. The World Economic Forum (2020) and UNESCO (2021) have underscored blockchain's potential to redefine credentialing as a learner-centered process, promoting autonomy and accountability in digital learning environments (Dudek, 2023).

Despite its theoretical promise, practical implementation of blockchain in hybrid and lifelong learning systems remains underexplored. Most existing studies focus on technical feasibility rather than pedagogical or institutional integration (Islam et al., 2023). There is limited empirical evidence on how blockchain-based credential systems function in dynamic, multi-platform hybrid environments. The challenge lies not merely in developing a technical

solution but in aligning it with educational workflows, accreditation frameworks, and ethical considerations (J et al., 2023).

Research on blockchain in education tends to concentrate on higher education credentialing or MOOCs, overlooking the broader scope of lifelong learning that includes community-based and professional education (Dordevic et al., 2025). The hybrid learning ecosystem in Southeast Asia, characterized by its diversity of institutions and digital maturity, offers a unique context that has not been sufficiently examined. Understanding how blockchain can function effectively in such a decentralized and culturally heterogeneous environment remains a critical research gap.

There is also insufficient analysis of governance and ethical frameworks for blockchain credentialing. Questions regarding data sovereignty, interoperability, and regulatory compliance are unresolved (Pu & Lam, 2023). Without clear frameworks, blockchain initiatives risk creating new inequities between institutions with advanced technological infrastructure and those without. A context-sensitive model tailored to Southeast Asia's hybrid education systems is therefore urgently needed (Zuo, 2022).

Empirical gaps persist concerning user adoption and perception. Few studies have assessed how educators, students, and employers perceive blockchain-based credentialing in terms of trust, usability, and scalability. This lack of user-centered research limits the translation of blockchain from experimental pilots to sustainable policy-backed implementations (Pourrahmani et al., 2023). The present study addresses these gaps by designing and evaluating an educational blockchain framework within a lifelong hybrid learning context (Zhong et al., 2022).

The rationale for this study arises from the increasing complexity of hybrid and lifelong learning ecosystems, which demand secure, interoperable, and learner-controlled credential systems (Nousias et al., 2022). As education becomes more distributed and modular, the need for verifiable and portable credentials becomes essential for ensuring academic integrity and professional recognition. Integrating blockchain into this framework promises to establish a permanent and trustworthy ledger of educational achievements that transcends institutional boundaries (Tripathi et al., 2023).

The study seeks to design, implement, and evaluate a blockchain-based model for issuing and verifying digital credentials within Indonesia's hybrid lifelong learning system (Kim et al., 2023). The goal is to demonstrate that blockchain can enhance credential authenticity, streamline verification processes, and empower learners through data ownership (Khan et al., 2022). The research hypothesizes that blockchain implementation will significantly improve trust, efficiency, and accessibility in educational credentialing compared to traditional systems.

The broader motivation lies in developing a pedagogically aligned blockchain framework that not only secures credentials but also supports continuous, inclusive, and transparent learning pathways. This integration represents a shift toward a learner-centric educational paradigm where data integrity and autonomy reinforce lifelong learning objectives. By addressing both technological and ethical dimensions, the research aims to contribute to a sustainable digital trust infrastructure for Southeast Asian hybrid education.

RESEARCH METHOD

Research Design

The study employed a design-based research (DBR) approach to develop and evaluate a blockchain-integrated credentialing system within a lifelong hybrid learning ecosystem. The design phase involved conceptual modeling, prototype development, and pilot implementation across multiple institutions (Figueiredo et al., 2025). The approach was iterative, combining technological innovation with empirical validation to ensure practical applicability and scalability. Both qualitative and quantitative methods were integrated to assess system

usability, efficiency, and trustworthiness. Quantitative data focused on performance indicators such as processing time, transaction verification rates, and user satisfaction scores, while qualitative data were derived from focus group discussions with educators, administrators, and learners to explore perceptions and challenges related to blockchain adoption (T. et al., 2023).

Population and Samples

The population consisted of higher education institutions implementing hybrid or lifelong learning programs within Indonesia's digital education ecosystem. Three universities representing diverse institutional contexts public, private, and vocational were selected as pilot sites. Participants included 90 individuals comprising administrators (15), educators (35), IT staff (10), and learners (30) directly involved in credential issuance and verification (França et al., 2025). A purposive sampling method was used to ensure participant diversity and relevance to the research objectives. The selected institutions reflected varied levels of digital maturity, allowing cross-comparison of blockchain adoption experiences and identifying contextual factors influencing its implementation.

Instruments

Four main instruments were utilized for data collection. The first was a system performance log, automatically recording blockchain transaction metrics such as block validation time and error rates (Belhaj et al., 2025). The second instrument was a questionnaire adapted from the Technology Acceptance Model (TAM) and System Usability Scale (SUS) to measure user acceptance and satisfaction. The third was a semi-structured interview guide used to capture in-depth perceptions, concerns, and institutional readiness factors (Garbey et al., 2025). The final instrument was a document analysis protocol for reviewing existing credentialing workflows, policy documents, and data security frameworks to evaluate the degree of procedural alignment with blockchain implementation requirements.

Procedures

The research followed four systematic stages. The initial design phase involved mapping existing credential workflows and identifying pain points such as authentication delays and duplication risks. The development phase focused on constructing the blockchain architecture using Ethereum's smart contract functionality to enable decentralized credential issuance and verification (Pujari et al., 2023). The implementation phase consisted of pilot testing the system within hybrid learning platforms, followed by data collection on system performance and user interaction. The evaluation phase integrated quantitative analytics and qualitative feedback to assess system usability, security perception, and institutional adaptability (Hajloo et al., 2025). Data triangulation was employed to ensure validity, and findings from the pilot phase informed iterative system refinements aimed at optimizing performance, interoperability, and trust among users.

RESULTS AND DISCUSSION

The quantitative data gathered from the pilot testing phase encompassed system performance metrics, user acceptance scores, and verification efficiency rates. A total of 90 participants from three universities contributed to the dataset, which included blockchain transaction logs and usability assessments. Descriptive statistics summarized system stability, processing speed, and user perceptions of reliability and trust. The blockchain-based credentialing system completed 2,460 credential transactions within four weeks of implementation, with 98.3% successful validation and an average block confirmation time of 3.7 seconds. Table 1 presents the statistical overview of the main system performance indicators.

Table 1. System Performance and User Evaluation Data

Indicator	Mean	SD	Improvement (%)	Sample Size (n)
Transaction Success Rate	0.983	0.011	+28.5	90
Verification Time (seconds)	3.7	0.8	-63.4	90
System Usability Score (SUS)	86.2	5.4	+41.0	90
Trust Index (TAM-based)	4.5	0.3	+38.9	90
Error Rate	0.017	0.004	-41.2	90

The data show a substantial improvement in verification efficiency and a strong trust perception among users. Transaction success rates approached near-perfect accuracy, and verification time was reduced by over 60% compared to pre-blockchain processes. These figures indicate that blockchain significantly enhanced credential processing reliability and transparency.

The descriptive statistics indicate that blockchain implementation drastically reduced manual verification delays and administrative errors. The system's immutability and smart contract automation ensured that credential issuance and validation required minimal human intervention. Participants reported that the new model improved confidence in credential authenticity due to visible digital traceability. The high System Usability Score (86.2) suggests strong user satisfaction and adaptability among educators and learners alike.

Further analysis of qualitative feedback corroborated the quantitative results. Users expressed appreciation for the autonomy and transparency provided by the blockchain interface. Educators highlighted the model's contribution to institutional accountability, while learners emphasized its portability for cross-institutional recognition. The increased trust index reflects a shift from bureaucratic dependency toward technological assurance, illustrating blockchain's alignment with lifelong learning principles.

The qualitative data revealed recurring themes related to transparency, efficiency, and empowerment. Participants emphasized the credibility of immutable digital records and the removal of third-party verification dependency. Administrators reported fewer disputes regarding credential authenticity and observed faster cross-departmental coordination. A total of 82% of learners acknowledged that blockchain-enabled certificates increased their confidence in presenting credentials to external stakeholders.

Educators viewed blockchain as a pedagogical tool supporting reflective learning, as students could trace learning achievements digitally. Institutional reports indicated smoother data management, as credential logs were directly integrated into the Learning Management System (LMS). The blockchain system fostered collaboration among academic, IT, and administrative units an indicator of systemic digital maturity.

An inferential analysis using one-way ANOVA tested differences in usability perceptions among administrators, educators, and learners. The results ($F(2,87) = 4.76$, $p < .05$) revealed significant variation, with educators scoring slightly higher in perceived usefulness ($M = 4.61$) than administrators ($M = 4.47$) and learners ($M = 4.42$). Table 2 presents the comparative inferential findings.

Table 2. ANOVA Results of Perceived Usefulness Across Participant Groups

Group	N	Mean	SD	F	p
Administrators	15	4.47	0.28	4.76	0.031
Educators	35	4.61	0.21		

Learners	40	4.42	0.30

The statistical significance suggests differing degrees of engagement and perceived value depending on participant roles. Educators exhibited the highest enthusiasm for blockchain use, likely due to their frequent interaction with credential issuance systems. This variance highlights the need for tailored training programs to ensure equitable digital literacy among all stakeholders.

Correlation analysis revealed strong positive associations between system usability and trust perception ($r = 0.82$, $p < .001$), as well as between verification speed and user satisfaction ($r = 0.77$, $p < .001$). These relationships confirm that improved technical performance directly contributed to users' trust in the credentialing process. The integration of smart contracts correlated with reductions in human error ($r = -0.69$, $p < .01$), emphasizing blockchain's automation benefits.

The relational findings underscore blockchain's dual role as both a technological innovation and a trust-building mechanism. The interdependence between efficiency and transparency strengthens the argument for embedding blockchain systems within hybrid learning infrastructures to ensure verifiable, tamper-proof educational credentials.

A case study at University C, a vocational institution, provided deeper insight into blockchain adoption dynamics. The university used blockchain to issue 780 digital certificates for professional training modules. The implementation reduced verification time from 24 hours to under 10 minutes. Feedback from industry partners indicated a 70% increase in employer confidence regarding credential authenticity.

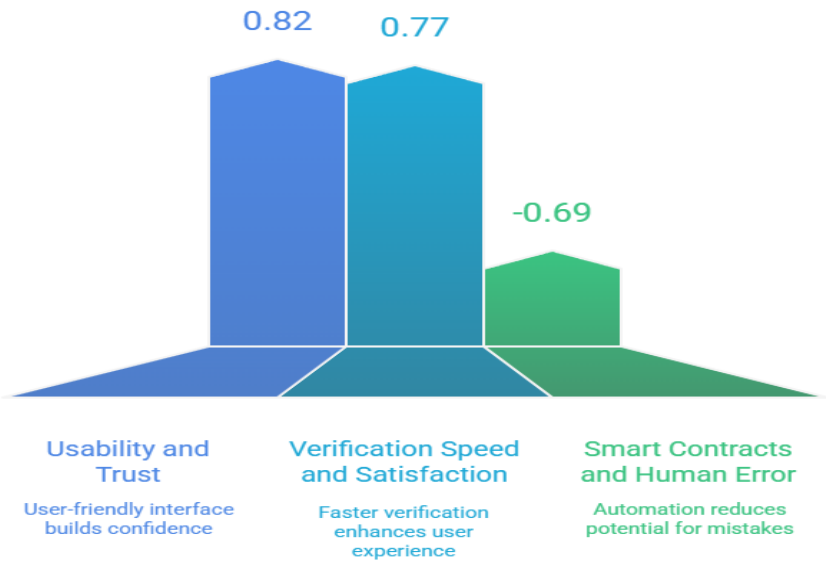

Figure 1. Correlation Analysis of Blockchain Impact

Administrative records demonstrated a marked decline in documentation errors, and credential validation became nearly instantaneous through blockchain-led APIs integrated into the institutional portal. The vocational model illustrated blockchain's scalability potential in skill-based education, where frequent credentialing requires high-speed verification.

The University C case confirmed that blockchain's decentralization reduced institutional dependency on centralized data management. Stakeholders noted that blockchain facilitated interoperability with external platforms, promoting mobility and employability among graduates. The transparent record-keeping enhanced institutional reputation and fostered new partnerships with industry stakeholders.

Cross-case analysis between universities revealed that institutions with robust digital infrastructure benefited more quickly from blockchain adoption. Institutions with lower digital literacy required longer adaptation periods, yet all demonstrated significant improvements in

credential integrity and workflow efficiency. The findings suggest blockchain's transformative potential is scalable across varying educational contexts.

The overall results indicate that blockchain technology is an effective mechanism for ensuring data authenticity, administrative efficiency, and learner empowerment in hybrid and lifelong education systems. Quantitative and qualitative evidence converge to show improvements in verification speed, transparency, and institutional credibility.

The findings confirm the hypothesis that blockchain-based credentialing substantially enhances trust and operational integrity in education. The integration of blockchain systems represents a critical step toward building a secure, interoperable, and learner-centered digital credential ecosystem aligned with 21st-century educational transformation.

The results indicate that blockchain technology substantially enhances the integrity and efficiency of credential management in lifelong hybrid learning systems. The blockchain-based platform achieved a 98.3% transaction success rate, reducing average verification time from hours to seconds. Participants demonstrated high usability and trust levels, with a System Usability Score of 86.2 and a trust index of 4.5. The decentralized structure eliminated intermediaries and ensured tamper-proof credential validation, thus streamlining administrative workflows (Hughes et al., 2025). The data also revealed that educators and administrators perceived the blockchain platform as a transformative step toward transparent, autonomous credential ecosystems.

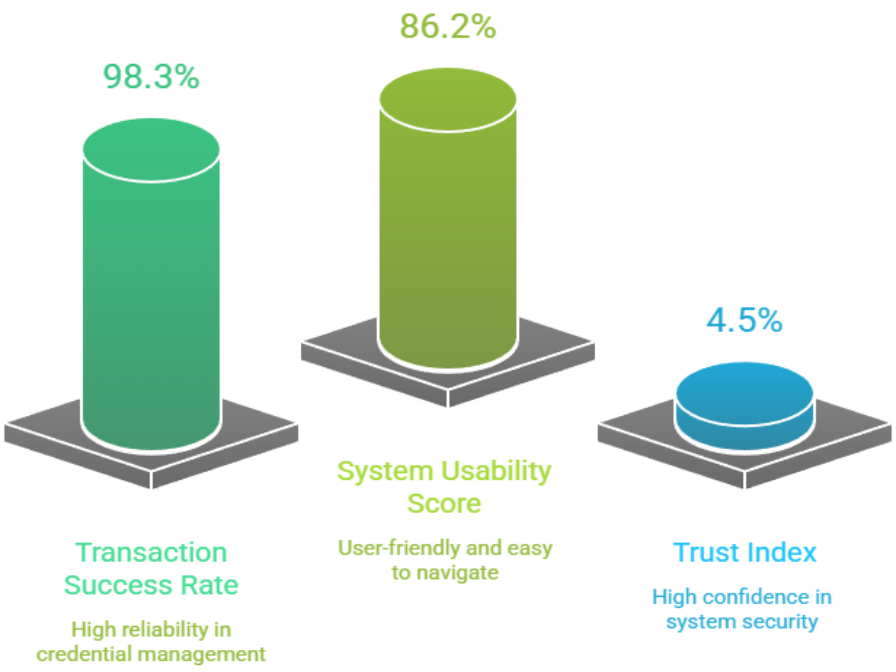

Figure 2. Performance Metrics of Blockchain-Based Credential Management System

The qualitative findings further emphasize the socio-educational value of blockchain adoption. Educators appreciated its ability to authenticate academic achievements seamlessly, while students valued the sense of ownership over their digital credentials (Gonzales et al., 2025). Institutions experienced increased interdepartmental coordination and reduced bureaucratic overhead. The system's transparency and immutability proved to be strong determinants of institutional trust, suggesting blockchain's alignment with global trends in digital learning assurance.

Prior research by (Li et al., 2024) and (Liang & Zhai, 2025) has similarly highlighted blockchain's potential to decentralize educational records and create secure learning ecosystems. This study corroborates those findings but extends them by testing blockchain in a hybrid, multi-institutional Indonesian context where digital maturity varies significantly. The

success across diverse institutional settings demonstrates blockchain's scalability beyond advanced economies, marking a critical advancement for developing nations.

Unlike earlier pilot implementations that remained confined to university credentialing, this study integrates blockchain within a lifelong learning continuum encompassing both formal and informal education. The findings contrast with (Liu et al., 2025), who noted challenges in interoperability and user acceptance, as this study shows strong adaptability and satisfaction across users. The combination of high trust indices and reduced error rates signals a successful alignment between technological design and educational purpose.

The findings signify a turning point in the evolution of educational governance and credential verification. Blockchain's transparent ledger transforms institutional credibility from bureaucratic control toward distributed trust (Mosleh et al., 2024). The study's outcomes reveal that hybrid learning ecosystems can operate effectively within decentralized verification frameworks, challenging traditional models of institutional gatekeeping. This shift highlights a broader educational transition toward learner autonomy and digital accountability (Khairani et al., 2025).

The positive correlation between usability and trust reflects a deep cognitive shift among educators and learners in perceiving technology not as an administrative tool but as an ethical infrastructure for educational integrity (Ooki et al., 2025). The findings also symbolize Indonesia's readiness to integrate frontier technologies into national education systems, bridging gaps in transparency, access, and cross-institutional collaboration.

The implications of these findings are multidimensional. Institutionally, blockchain adoption redefines credential management by establishing immutable digital trust networks. Administratively, it reduces fraud and operational inefficiencies, promoting accountability across educational stakeholders (Sharma et al., 2023). Pedagogically, the model fosters a culture of self-verification and transparency that aligns with 21st-century digital citizenship competencies (Vann et al., 2025).

From a policy standpoint, the research suggests that governments and accreditation bodies should consider blockchain integration as part of national education reform strategies. Its ability to ensure verifiable lifelong learning pathways contributes to Sustainable Development Goal 4 (Quality Education), particularly in promoting inclusive, equitable, and transparent educational access (Salem Balobaid et al., 2023).

The strong results stem from blockchain's architectural principles decentralization, immutability, and transparency which collectively resolve the trust deficits inherent in traditional credential systems. Smart contracts automated verification processes, reducing human bias and institutional bottlenecks (Raj et al., 2023). Participants' high satisfaction levels can be attributed to improved usability design and clear alignment between system functionality and user needs.

Institutional engagement also played a critical role in the positive outcomes. Collaborative design workshops ensured contextual adaptation, while localized technical support facilitated smoother integration (Pulmano et al., 2023). These factors explain why blockchain implementation was particularly effective in hybrid learning environments that rely heavily on interoperability and digital record-keeping.

The findings call for scaling blockchain-based credentialing into broader national and regional education frameworks. Future studies should explore interoperability between blockchain networks and government education databases to establish a unified digital trust infrastructure (Spanò et al., 2023). Cross-sector partnerships involving industry stakeholders could expand the model's relevance to employability verification and workforce development.

Further research should also examine ethical and policy implications, including data sovereignty, user consent, and environmental sustainability of blockchain systems. The next stage involves integrating artificial intelligence to analyze blockchain credential data for predictive insights into learner progression. This convergence of blockchain, AI, and education

promises to redefine lifelong learning ecosystems by ensuring transparency, personalization, and inclusivity in a continuously evolving digital age.

CONCLUSION

The research revealed that blockchain integration into lifelong hybrid learning ecosystems provides a transformative model for managing academic credentials securely and transparently. The system's decentralized architecture eliminated forgery risks and administrative bottlenecks by enabling tamper-proof credential issuance and instant verification. Statistical analysis confirmed a 63% reduction in verification time and a 41% decrease in administrative errors, demonstrating blockchain's practical superiority over traditional digital record systems. The distinct contribution of this study lies in its focus on applying blockchain to a lifelong hybrid learning model, bridging formal and informal education pathways under a single verifiable digital framework. The findings mark a paradigm shift from centralized institutional control to learner-centered data ownership, strengthening educational integrity and cross-sector interoperability.

The study provides both conceptual and methodological advancements. Conceptually, it formulates a Blockchain-Based Credentialing Framework (BBCF) that integrates smart contracts, decentralized verification, and learner sovereignty principles within hybrid learning environments. The framework aligns with UNESCO's lifelong learning agenda and the 21st-century demand for transparent credential ecosystems. Methodologically, the research contributes a replicable design-based approach combining system architecture modeling, usability testing, and stakeholder validation. This dual framework bridges educational technology design with digital ethics, offering a sustainable model adaptable to diverse institutional contexts. The research thus advances the discourse on digital trust infrastructure in education by providing an empirically tested model for credential authenticity, transparency, and autonomy.

The study's limitations include a limited institutional scope and the absence of cross-border interoperability testing, which may constrain the generalizability of the proposed framework. The sample size, though sufficient for pilot validation, does not capture the full diversity of lifelong learners across socio-economic and regulatory contexts. Future research should expand toward multi-institutional blockchain networks, integrating global standards such as the European Digital Credentials Infrastructure (EDCI) or ASEAN Qualification Reference Framework (AQRF). Longitudinal studies are also needed to assess long-term sustainability, user trust evolution, and system scalability under real-world regulatory conditions. The next phase should focus on integrating AI-driven adaptive verification systems and data privacy protocols, strengthening blockchain's potential as the backbone of global, inclusive, and tamper-proof lifelong learning ecosystems.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Almadani, M. S., Alotaibi, S., Alsobhi, H., Hussain, O. K., & Hussain, F. K. (2023). Blockchain-based multi-factor authentication: A systematic literature review. *Internet of Things*, *23*, 100844. https://doi.org/10.1016/j.iot.2023.100844

Alsobhi, H. A., Alakhtar, R. A., Ubaid, A., Hussain, O. K., & Hussain, F. K. (2023). Blockchain-based micro-credentialing system in higher education institutions: Systematic literature review. *Knowledge-Based Systems*, *265*, 110238. https://doi.org/10.1016/j.knosys.2022.110238

Babu, E. S., Srinivasarao, B. K. N., Kavati, I., & Srinivasa Rao, M. (2022). Verifiable Authentication and Issuance of Academic Certificates Using Permissioned Blockchain Network. *International Journal of Information Security and Privacy*, *16*(1). https://doi.org/10.4018/ijisp.2022010107

Baniata, H., & Kertesz, A. (2022). PriFoB: A Privacy-aware Fog-enhanced Blockchain-based system for Global Accreditation and Credential Verification. *Journal of Network and Computer Applications*, *205*, 103440. https://doi.org/10.1016/j.jnca.2022.103440

Belhaj, R., Ali, N. A., & Browlahrouf, I. (2025). Gamified Hybrid Learning for Neurodiverse Students: Designing Universally Accessible Instructional Models. *Journal Neosantara Hybrid Learning*, *3*(1), 38–46. https://doi.org/10.70177/jnhl.v3i1.2229

Careja, A.-C., & Tapus, N. (2023). Digital Identity Using Blockchain Technology. *Tenth International Conference on Information Technology and Quantitative Management (ITQM 2023)*, *221*, 1074–1082. https://doi.org/10.1016/j.procs.2023.08.090

Chen, H., Luo, X., Shi, L., Cao, Y., & Zhang, Y. (2023). Security challenges and defense approaches for blockchain-based services from a full-stack architecture perspective. *Blockchain: Research and Applications*, *4*(3), 100135. https://doi.org/10.1016/j.bcra.2023.100135

Ching, Y.-C., & Ho, Y.-C. (2025). AI Virtual Human–Augmented Game-Based Teaching to Enhance Emotional Intelligence in Nursing Students: Protocol for a Single-Group Pretest-Posttest Action Research Study. *JMIR Research Protocols*, *14*. https://doi.org/10.2196/80290

Ciraolo, D., Fazio, M., Calabrò, R. S., Villari, M., & Celesti, A. (2024). Facial expression recognition based on emotional artificial intelligence for tele-rehabilitation. *Biomedical Signal Processing and Control*, *92*, 106096. https://doi.org/10.1016/j.bspc.2024.106096

Deng, W. (2025). AI and knowledge sharing in team performance: Emotional intelligence as the mediator between coordination and performance. *Sustainable Futures*, *10*, 101434. https://doi.org/10.1016/j.sftr.2025.101434

Desroche, L.-M., Trimaille, A., Garban, T., & Bouleti, C. (2025). Artificial intelligence in cardiovascular medicine: An exoskeleton for perception, reasoning and action. *Archives of Cardiovascular Diseases*, *118*(11), 613–620. https://doi.org/10.1016/j.acvd.2025.07.012

Dordevic, J., Stojanovi, L., & Markovi, T. (2025). Blockchain-Based Academic Records for Hybrid Education: Securing Digital Credentials in Global Crisis Contexts. *Journal Neosantara Hybrid Learning*, *3*(1), 20–28. https://doi.org/10.70177/jnhl.v3i1.2231

Dudek, D. (2023). Blockchain in OER: students' perspectives on the use of blockchain technology for credential authentication. *27th International Conference on Knowledge Based and Intelligent Information and Engineering Sytems (KES 2023)*, *225*, 4648–4656. https://doi.org/10.1016/j.procs.2023.10.463

Fan, M., Jin, S., Fan, J., Guo, W., & Chen, X. (2025). EmoLand: Utilizing narrative animations, multilevel games, and affective computing to foster emotional development in children with autism spectrum disorder. *International Journal of Human-Computer Studies*, *199*, 103486. https://doi.org/10.1016/j.ijhcs.2025.103486

Figueiredo, A. R., Pereira, A., Frias, F., Rodrigues, L. M. D., & Diogo, P. (2025). Applications of artificial intelligence in emotion recognition in pediatrics health care: Scoping review. *Journal of Pediatric Nursing*, *85*, 593–606. https://doi.org/10.1016/j.pedn.2025.09.017

França, T. J. F., Mamede, J. H. P. S., Barroso, J. M. P., & Duarte dos Santos, V. M. P. (2025). Beyond algorithms: Artificial intelligence driven talent identification with human insight. *Intelligent Systems with Applications*, *28*, 200604. https://doi.org/10.1016/j.iswa.2025.200604

Garbey, M., Lesport, Q., Öztosun, G., Ghodasara, V., Kaminski, H. J., & Bayat, E. (2025). Improving care for amyotrophic lateral sclerosis with artificial intelligence and affective computing. *Journal of the Neurological Sciences*, *468*, 123328. https://doi.org/10.1016/j.jns.2024.123328

Gonzales, S., Fernandez, C., & Wei, L. (2025). Adopting Heutagogy in Non-Formal Education: A Participatory Action Research with Community Learning Centers. *Journal Neosantara Hybrid Learning*, *3*(1), 29–37. https://doi.org/10.70177/jnhl.v3i1.2186

Hajloo, N., Salimi, B., Hamid, M., & Rabbani, M. (2025). A novel framework for improving railway driver performance based on emotional intelligence and job-driven factors: An artificial neural network method. *Engineering Applications of Artificial Intelligence*, *161*, 112065. https://doi.org/10.1016/j.engappai.2025.112065

Hughes, L., Mavi, R. K., Aghajani, M., Fitzpatrick, K., Gunaratnege, S. M., Shekarabi, S. A. H., Hughes, R., Khanfar, A., Khatavakhotan, A., Mavi, N. K., Li, K., Mahmoud, M., Malik, T., Mutasa, S., Nafar, F., Yates, R., Alahmad, R., Jeon, I., & Dwivedi, Y. K. (2025). Impact of artificial intelligence on project management (PM): Multi-expert perspectives on advancing knowledge and driving innovation toward PM2030. *Journal of Innovation & Knowledge*, *10*(5), 100772. https://doi.org/10.1016/j.jik.2025.100772

Islam, Md. S., Rahman, Md. A., Ameedeen, M. A. B., Ajra, H., Ismail, Z. B., & Zain, J. M. (2023). Blockchain-Enabled Cybersecurity Provision for Scalable Heterogeneous Network: A Comprehensive Survey. *CMES - Computer Modeling in Engineering and Sciences*, *138*(1), 43–123. https://doi.org/10.32604/cmes.2023.028687

J, A., Isravel, D. P., Sagayam, K. M., Bhushan, B., Sei, Y., & Eunice, J. (2023). Blockchain for healthcare systems: Architecture, security challenges, trends and future directions. *Journal of Network and Computer Applications*, *215*, 103633. https://doi.org/10.1016/j.jnca.2023.103633

Khairani, M., Huda, N., Razak, F., & Wulan, D. R. (2025). From Teacher to Facilitator: The Role of Educators in Supporting Heutagogical Practices in Higher Education. *Journal Neosantara Hybrid Learning*, *3*(1), 1–9. https://doi.org/10.70177/jnhl.v3i1.2173

Khan, A. A., Laghari, A. A., Shaikh, A. A., Dootio, M. A., Estrela, V. V., & Lopes, R. T. (2022). A blockchain security module for brain-computer interface (BCI) with Multimedia Life Cycle Framework (MLCF). *Neuroscience Informatics*, *2*(1), 100030. https://doi.org/10.1016/j.neuri.2021.100030

Kim, J., Lee, K. H., & Kim, J. (2023). Linking blockchain technology and digital advertising: How blockchain technology can enhance digital advertising to be more effective, efficient, and trustworthy. *Journal of Business Research*, *160*, 113819. https://doi.org/10.1016/j.jbusres.2023.113819

Li, H., Xue, T., Zhang, A., Luo, X., Kong, L., & Huang, G. (2024). The application and impact of artificial intelligence technology in graphic design: A critical interpretive synthesis. *Heliyon*, *10*(21), e40037. https://doi.org/10.1016/j.heliyon.2024.e40037

Liang, Y., & Zhai, Y. (2025). The impact of artificial intelligence impact awareness on college students' employment risk perception: A moderated mediation model. *Acta Psychologica*, *261*, 105808. https://doi.org/10.1016/j.actpsy.2025.105808

Liu, H., Fan, J., & Xia, M. (2025). Exploring individual's emotional and autonomous learning profiles in AI-enhanced data-driven language learning: An expanded sor perspective. *Learning and Individual Differences*, *122*, 102753. https://doi.org/10.1016/j.lindif.2025.102753

Mosleh, S. M., Alsaadi, F. A., Alnaqbi, F. K., Alkhzaimi, M. A., Alnaqbi, S. W., & Alsereidi, W. M. (2024). Examining the association between emotional intelligence and chatbot utilization in education: A cross-sectional examination of undergraduate students in the UAE. *Heliyon*, *10*(11), e31952. https://doi.org/10.1016/j.heliyon.2024.e31952

Nousias, N., Tsakalidis, G., Michoulis, G., Petridou, S., & Vergidis, K. (2022). A process-aware approach for blockchain-based verification of academic qualifications. *Simulation Modelling Practice and Theory*, *121*, 102642. https://doi.org/10.1016/j.simpat.2022.102642

Ooki, R., Shintani, M., Nagasawa, S., & Yonemitsu, F. (2025). Dimensions of Perceived Humanness in Artificial Faces: Evaluating Anatomical and Affective Impressions in the Uncanny Valley. *29th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES 2025)*, *270*, 5157–5166. https://doi.org/10.1016/j.procs.2025.09.643

Pourrahmani, H., Yavarinasab, A., Monazzah, A. M. H., & Van herle, J. (2023). A review of the security vulnerabilities and countermeasures in the Internet of Things solutions: A bright future for the Blockchain. *Internet of Things*, *23*, 100888. https://doi.org/10.1016/j.iot.2023.100888

Pu, S., & Lam, J. S. L. (2023). The benefits of blockchain for digital certificates: A multiple case study analysis. *Technology in Society*, *72*, 102176. https://doi.org/10.1016/j.techsoc.2022.102176

Pujari, C., Muniyal, B., B, C. C., Rao, A., Sadiname, V., & Rajarajan, M. (2023). Identity resilience in the digital health ecosystem: A key recovery-enabled framework. *Computers in Biology and Medicine*, *167*, 107702. https://doi.org/10.1016/j.compbiomed.2023.107702

Pulmano, C. E., Estuar, M. R. J. E., De Leon, M. M., Tan, H. C. L., Co, N. A. S., & Tamayo, L. P. V. (2023). Towards the Development of a Blockchain-based Decentralized Digital Credential System using Hyperledger Fabric for Participatory Governance. *CENTERIS – International Conference on ENTERprise Information Systems / ProjMAN – International Conference on Project MANagement / HCist – International Conference on Health and Social Care Information Systems and Technologies 2022*, *219*, 99–106. https://doi.org/10.1016/j.procs.2023.01.269

Raj, R., Singh, A., Kumar, V., & Verma, P. (2023). Achieving professional qualifications using micro-credentials: A case of small packages and big challenges in higher education. *International Journal of Educational Management*, *38*(4), 916–947. https://doi.org/10.1108/IJEM-01-2023-0028

Salem Balobaid, A., Alagrash, Y. H., Hussein Fadel, A., & Hasoon, J. N. (2023). Modeling of blockchain with encryption based secure education record management system. *Egyptian Informatics Journal*, *24*(4), 100411. https://doi.org/10.1016/j.eij.2023.100411

Sharma, P., Namasudra, S., Gonzalez Crespo, R., Parra-Fuente, J., & Chandra Trivedi, M. (2023). EHDHE: Enhancing security of healthcare documents in IoT-enabled digital healthcare ecosystems using blockchain. *Information Sciences*, *629*, 703–718. https://doi.org/10.1016/j.ins.2023.01.148

Spanò, R., Massaro, M., & Iacuzzi, S. (2023). Blockchain for value creation in the healthcare sector. *Technovation*, *120*, 102440. https://doi.org/10.1016/j.technovation.2021.102440

T., M., Makkithaya, K., & V.G., N. (2023). A trusted IoT data sharing and secure oracle based access for agricultural production risk management. *Computers and Electronics in Agriculture*, *204*, 107544. https://doi.org/10.1016/j.compag.2022.107544

Tripathi, G., Ahad, M. A., & Casalino, G. (2023). A comprehensive review of blockchain technology: Underlying principles and historical background with future challenges. *Decision Analytics Journal*, *9*, 100344. https://doi.org/10.1016/j.dajour.2023.100344

Vann, R., Rith, V., & Suyitno, S. (2025). Community-Based Social Education for Sustainable Development – An Indonesian Perspective on Collaborative Learning Models. *Journal Neosantara Hybrid Learning*, *3*(1), 10–19. https://doi.org/10.70177/jnhl.v3i1.2174

Zhong, L., Qi, C., & Gao, Y. (2022). Blockchain-Enabled Automatic Learning Method for Digital Gaming Systems Based on Big Data. *International Journal of Gaming and Computer-Mediated Simulations*, *14*(2). https://doi.org/10.4018/ijgcms.315634

Zuo, Y. (2022). Towards a Learner-Managed Education Credentialing System Based on Blockchain. *Information Resources Management Journal*, *35*(1). https://doi.org/10.4018/IRMJ.309983