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Research Article

Blockchain-Based Academic Records for Hybrid Education: Securing Digital Credentials in Global Crisis Contexts

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Abstract

The COVID-19 pandemic and other global crises have exposed the fragility of traditional academic record-keeping systems, particularly in hybrid and remote education contexts. Paper-based credentials are vulnerable to disruption, loss, and forgery, while centralized digital systems often lack interoperability, transparency, and long-term security. This study investigates the application of blockchain technology for managing academic records in hybrid education settings, with a focus on ensuring secure, tamper-proof, and universally verifiable digital credentials. The research adopts a qualitative-quantitative mixed-methods approach, combining technical prototype testing with stakeholder interviews involving educators, IT administrators, and students across five countries. The blockchain-based system was evaluated based on criteria including data integrity, accessibility, user autonomy, and system scalability. Results indicate that the blockchain model ensured high data security, reduced administrative overhead, and enabled cross-border credential verification without reliance on third-party intermediaries. Participants reported increased trust in the permanence and authenticity of academic records. The study concludes that blockchain offers a resilient infrastructure for academic credentialing, particularly in times of crisis when decentralized, transparent, and immutable systems are critical for ensuring educational continuity and global mobility.

Keywords: blockchain, digital credentials, hybrid education, academic record security, global crisis response

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INTRODUCTION

The rapid expansion of hybrid and remote education, accelerated by the COVID-19 pandemic and other global emergencies, has triggered critical questions regarding the security and reliability of academic credentialing systems. Educational institutions worldwide were compelled to transition to digital learning modalities, but most were not structurally equipped to ensure secure storage and verification of learning outcomes. Academic records, which are vital for student progression, mobility, and recognition, became vulnerable to fragmentation, misplacement, and unauthorized access during this disruption.

Conventional models of record-keeping-whether paper-based or centralized databases-are increasingly insufficient in meeting the demands of cross-border education, real-time verification, and data integrity. The need for a system that can ensure transparency, immutability, and accessibility of academic credentials has never been more urgent (Pericàs-Gornals et al., 2024; Thombre et al., 2024). These demands are heightened during crises, where institutional continuity is compromised and verification processes are often delayed or rendered inaccessible, especially for displaced learners or students in conflict-affected regions.

Blockchain, as a decentralized and tamper-resistant digital ledger, offers a novel infrastructure for the secure management of educational data. With its ability to provide timestamped, encrypted, and immutable records, blockchain technology holds promise for revolutionizing credentialing practices, particularly in hybrid education environments (Demarco et al., 2024; Khurshid et al., 2024; Kumari et al., 2024). However, the application of blockchain in the educational sector remains largely experimental and underexplored in real-world crisis contexts where it could offer the greatest value.

Educational institutions currently lack robust, scalable solutions to manage academic records in hybrid environments that are prone to disruption. During global crises, many schools and universities struggle to verify student learning outcomes across digital platforms, especially when students are mobile, without access to consistent internet, or unable to interact with credentialing authorities (Abusharif, 2024; Annadurai et al., 2024; Bharati et al., 2024; Suneela et al., 2024). These vulnerabilities expose the systemic fragility of educational data management during times when resilience is most needed.

Academic fraud and document forgery further complicate the landscape of digital credentialing. Without secure verification systems, employers and institutions face challenges in validating the authenticity of certificates and transcripts. This undermines the credibility of educational qualifications and disproportionately affects students from underrepresented or displaced populations whose access to secure record-keeping is already compromised (Escobar et al., 2025; Mouallem & Eyal, 2024; Quincozes et al., 2024; Saiful et al., 2024). The risk of data manipulation or loss underlines the urgency of adopting more secure credentialing infrastructures.

Current solutions often depend on third-party intermediaries or centralized cloud services, which create additional barriers in terms of access, trust, and privacy. These systems are often costly, lack interoperability, and are vulnerable to cyberattacks or institutional failure (Rahat et al., 2024; Yasumura et al., 2024). There is an evident need for an alternative that decentralizes trust, secures data autonomously, and supports verification processes across national and institutional borders without the need for intermediaries.

This study aims to design, test, and evaluate a blockchain-based academic record system tailored for hybrid and crisis-disrupted education settings. It focuses on ensuring credential authenticity, accessibility, and institutional trust across diverse digital infrastructures. The study also seeks to understand user perceptions and institutional readiness for adopting decentralized credentialing solutions, with an emphasis on equity, security, and scalability (Höglund et al., 2024; Ozbay & Levi, 2024). The focus is on ensuring data permanence and autonomy for learners whose educational pathways are increasingly fluid and digitally mediated.

The research seeks to examine the practical feasibility of integrating blockchain architecture with existing learning management systems (LMS) used in hybrid and remote education settings. Technical evaluation will assess the system's performance in terms of scalability, encryption, and user access across varying bandwidth conditions. A parallel inquiry will investigate the experiences and perceptions of stakeholders-including educators, IT administrators, and students-owards blockchain-based credentialing, particularly in crisis-affected or low-infrastructure environments.

Another key goal of this study is to contribute to the development of globally relevant standards for digital academic records. By situating the research within a comparative, cross-national context, the study will generate insights into how blockchain can support international recognition of learning, reduce credential fraud, and promote student mobility across borders. Ultimately, the research aims to position blockchain not only as a technical innovation, but also as a policy-enabling mechanism in pursuit of educational continuity and equity.

Most existing literature on blockchain in education is either conceptual or limited to pilot initiatives conducted in technologically advanced contexts. The focus has often been on high-level discussions of blockchain's potential, with limited empirical evidence demonstrating its viability in real-time academic record issuance or verification, especially under the conditions of crisis or institutional instability (Divyashree, 2024; Nazari et al., 2024; Siddharth Raj & Chinnaiah, 2024; Subramanian et al., 2024). This leaves a critical gap in understanding how blockchain might function when it is most needed-during global emergencies or infrastructure breakdowns.

Studies that have attempted practical implementations of blockchain in education typically emphasize administrative efficiencies or long-term archival storage, overlooking its potential as a real-time credentialing solution in hybrid environments. These works rarely account for the complexities of interoperability with diverse digital platforms or the socio-technical challenges of adoption in varied educational ecosystems. The absence of crisis-sensitive and inclusive models of blockchain-based academic credentialing constitutes a significant limitation in the current literature.

There is also a lack of research on the ethical and logistical implications of decentralizing academic data ownership through blockchain. While decentralization may empower learners, it also raises questions about data privacy, governance, and digital literacy. The present study addresses this gap by exploring not only the technical feasibility of blockchain credentialing but also its alignment with values of autonomy, transparency, and inclusion in disrupted or transitional educational settings.

This research introduces a novel approach to academic credentialing by embedding blockchain technology within hybrid education systems explicitly designed for resilience during global crises. The innovation lies not merely in the use of blockchain, but in its application to safeguard digital academic records in unpredictable, high-risk environments. By doing so, the study challenges conventional notions of credential management and offers a future-ready model for secure educational documentation.

The research is methodologically distinct in its mixed-method design that combines technical prototyping with multi-stakeholder engagement across diverse geographic regions. This approach ensures that the technological solution is grounded in practical needs and sociocultural realities, rather than being developed in isolation. The study's cross-contextual insights will contribute to the creation of scalable, adaptable frameworks for educational data security applicable in both developed and developing countries.

The importance of this research is magnified in a world increasingly shaped by climate crises, conflict, pandemics, and migration. As education systems become more decentralized and digitally mediated, ensuring the credibility and accessibility of academic credentials becomes a matter of both individual agency and systemic justice. This study seeks to offer a viable, ethical, and globally responsive model for securing academic records-one that supports learners wherever they are and under whatever conditions they may find themselves.

RESEARCH METHOD

Research Design

A convergent parallel mixed-methods design was employed. Quantitative metrics (transaction time, verification rate) were collected through real-time blockchain testing across varying network conditions. Qualitative data were analyzed using thematic coding derived from interview transcripts and UX logs. Triangulation was conducted across data types to ensure methodological integrity (Dhasarathan et al., 2024; Radutoiu et al., 2024). To validate performance, benchmarks were set against World Bank guidelines for digital public infrastructure reliability. Regression analyses adhered to standard assumptions of linearity, normality, and homoscedasticity.

Research Target/Subject

The population comprised educational institutions and users from five countries across Asia, Africa, and Latin America that had experienced digital disruptions due to political instability, natural disasters, or pandemic-related closures. A purposive sample of 200 participants was drawn, including 150 students, 30 educators, and 20 IT administrators involved in hybrid or fully digital learning environments. Selection criteria emphasized institutional diversity, digital infrastructure variability, and prior experience with digital credentialing. The multi-national scope ensured that the sample represented both high- and low-resource educational contexts, enabling cross-contextual insight into the blockchain model's adaptability.

Research Procedure

The research procedures unfolded in four sequential stages. In the first stage, a blockchain credentialing prototype was designed and piloted in collaboration with partner institutions using real academic data from prior academic terms. In the second stage, technical tests were conducted to assess system functionality across bandwidth variations, including offline verification simulations using distributed ledgers. In the third stage, end users interacted with the system and provided feedback through guided tasks, after which qualitative data were collected via interviews and surveys. In the final stage, the research team triangulated findings from technical performance, user responses, and institutional observations to evaluate the feasibility and scalability of blockchain credentialing in hybrid education. Ethical clearance was obtained from all partner institutions, and informed consent was secured from all participants in compliance with international research standards.

Instruments, and Data Collection Techniques

The study employed a range of instruments to gather both technical and perceptual data. A blockchain prototype was developed using Ethereum-based smart contracts to issue tamper-proof, verifiable academic certificates. System performance was measured using metrics such as transaction speed, data immutability, access latency, and interoperability with common learning management systems. Semi-structured interviews, survey questionnaires, and user experience logs were used to collect qualitative data from educators, students, and IT staff. A usability evaluation rubric was developed to assess trust, perceived security, interface clarity, and ease of verification.

RESULTS AND DISCUSSION

The study collected both technical and user-experience data from 200 participants across five countries using the blockchain-based academic credentialing system. System performance metrics were compiled based on real-time testing and simulations of academic certificate issuance and verification processes. Table 1 presents summary statistics for key performance indicators, including transaction speed, access latency, and verification success rates, observed during the 8-week pilot implementation.

Table 1. Performance metrics of blockchain-based credentialing system (n = 200)

Metric	Mean Value	Standard Deviation	Min	Max
Transaction Completion Time (s)	5.3	1.2	3.1	8.6
Access Latency (s)	2.7	0.8	1.5	4.2
Verification Accuracy (%)	100.0	0.0	100.0	100.0
Offline Verification Success (%)	92.4	3.1	85.0	97.0

System performance data indicate that the blockchain prototype operated with high reliability and speed. Certificate transactions were completed in an average of 5.3 seconds, and credential verification was successful in all online attempts. Offline verification-conducted via distributed nodes and QR-encoded hashes-achieved a 92.4% success rate, demonstrating resilience even in low-connectivity

environments. These metrics support the viability of decentralized record-keeping in global crisis contexts.

User surveys and interviews revealed strong perceptions of security, usability, and institutional trust in the blockchain system. Approximately 89% of students and educators agreed that blockchain-enhanced records improved their confidence in the authenticity and permanence of digital credentials. IT administrators noted that the decentralized model reduced reliance on centralized databases and mitigated risks of data corruption and administrative bottlenecks. A large majority favored the platform's potential for cross-border academic recognition.

Data on user interaction patterns also showed positive engagement across participant categories. Students reported high levels of satisfaction with the self-service credential retrieval interface, while educators valued the automated issuance and time-stamped immutability of transcripts. Administrative staff appreciated the reduced workload and enhanced transparency afforded by smart contracts and verifiable audit trails. These outcomes suggest that blockchain integration is not only technically feasible but socially and institutionally welcomed.

Inferential statistical analysis was conducted to examine the relationship between digital infrastructure quality and system usability ratings. Regression analysis revealed that usability satisfaction scores were significantly predicted by participants' baseline access to digital infrastructure ($\beta = 0.41$, $p < 0.01$). Nonetheless, no significant differences were observed in verification success across regions with varied bandwidth conditions, suggesting the system's technical consistency across diverse contexts.

A moderate positive correlation ($r = 0.59$, $p < 0.01$) was found between users' perceived trust in the credentialing system and their likelihood to recommend it for national adoption. Another correlation ($r = 0.47$, $p < 0.05$) indicated that users who had previously encountered issues with centralized record systems rated blockchain-based credentials more favorably. These relational findings highlight the potential of decentralized trust models in addressing institutional credibility gaps.

A case study from a university in the Philippines illustrated the practical impact of the system during a typhoon-induced campus closure. Academic operations shifted entirely online, and student transcripts were issued through the blockchain platform without disruption. Faculty were able to issue credentials from remote locations, and students successfully verified and submitted them to scholarship providers and transfer institutions. This case confirmed the system's utility during crisis-driven operational discontinuities.

Participants in the case study emphasized the system's reliability and reduced turnaround time. Verification that previously required up to two weeks was completed in under one minute. These experiences reinforced participant confidence in blockchain as a durable and scalable solution for crisis-responsive credentialing. The positive institutional feedback also led to an administrative decision to expand the system's use beyond pilot status.

Findings from both technical and experiential data streams point to the conclusion that blockchain-based academic records offer a high level of integrity, efficiency, and inclusivity for hybrid education. The system performed well across varied geographical and infrastructural conditions, supporting its applicability in low- and middle-income settings. Stakeholders expressed confidence in the model's scalability and long-term sustainability, especially in contexts requiring continuity under crisis constraints. These results validate blockchain's potential to redefine the global landscape of academic credentialing.

The results of this study confirm that blockchain-based academic record systems are both technically viable and socially acceptable for use in hybrid education contexts, especially under conditions of crisis. The system demonstrated high performance in terms of transaction speed, data integrity, and verification accuracy, with a 100% success rate for online credential validation and over 92% for offline verification. Participants across all stakeholder groups expressed strong trust in the security and reliability of the decentralized system, and reported improved efficiency, accessibility, and autonomy in managing academic credentials. These outcomes validate the operational potential of blockchain to serve as a foundational infrastructure for secure digital credentialing in educational settings that are increasingly fluid and digitally mediated.

The findings align with emerging literature that has highlighted blockchain's capacity to enhance trust, transparency, and data permanence in educational environments (Sharples & Domingue, 2016; Turkanović et al., 2018). However, this study differs by focusing explicitly on institutions in under-resourced and crisis-affected regions, where technical disruptions and administrative breakdowns are

more prevalent (Jaques et al., 2024; Kulkarni et al., 2024; Rodríguez Montequín et al., 2024; Vordenberg et al., 2024). Previous implementations have largely centered on elite institutions or experimental pilots in high-infrastructure contexts, whereas this study presents evidence of successful deployment in variable bandwidth conditions and across international settings. This divergence emphasizes the inclusive potential of blockchain when deployed with accessibility and resilience as design priorities.

The study's outcomes signal a broader transformation in how academic records can be managed in the digital age. The positive reception of decentralized credentialing among users—particularly in response to historical inefficiencies and credibility gaps in centralized systems—indicates a shifting paradigm toward trustless, tamper-proof models of academic documentation. The consistency of system performance even in low-bandwidth environments challenges assumptions that high-tech solutions cannot serve low-resource contexts (Ifeyemi et al., 2024; Pachoulas et al., 2024; Puttoo & Sungkur, 2024; Shingari & Mago, 2024). The findings suggest that blockchain, when thoughtfully designed, can equalize access to secure credentialing regardless of geography or institutional wealth.

The implications of these results are far-reaching for education systems seeking scalable solutions to the challenges of academic mobility, credential fraud, and administrative continuity. Blockchain offers an infrastructure that not only secures digital academic records but also empowers learners to control and share their credentials globally without institutional gatekeeping. In the context of global crises—whether pandemics, political instability, or climate disasters-such technology provides continuity and credibility that paper-based and centralized digital systems often cannot sustain (Astor et al., 2024; Väätäjä et al., 2024). Policymakers and education leaders are thus encouraged to explore blockchain as part of broader strategies for digital transformation and educational resilience.

The strength of these findings is grounded in the system's capacity to function across diverse institutional and technical contexts. High verification success rates and positive user feedback were achieved not despite infrastructural variability, but through intentional design choices that emphasized interoperability and decentralization. The ability to execute credential transactions rapidly and without dependence on third-party validators proved especially critical in crisis situations where administrative workflows were disrupted. Stakeholders valued the sense of permanence, security, and autonomy offered by the blockchain system, which they associated with increased institutional transparency and learner agency.

The results can be attributed in part to the participatory design process that involved end-users in shaping the system's interface and features. Educators and students provided input on verification methods, usability requirements, and local constraints, ensuring that the blockchain solution was responsive to real-world challenges rather than imposed as a top-down innovation. This alignment between technical design and contextual realities is likely a key reason for the system's successful uptake. The study highlights the importance of socio-technical integration in digital education reforms, particularly in post-crisis recovery and long-term system resilience.

Future research should examine the longitudinal impacts of blockchain-based credentialing on student outcomes, institutional workflows, and cross-border academic recognition. Studies are needed to assess how such systems integrate with national qualification frameworks, labor markets, and international accreditation bodies. Exploration into the ethical dimensions of decentralized data ownership, including privacy, consent, and algorithmic accountability, is also essential. Understanding how blockchain can intersect with inclusive data governance models will be critical as the technology moves from pilot to policy.

Education systems must now consider how to operationalize these findings into sustainable practice. Institutions should invest in open-source blockchain credentialing tools that are interoperable with existing learning management systems and aligned with international standards. Professional development for educators and administrators must include digital credential literacy, and policy frameworks should ensure data equity and student-centered governance. This research demonstrates that blockchain is not only a technological intervention but a pedagogical and institutional opportunity to secure education for all-especially when traditional systems fail.

CONCLUSION

This study confirms that blockchain-based credentialing can address gaps in academic record security, accessibility, and verification in hybrid education settings, particularly during crises. The system demonstrated high scalability, resilience, and user trust across diverse socio-technical contexts.

Conceptually, this research advances the field by framing blockchain as a decentralized trust mechanism embedded in educational ecosystems. Methodologically, it integrates technical prototyping with lived user insights across five countries.

Limitations include the pilot-scale deployment and variation in institutional readiness. Future work should explore full-scale integration with national qualification frameworks and ethical concerns such as data sovereignty and informed consent.

Policymakers are urged to invest in open, interoperable blockchain infrastructure, embed digital credential literacy in professional development, and align credentialing standards with international mobility frameworks.

AUTHOR CONTRIBUTIONS

Jelena Dordevic: Conceptualization; Project administration; Validation; Writing - review and editing; Conceptualization; Data curation; In-vestigation.

Luka Stojanović: Data curation; Investigation; Formal analysis; Methodology; Writing - original draft.

Tamara Markovic: Supervision; Validation; Other contribution; Resources; Visuali-zation; Writing - original draft.

CONFLICTS OF INTEREST

No conflict interest.

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