

Data Governance in Blockchain-Based Systems for Internship Grade Conversion

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ABSTRACT

Higher education institutions face challenges in collaborating with the corporate sector and other academic entities, necessitating secure and effective communication channels. The Merdeka Learning program provides students with an expansive platform to acquire scientific knowledge and ensures equitable competencies among graduates. **This study aims** to address the increasing importance of data governance in such collaborations by proposing a blockchain-based framework specifically for internship grade conversion. Blockchain technology offers a secure and tamper-proof solution for managing and sharing data, addressing challenges in transparency and consistency. **The research adopts** an experimental approach combined with a comprehensive review of blockchain technology and its integration into existing data governance frameworks. **The proposed** outcome includes a detailed data governance framework with a prototype data management layer built on blockchain, ensuring robust data security and reliable internship evaluations. By leveraging blockchain immutability and transparency, the framework enhances the reliability of grade conversion, reduces manual errors, and promotes fair assessments. This research contributes to improving the operational efficiency of academic institutions and fostering trust among stakeholders. Furthermore, the framework aligns with the goals of Merdeka Learning by supporting seamless internship management and ensuring transparent evaluation processes. **The findings aim** to provide a scalable and impactful solution for higher education institutions, facilitating a more reliable and innovative approach to managing data in collaborative environments.

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1. INTRODUCTION

The need for effective and secure systems has sparked the transition to digital data management in higher education [1]. This transition has highlighted the importance of ensuring data security, transparency, and consistency in all processes, including evaluation. The integration of blockchain technology and fuzzy logic offers a promising solution to address these challenges and improve the overall efficiency of the evaluation process. This research aims to provide a comprehensive framework that not only enhances data governance but also ensures a fair and reliable assessment of interns in higher education settings [2, 3]. By synergizing the security and transparency of blockchain technology with the flexibility and adaptability of fuzzy logic, this framework will revolutionize the way intern evaluations are conducted. It will streamline the process, reduce errors, and provide a more accurate representation of each intern performance [4]. Ultimately, this research will

contribute to the advancement of data management practices in higher education and pave the way for more objective and consistent evaluation processes in the future. Traditional methods of evaluating internships are prone to subjectivity and inconsistencies, leading to unreliable results and longer processing times [5].

How can blockchain and fuzzy logic be integrated to improve the governance of data in the context of internship grade conversion in higher education? Blockchain technology can be utilized to create a secure and transparent system for storing internship data, ensuring that all information is tamper-proof and easily accessible [6]. Fuzzy logic, on the other hand, can help in handling the uncertainties and complexities involved in evaluating a wide range of performance metrics. By combining these two innovative approaches, internship grade conversion can be streamlined, leading to more accurate and fair assessments of interns achievements [7]. This integration has the potential to revolutionize the way internships are evaluated in higher education, setting a new standard for data governance and evaluation processes. With blockchain technology and fuzzy logic working together, institutions can track the progress of interns in real time and make more informed decisions about their performance [8]. This collaboration also opens up opportunities for personalized feedback and tailored development plans, ultimately benefiting both interns and organizations. The future of internship evaluation is bright with these cutting-edge tools at our disposal, paving the way for a more transparent and efficient system that promotes growth and success for all parties involved [9, 10].

- The integration of blockchain technology and fuzzy logic in internship evaluation processes will revolutionize the way organizations monitor and assess intern performance.
- The positive impact of personalized feedback and tailored development plans resulting from this collaboration can significantly enhance the overall experience for both interns and organizations.
- By leveraging these cutting-edge tools, institutions can establish a transparent and efficient system that actively promotes growth and success for all parties involved in the internship process.
- Real-time tracking enables immediate intervention in case of issues, resulting in swift resolutions and improved outcomes for interns.
- In the future, continuous advancements in governance and evaluation processes through technology have the potential to drive even further improvements in how internships are managed and assessed.

This study aims to evaluate the impact of technology utilization on the satisfaction and success of interns, analyze the role of real-time tracking and data analysis in enhancing communication and support between interns and organizations, explore how technology can streamline administrative tasks and reduce barriers in the internship process, and examine the long-term benefits of technological tools for both interns and organizations.



Figure 1. Sustainable Development Goals

This research aims to assess the impact of technology integration in internship programs, focusing on various aspects such as intern satisfaction, communication, and administrative efficiency. By investigating

real-time tracking and data analysis, this study seeks to identify how technology can enhance the interaction between interns and organizations [11]. Additionally, the research will explore how technological tools can reduce administrative barriers and streamline processes, ultimately benefiting both interns and organizations in the long term. Through this, the study intends to contribute to the understanding of how technology can improve the internship experience, making it more efficient and impactful for all stakeholders involved [12, 13].

From Figure 1 the research aligns with several Sustainable Development Goals (SDGs) by addressing critical challenges in education and data governance through innovative technologies. Specifically, it supports SDG 4: Quality Education by enhancing the transparency, fairness, and efficiency of internship evaluations, which fosters equitable and inclusive access to quality education for all students. By integrating blockchain and fuzzy logic, the research also contributes to SDG 9: Industry, Innovation, and Infrastructure, as it introduces cutting-edge technological solutions to improve data governance and institutional workflows, bridging the gap between academia and industry [14]. Furthermore, the emphasis on transparency, data integrity, and trust in educational systems aligns with SDG 16: Peace, Justice, and Strong Institutions, promoting accountable and robust governance in higher education institutions. These contributions demonstrate how technology-driven innovation in education not only enhances institutional effectiveness but also advances global sustainability objectives, positioning this research as a significant step toward achieving the SDGs [15].

2. LITERATURE REVIEW

Blockchain offers a dependable and impartial data storage platform for extensive software systems that incorporate blockchain as a constituent. Trust and neutrality are inherent in the book structure, network, consensus process, and cryptographic techniques.

- **Transparency:** The information stored on the blockchain may be accessed by all individuals who are part of the blockchain network.
- **Perpetuity:** Due to the decentralized consensus mechanism, once data is appended to the blockchain, it becomes immutable and cannot be modified or removed. However, the maintenance of a blockchain employing a specific consensus mechanism may be probabilistic.
- **Consistency:** Distributed consensus and perspective guarantee that all data that is committed is accessible to all subsequent data changes, establishing a singular truth throughout the whole blockchain.
- **Equal Right:** Due to its intermediation, every participant in the network possesses an equal entitlement to manipulate and access the blockchain.

Every participant in the blockchain network has the capability to store a complete copy of the blockchain data [16]. Smart Contract (SC) enable the automation of grade conversion, guaranteeing transparency and minimizing the need for manual intervention. By employing smart contracts, the system can autonomously convert grades across several grading systems, eradicating the possibility of human mistakes and guaranteeing uniformity. This automation not only simplifies the grading process but also enhances confidence in the precision of the data being conveyed. Incorporating fuzzy logic and blockchain technology into internship program grading methods has the potential to fundamentally transform the evaluation and recognition of student success. Internship programs aim to provide a thorough and precise portrayal of a student abilities and likelihood of achieving success in their desired area of expertise.

Effective data governance involves policies, standards, and procedures that ensure data is managed as a valuable asset. Key aspects include data quality, data protection, and compliance with regulations and industry standards. By incorporating fuzzy logic into the data governance framework, organizations can more effectively address the complexities and uncertainties that come with managing data. This can lead to more robust data governance practices that enhance overall data quality, security, and compliance efforts. Ultimately, integrating fuzzy logic into data governance can help organizations achieve their data management goals more effectively and efficiently [17].

Blockchain technology offers transparency, immutability, and security, making it suitable for managing educational records. It ensures that data is tamper-proof and verifiable, addressing many challenges faced in traditional data management systems. For example, blockchain can provide a secure and decentralized way to store academic credentials, preventing fraud and ensuring the authenticity of qualifications. Additionally,

the transparent nature of blockchain allows for easy verification of academic records, reducing the time and resources needed for credential verification processes. By incorporating blockchain technology into education data management, institutions can streamline operations, improve data integrity, and enhance trust in the educational system. A Smart Contract is a software application that is implemented on a blockchain network. The system takes predefined actions when specific circumstances are fulfilled, defining the operational rules of a service that all participants have consented to. The content of the SC is accessible to all participants as a mutual agreement [18, 19].

3. RESEARCH METHOD

Data is collected through interviews with stakeholders involved in internship programs, such as mentors, academic coordinators, and students, to gather insights on current grading practices, challenges, and opportunities [20]. Additionally, analysis of existing grading systems and practices is conducted to understand the strengths and weaknesses of current methods. This data serves as the foundation for designing the improved grading system using fuzzy logic and blockchain technology [21].

The system design is based on a multi-layered architecture that integrates blockchain and fuzzy logic technologies to enhance the accuracy, transparency, and security of internship program evaluations [22, 23]. The user interface layer provides a seamless platform for students, supervisors, and administrators to interact with the system, offering features such as dashboards and real-time notifications. The data access layer ensures secure communication between the application and the blockchain network using tools like Ethereum and Metamask, while the business logic layer incorporates a fuzzy logic system to calculate grades and SC to automate workflows and enforce evaluation rules. The blockchain layer guarantees data integrity and transparency by recording all transactions on an immutable ledger, supported by the physical data storage layer, which secures and manages the blockchain blocks and transactions. The integration layer facilitates smooth communication between the new system and existing academic platforms, ensuring compatibility and ease of adoption [24]. Additionally, the consensus layer validates all transactions through Ethereum network, while the reporting and analytics layer generates actionable insights for administrators to optimize program effectiveness. This comprehensive design ensures a secure, flexible, and efficient framework that supports holistic and reliable evaluations of student performance in internship programs [25, 26].

- The Blockchain Layer establishes a secure and immutable ledger for storing evaluation data, ensuring that once a grade or evaluation is recorded, it cannot be altered or deleted. This guarantees transparency and data integrity, with each block containing encrypted information about the evaluation process, such as performance metrics, dates, and evaluator details. The blockchain interacts with fuzzy logic algorithms and SC to securely store all evaluations, making them tamper-proof and providing a permanent, verifiable record of each intern performance [27].
- The Fuzzy Logic Algorithm employs fuzzy logic to calculate grades based on multiple criteria while addressing uncertainties in student performance. By transforming subjective and qualitative inputs, such as performance evaluations, into quantitative values, the system uses fuzzy sets and membership functions to categorize criteria and generate a final grade that considers ambiguity in assessments. This algorithm interacts with the blockchain layer to securely store results and with the user interface to provide real-time feedback to stakeholders, ensuring a flexible and nuanced evaluation of intern performance.
- The Integration Layer connects the blockchain layer with existing grading systems, facilitating seamless data transfer and communication with external databases and legacy software. It ensures the new framework can be adopted without requiring an overhaul of the institution existing infrastructure. Acting as a bridge, this layer enables data flow between all system components, ensuring that evaluation data processed by the fuzzy logic algorithm is securely recorded on the blockchain and accessible to authorized stakeholders via the user interface [28].
- The User Interface provides a user-friendly platform for stakeholders, including mentors, students, and academic coordinators, to input performance data and access evaluation results. Equipped with dashboards and visualization tools, it presents real-time data such as grades, performance trends, and feedback, ensuring ease of interpretation. By communicating with the blockchain and fuzzy logic layers, the

interface ensures accurate data processing and transparent result display [29, 30]. It simplifies interaction with the underlying systems, making the evaluation process accessible to all stakeholders.

Overall, the methodology aims to leverage fuzzy logic and blockchain technology to enhance the transparency and accuracy of grading practices in internship programs, leading to improved decision-making and a more personalized learning experience for students.

4. FINDINGS

The findings of the discussed observations and the objective of the research center around the process of students value conversion. To construct a conceptual framework illustrating the process of value conversion, incorporating distinct stages as depicted in the accompanying diagram. The data architecture for case studies of conversion values utilizes layers that incorporate fuzzy logic and blockchain technology. The primary objective is to analyze the functionality and interaction of each layer. Paik idea posits that a blockchain architecture and a database can be compared based on four distinct factors.

- **Application Layer:** Interfaces for students, instructors, and administrators to interact with the system, ensuring ease of use and accessibility. This layer will also include features such as real-time progress tracking, personalized goal setting, and virtual career counseling to help students stay on track and motivated. By providing a user-friendly experience, the application layer will enhance engagement and encourage active participation in the learning process. Additionally, it will streamline communication between students, instructors, and administrators, fostering a collaborative and supportive learning environment. Overall, the proposed data governance model application layer will play a crucial role in facilitating a personalized and effective approach to education.
- **Data Access Layer:** SC handle transactions and enforce rules for data access and modification. The data access layer ensures that only authorized users can access and modify data, providing a secure and transparent system. By utilizing smart contracts, the system can automatically enforce rules and agreements, reducing the risk of fraud or errors. This layer plays a vital role in maintaining the integrity and confidentiality of the data, ultimately contributing to the overall success of the data governance model.
- **Logical Data Store:** Structures data in a way that supports both blockchain storage and retrieval operations. The logical data store organizes data in a format that is compatible with blockchain technology, allowing for efficient storage and retrieval processes. By ensuring that all authorized parties can easily access and verify the data, this increases system transparency and trust. By incorporating the logical data store into the data governance model, organizations can effectively manage and protect their data assets, leading to improved decision-making and operational efficiency.
- **Physical Data Store:** Ensures that all data is recorded on the blockchain, providing a transparent and auditable trail. This level of transparency and auditability is crucial for organizations looking to maintain compliance with regulations and industry standards. Additionally, the physical data store enhances data security by encrypting data and distributing it across multiple nodes on the blockchain network. This decentralized approach minimizes the risk of data tampering or loss, further bolstering the integrity and reliability of the organization data assets. Overall, the physical data store plays a vital role in ensuring the trustworthiness and immutability of data within the organization blockchain ecosystem. By utilizing the physical data store, organizations can rest assured that their data is secure, transparent, and easily traceable. This not only helps in maintaining regulatory compliance but also instills confidence in customers and stakeholders regarding the organization commitment to data integrity. With the decentralized nature of the blockchain network and the robust security measures of the physical data store, organizations can confidently leverage their data assets for strategic decision-making and operational efficiency, knowing that their data is protected and reliable.

Blockchain technology can improve data governance in internship programs by strengthening the aggregation and preservation of a person data over time, verifying identity system-wide, and allowing for secure sharing of data to benefit individuals. It also enables the creation of portable identities, which necessitates interoperable standards and data governance policies in the blockchain space [31]. The limitations of blockchain

in data governance include limited storage space, which makes it challenging to store large amounts of data securely. Solutions such as separating and storing data in a central database have been proposed to address this issue, but they compromise security compared to storing all data in the blockchain network [32]. The use of Consortium Blockchain architecture for personnel information management systems can help address privacy concerns, but it also has its limitations in terms of data security [33, 34].

Blockchain can improve data governance in the public sector by simplifying the management of trusted information, making it easier for government agencies to access critical data while maintaining security. It allows for decentralized verification of information added to an encoded digital ledger, ensuring data integrity and security [35].

Challenges associated with implementing blockchain for data governance in the Canadian health care system include complicated regulations surrounding health and personal data, the government universal involvement, and transitional issues between different information systems. Identifying gaps in the current infrastructure and creating a realistic implementation plan for blockchain systems will require in-depth strategic analysis [36].

4.1. Problem

The conversion of MBKM internship grades is manually conducted by mapping them to specific courses under the supervision of the Chairman, with input from the lecturer [37]. This procedure is time-consuming due to the need to assess each competency based on the mathematical learning access. Ensure transparency in the process of converting value and clearly communicate to students regarding the calculation and recording of the internship worth. Ensure equitable recognition and evaluation of all forms of experience, including internships in industry or research initiatives [38].

4.2. Research Implementation

To conduct an analysis of the data layers pertaining to internship evaluation. This entails examining the diverse metrics and indicators that can be gathered and analyzed to assess the efficiency of using technology in internship programs [39]. Through the analysis of these data layers, researchers can get valuable knowledge on the precise manner in which technology influences the contentment, achievement, and overall encounter of interns. This analysis can assist companies in making well-informed decisions regarding the integration of technological tools into their internship programs, ultimately resulting in enhancements in communication, support, and efficiency.

Figure 2 to create a system using blockchain technology that guarantees the integrity and security of data. Organizations can establish a secure and transparent system for storing and evaluating internship program data by leveraging blockchain technology [40]. This novel methodology can establish a dependable basis for quantifying the influence of technology integration on interns experiences. Organizations may enhance their trust in the veracity of their analysis and make data-driven decisions to continually enhance their internship programs by prioritizing data integrity and security. Implementing this progressive approach can result in improved communication, heightened intern support, and enhanced general efficiency within the organization [41].

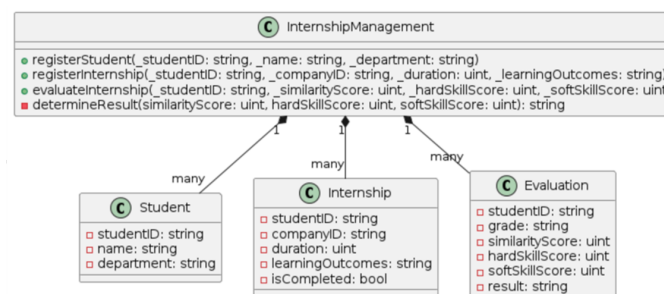


Figure 2. Model Data Internship

To apply fuzzy logic in order to tackle subjectivity in the process of converting grades. By considering the subtleties and intricacies of interns experiences, businesses may ensure a more precise evaluation of the

program efficacy. By integrating fuzzy logic into the data analysis procedure, businesses can gain a more comprehensive understanding of the subjective parts of interns experiences that may not be adequately measured using conventional metrics. Adopting this comprehensive method of data analysis can yield more subtle and profound insights, ultimately leading to a more successful internship program [42, 43].

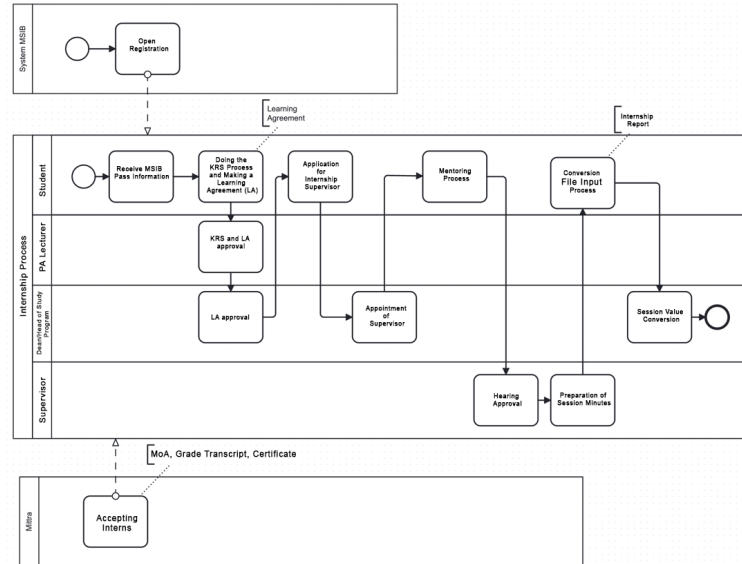


Figure 3. Process Model Internship

Figure 3 illustrates the workflow process for managing internship programs, specifically within the MSIB framework. It demonstrates the roles and interactions of various entities, including students, academic advisors, program coordinators, supervising lecturers, and partner organizations. Data Owners oversee the conversion of internship grades, which involves students, academic tutors, faculty/study program, and the Bureau of Academic Administration.

- The Dean/Head of Department and Head of the Office of Academic Administration: Responsible for being the Data Owner of academic data. They have the authority to adopt the policy on the evaluation and use of student data for internship evaluations.
- MBKM Coordinator: Serves as the exclusive custodian of all data pertaining to the MBKM program, encompassing information on attendance, evaluation, and feedback received from the firm on-site.

Data Stewards are persons responsible for overseeing and executing the policies established by Data Owners. These policies are specifically related to data management and implementation.

- MBKM Coordinator: Responsible for managing and supervising the gathering and handling of internship data, as well as guaranteeing the implementation of the regulations stated in the terms of the Statement, such as issuing instructions to utilize specific agreed-upon papers. The MoA documents are sourced from the partner of the internship activities. The Learning Agreement documents include mathematics that will be converted based on the activity/learning outcome/activity group provided by the partner. The training report, which follows the guidelines for interns, is the final document.
- Data Administrator/BAA: Accountable for maintaining the accuracy and protection of data. Collaborating with the IT department to incorporate the assessment system onto the blockchain.

Figure 4 illustrates the data flow and interactions among stakeholders involved in managing internships under the MBKM (Merdeka Belajar Kampus Merdeka) framework. It highlights how students, faculties, academic systems, administrative units, and partner organizations communicate to facilitate internship management [44]. Blockchain technology plays a critical role by providing a secure and immutable ledger for recording transactions such as grade submissions, evaluations, and approvals. This ensures transparency and

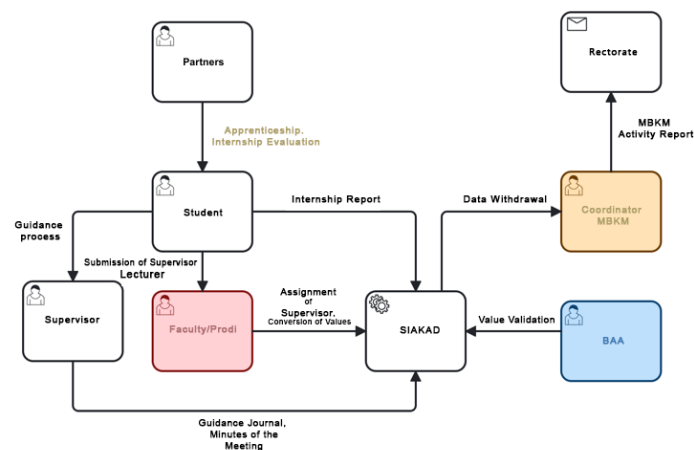


Figure 4. Data Owner dan Data Steward

prevents unauthorized modifications to academic records. The decentralized nature of blockchain promotes seamless communication between stakeholders, enabling real-time updates and fostering an integrated system that reduces delays in administrative processes. Students internship reports, feedback from partner organizations, and grades are securely stored, ensuring data integrity throughout the evaluation process [45].

Fuzzy logic enhances the flexibility of the system by addressing subjectivity and uncertainties in evaluating student performance. This methodology allows qualitative aspects like professional attitudes, interpersonal skills, and adaptability to be assessed alongside traditional metrics [46]. By enabling a more nuanced grading process, fuzzy logic ensures that assessments are holistic and fair. The integration of blockchain and fuzzy logic creates a robust system that not only streamlines grade conversion but also reduces bias and enhances the credibility of evaluations. Together, these technologies align with the MBKM program objective of fostering a transparent and efficient framework for assessing internship outcomes. The inclusion of SIKAD and the Academic Administration Bureau (BAA) in this workflow further ensures that institutional processes are synchronized, promoting a smooth exchange of data between academic units and external stakeholders [47].

The relevance of Figure 3 extends beyond academic contexts, as blockchain technology is also being explored in other fields, such as healthcare. In systems like the Canadian healthcare network, blockchain could enhance data governance by ensuring secure storage, real-time sharing, and compliance with regulatory standards. For example, blockchain enables healthcare providers to store and retrieve patient records securely, reducing the risk of breaches and improving coordination among professionals. These parallels underscore the transformative potential of blockchain in fostering secure, transparent, and efficient data management across various domains. By adopting blockchain-based systems, institutions in education and healthcare can revolutionize their operations, reducing administrative burdens while prioritizing transparency and stakeholder satisfaction [48].

Table 1. Mapping Internship Value Composition

Components of Value	Data Source	Assessment of Hard Skills	Soft Skill Value
Student attendance rate	Internal		✓
Proposal for an independent study/project activity	Internal	✓	
Evaluation of students attitudes and performance by Field Supervisors and Partner Institutions	Internal	✓	
Final output and report of independent study/project activities	Internal	✓	
Presentation of internship/work placement results	Internal	✓	
Competence of Internship Activities	External	✓	
Soft skills and career development	External		✓

Table 1 provides a detailed mapping of the value composition for internship evaluations, emphasizing both hard and soft skills. It categorizes the components of assessment and identifies the corresponding data sources, which are divided into internal and external origins. Internal data sources include information gathered directly from the educational institution or the internship activities, such as attendance records, proposal submissions, and final reports. External data sources, on the other hand, focus on feedback and evaluations provided by partner institutions or field supervisors, capturing insights into the broader competencies developed during the internship. The assessment of hard skills centers on measurable and task-oriented abilities, such as the quality of project proposals, final reports, and presentations. Meanwhile, soft skills are evaluated based on interpersonal attributes and career readiness, often through external feedback. This framework ensures a comprehensive approach to internship evaluation by integrating both internal academic metrics and external practical feedback, fostering a holistic understanding of student performance.

Data communication can be achieved through interaction with the aforementioned SC as follows:

- **Student Registration:** The `registerStudent` function is called using the student ID, name, and department to enroll a new student.
- **Internship Registration:** The `registerInternship` function is called with the student ID, company ID, duration, and learning outcomes to register internship details.
- **Internship Evaluation:** The `evaluateInternship` function is called using the student ID and scores for attendance, performance, report quality, and presentation quality to evaluate the internship.

The SC is executed, the outcomes that will be observed on the blockchain are:

- **Event StudentRegistered:** This indicates that the student has been successfully registered in the system.
- **Event Internship Registered:** This indicates that the student internship details have been successfully recorded on the blockchain.
- **Event Internship Evaluation Completed:** This indicates that the internship evaluation has been finished and its results have been recorded in a transcript document that includes learning outcomes and grades.

The integration of smart contracts and blockchain technology streamlines the internship evaluation process by enabling secure and automated functions, including student registration, internship data entry, and performance assessment. Each action is securely recorded on the blockchain, providing a verifiable and immutable record of achievements. This system enhances the accuracy and reliability of evaluations while ensuring data integrity. By eliminating manual errors and increasing transparency, it fosters trust among stakeholders and supports a more efficient and secure approach to managing internship programs.

By combining blockchain with fuzzy logic in data governance, the reliability and security of educational records are improved, which has the potential to be a blueprint for other institutions. This integration guarantees the security of student data by preventing unwanted access or alteration, resulting in a greater degree of confidence in the shared information. Moreover, the utilization of blockchain technology and fuzzy logic in data governance has the potential to optimize administrative procedures, minimize paperwork, and enhance the overall operational effectiveness of educational institutions. Consequently, students, educators, and administrators can get advantages from a system that is more open and safe, and that gives importance to the privacy and correctness of data.

Figure 5 presents a detailed layered architecture for blockchain-based data governance, outlining the technical framework and tools utilized at each level, from user interaction to data processing and storage. The architecture is designed to enhance modularity, scalability, and security, ensuring a robust and efficient system for managing internship data. At the top is the User Interface Layer, which provides stakeholders—students, administrators, and supervisors with a user-friendly platform to input and access data. Dashboards and notifications streamline interactions, supported by tools like Visual Studio Code and Node.js for seamless development. Below this, the Data Access Layer facilitates secure communication with the blockchain network using tools such as Ethereum and Metamask, ensuring authentication and protecting sensitive information.

The Business Logic Layer incorporates smart contracts and fuzzy logic systems. SC automate rules for tasks like grade submissions and evaluations, ensuring consistency and minimizing errors, while fuzzy logic evaluates subjective criteria, enabling a fair and comprehensive assessment of performance. The Logical

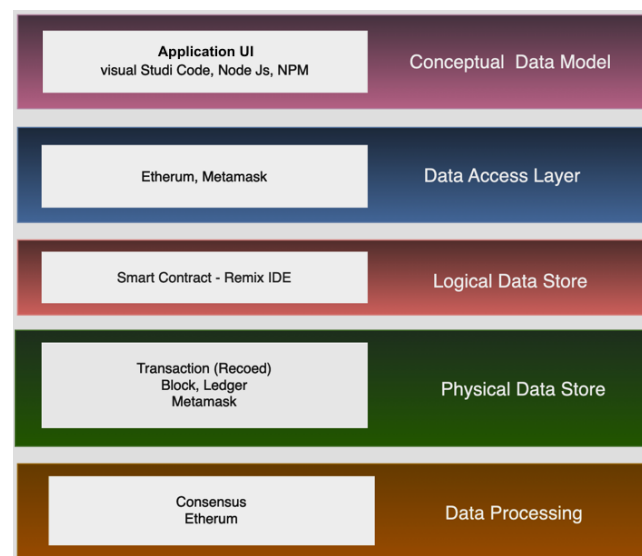


Figure 5. Architecture Data Management at Blockchain

Data Store Layer organizes data efficiently for blockchain storage, allowing rapid retrieval and enhancing transparency. At the foundation, the Physical Data Store Layer securely records all data on the blockchain, providing immutability and transparency. Combined with the Data Processing Layer and Ethereum consensus protocols, this architecture guarantees secure, validated, and efficient data governance.

5. MANAGERIAL IMPLICATION

The integration of blockchain technology and fuzzy logic into educational systems enhances the security, transparency, and efficiency of internship evaluations. Blockchain ensures data integrity by preventing unauthorized modifications, while fuzzy logic provides adaptive and nuanced assessments. This combination reduces administrative workloads, streamlines workflows, and fosters trust among stakeholders, including students, educators, and industry partners. Automation through smart contracts further improves accuracy and reliability, eliminating manual errors and ensuring compliance with regulatory standards. This framework supports scalable and innovative data management, enabling institutions to adapt to the growing demands of academic and industry collaboration while ensuring fair and transparent evaluation processes.

6. CONCLUSION

This study presents an advanced data governance framework for converting internship grades, leveraging blockchain technology for enhanced security and fuzzy logic for adaptable, impartial evaluations. By implementing this framework, educational institutions can achieve accurate and equitable grade conversions, fostering a reliable and transparent system for all stakeholders. Blockchain ensures data security and integrity, while fuzzy logic facilitates nuanced and personalized assessments. This innovative approach improves operational efficiency, builds stakeholder trust, and ensures compliance with regulatory standards, benefiting students, educators, and administrators alike. Furthermore, blockchain simplifies the verification of grades, reducing the risk of fraud and safeguarding the authenticity of students' achievements. By integrating fuzzy logic, the framework supports a more holistic evaluation of student performance and enables a tailored learning experience. Together, these advancements empower institutions to adopt modern and flexible strategies for internship assessments, preparing students for future success.

Nevertheless, this study acknowledges limitations, such as the need for broader testing across varied educational settings to validate scalability and effectiveness. The integration of blockchain and fuzzy logic also involves significant technical and resource challenges for some institutions. Future research should focus on refining fuzzy logic algorithms, improving blockchain scalability, and addressing implementation costs and complexities. Additionally, the development of sophisticated algorithms to detect and prevent fraud more effec-

tively remains a critical area of exploration. By overcoming these challenges and continuously enhancing these technologies, educational institutions can provide a secure, dependable, and scalable system for evaluating internships, revolutionizing assessment processes while maintaining the integrity and authenticity of student achievements.

7. DECLARATIONS

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7.2. Author Contributions

Conceptualization: RW and AB; Methodology: RW; Software: RW; Validation: RW; Formal Analysis: RW, AB, and AT; Investigation: AT; Resources: AB; Data Curation: AB; Writing Original Draft Preparation: AB and RW; Writing Review and Editing: RW, AB, and AT; Visualization: RW; All authors, RW, AB, AT, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

REFERENCES

- [1] A. Choudhary, M. Chawla, and N. Tiwari, "A blockchain-based framework for academic bank of credit with transparent credit mobility," *Cluster Computing*, pp. 1–22, 2024.
- [2] E. Ligia, K. Iskandar, I. K. Surajaya, M. Bayasut, O. Jayanagara, and K. Mizuno, "Cultural clash: Investigating how entrepreneurial characteristics and culture diffusion affect international interns' competency," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 2, pp. 182–198, 2024.
- [3] S. Jadon, K. Bhat, K. R. Jenni, K. Vedantha, R. Likith, and P. B. Honnavalli, "Non-fungible token enhanced blockchain-based online social network," *IEEE Access*, 2024.
- [4] Y. Liu, "Digital management of e-commerce innovation and entrepreneurial education based on blockchain technology," in *2024 IEEE 4th International Conference on Electronic Communications, Internet of Things and Big Data (ICEIB)*. IEEE, 2024, pp. 383–386.
- [5] R. Shinde, S. Patil, K. Kotecha, V. Potdar, G. Selvachandran, and A. Abraham, "Securing ai-based healthcare systems using blockchain technology: A state-of-the-art systematic literature review and future research directions," *Transactions on Emerging Telecommunications Technologies*, vol. 35, no. 1, p. e4884, 2024.
- [6] P. Rastogi, D. Singh, and S. S. Bedi, "An improved blockchain framework for orap verification and data security in healthcare," *Journal of Ambient Intelligence and Humanized Computing*, pp. 1–16, 2024.
- [7] I. Zrelli and A. Rejeb, "A bibliometric analysis of iot applications in logistics and supply chain management," *Heliyon*, vol. 10, no. 16, 2024.
- [8] S. Mukherjee, "Machine learning methodologies for beyond 5g and 6g heterogeneous networks: Prediction, automation, and performance analysis," Ph.D. dissertation, University of Missouri-Kansas City, 2024.
- [9] A. Rustemi, F. Dalipi, V. Atanasovski, and A. Risteski, "A systematic literature review on blockchain-based systems for academic certificate verification," *IEEE Access*, vol. 11, pp. 64 679–64 696, 2023.

- [10] J. Xiao, Y. Jiao, Y. Li, and Z. Jiang, "Towards a trusted and unified consortium-blockchain-based data sharing infrastructure for open learning—tolfob architecture and implementation," *Sustainability*, vol. 13, no. 24, p. 14069, 2021.
- [11] Y. Gao, P. Xu, H. Yu, and X. Xu, "A novel blockchain-based system for improving information integrity in building projects from the perspective of building energy performance," *Environmental Impact Assessment Review*, vol. 109, p. 107637, 2024.
- [12] I. Masood, A. Daud, Y. Wang, A. Banjar, and R. Alharbey, "A blockchain-based system for patient data privacy and security," *Multimedia Tools and Applications*, vol. 83, no. 21, pp. 60 443–60 467, 2024.
- [13] Y. Xu, Z. A. Long, and D. B. Setyohadi, "A comprehensive review on the application of artificial intelligence in chronic obstructive pulmonary disease (copd) management," in *2024 18th International Conference on Ubiquitous Information Management and Communication (IMCOM)*. IEEE, 2024, pp. 1–8.
- [14] U. Nations, "The 17 goals – sustainable development goals," 2024, accessed: 2024-12-19. [Online]. Available: <https://sdgs.un.org/goals>
- [15] K. R. Hope Sr, "Peace, justice and inclusive institutions: overcoming challenges to the implementation of sustainable development goal 16," *Global Change, Peace & Security*, vol. 32, no. 1, pp. 57–77, 2020.
- [16] A. Tharatipyakul and S. Pongnumkul, "User interface of blockchain-based agri-food traceability applications: A review," *IEEE Access*, vol. 9, pp. 82 909–82 929, 2021.
- [17] S. Purnama and C. S. Bangun, "Strategic management insights into housewives consumptive shopping behavior in the post covid-19 landscape," *APTISI Transactions on Management*, vol. 8, no. 1, pp. 71–79, 2024.
- [18] D. Marbough, M. C. E. Simsekler, K. Salah, R. Jayaraman, and S. Ellahham, "A blockchain-based regulatory framework for mhealth," *Data*, vol. 7, no. 12, p. 177, 2022.
- [19] R. Shankar, B. Sarojini, H. Mehraj, A. S. Kumar, R. Neware, and A. Singh Bist, "Impact of the learning rate and batch size on noma system using lstm-based deep neural network," *The Journal of Defense Modeling and Simulation*, vol. 20, no. 2, pp. 259–268, 2023.
- [20] T. A. Alghamdi, R. Khalid, and N. Javaid, "A survey of blockchain based systems: Scalability issues and solutions, applications and future challenges," *IEEE Access*, 2024.
- [21] Q. Yu, M. Zhang, and A. S. Mujumdar, "Blockchain-based fresh food quality traceability and dynamic monitoring: Research progress and application perspectives," *Computers and Electronics in Agriculture*, vol. 224, p. 109191, 2024.
- [22] A. Haddad, M. H. Habaeabi, E. A. Elsheikh, M. R. Islam, S. A. Zabidi, and F. E. M. Suliman, "E2ee enhanced patient-centric blockchain-based system for ehr management," *Plos one*, vol. 19, no. 4, p. e0301371, 2024.
- [23] T. Wahyuningsih, E. Sedyono, K. D. Hartomo, and I. Sembiring, "The role of gamification implementation in improving quality and intention in software engineering learning," *Journal of Education and Learning (EduLearn)*, vol. 18, no. 1, pp. 173–184, 2024.
- [24] K. M. u. Mannonov and S. Myeong, "Citizens' perception of blockchain-based e-voting systems: Focusing on tam," *Sustainability*, vol. 16, no. 11, p. 4387, 2024.
- [25] E. Zeydan, L. Blanco, J. Manges-Bafalluy, S. S. Arslan, Y. Turk, A. K. Yadav, and M. Liyanage, "Blockchain-based self-sovereign identity: Taking control of identity in federated learning," *IEEE Open Journal of the Communications Society*, 2024.
- [26] Q. Mao, L. Wang, Y. Long, L. Han, Z. Wang, and K. Chen, "A blockchain-based framework for federated learning with privacy preservation in power load forecasting," *Knowledge-Based Systems*, vol. 284, p. 111338, 2024.
- [27] P. Qi, D. Chiaro, F. Giampaolo, and F. Piccialli, "A blockchain-based secure internet of medical things framework for stress detection," *Information Sciences*, vol. 628, pp. 377–390, 2023.
- [28] D. Shah, S. Rani, K. Shoukat, H. Kalsoom, M. U. Shoukat, H. Almujiabah, and S. Liao, "Blockchain factors in the design of smart-media for e-healthcare management," *Sensors*, vol. 24, no. 21, p. 6835, 2024.
- [29] I. Nur Muharam, I. P. Tusyadiah, and A. N. Kimbu, "A theoretical model of user acceptance of blockchain-based peer-to-peer accommodation," *Current Issues in Tourism*, vol. 27, no. 7, pp. 1008–1025, 2024.
- [30] M. Mohammed, M. Alzahrani, A. Hejjou, and M. Alharby, "Trustchain: Trusted blockchain-based system for supply chain traceability," *Arabian Journal for Science and Engineering*, pp. 1–19, 2024.

- [31] A. Mishra, S. Karmakar, A. Dutta, A. Bose, and M. Mohapatro, "Design and deployment of iot enabled blockchain based resilient supply-chain management system using ethereum," *International Journal of Computing and Digital Systems*, vol. 12, no. 1, pp. 1029–1050, 2022.
- [32] S. M. A. Nipu and T. Mahatab, "A new approach to inventory classification using a multi-criteria decision-making method to increase business efficiency," *International Journal of Management Concepts and Philosophy*, vol. 17, no. 3, pp. 305–321, 2024.
- [33] Q. Liu, Y. Dai, and W. Hong, "A blockchain based research on comprehensive quality evaluation of emerging engineering college students," in *Proceedings of the 2022 13th International Conference on E-Education, E-Business, E-Management, and E-Learning*, 2022, pp. 76–82.
- [34] E. R. D. Villarreal, J. García-Alonso, E. Moguel, and J. A. H. Alegría, "Blockchain for healthcare management systems: A survey on interoperability and security," *IEEE Access*, vol. 11, pp. 5629–5652, 2023.
- [35] M. Lnenicka, N. Rizun, C. Alexopoulos, and M. Janssen, "Government in the metaverse: Requirements and suitability for providing digital public services," *Technological Forecasting and Social Change*, vol. 203, p. 123346, 2024.
- [36] Y. Ding and J. Xu, "Blockchain-based student information management system," in *2023 4th International Conference on Information Science, Parallel and Distributed Systems (ISPDS)*. IEEE, 2023, pp. 12–16.
- [37] X. Huang, Y. Wang, H. Liang, Y. Ding, Q. Wu, Z. Zhang, and Q. Qu, "Educhain: A blockchain-based privacy-preserving lifelong education platform," in *International Conference on Database Systems for Advanced Applications*. Springer, 2023, pp. 701–706.
- [38] A. Choubey, S. Mishra, S. Behera, R. Misra, A. K. Pandey, and D. Pandey, "Smart homes, smart choices: Using big data to boost energy efficiency and environmental sustainability," *Electric Power Components and Systems*, pp. 1–19, 2024.
- [39] P. Raja and U. Mohan, "A conceptual framework proposed through literature review to determine the dimensions of social transparency in global supply chains," *Management Review Quarterly*, pp. 1–28, 2024.
- [40] D. Martinez, L. Magdalena, and A. N. Savitri, "Ai and blockchain integration: Enhancing security and transparency in financial transactions," *International Transactions on Artificial Intelligence*, vol. 3, no. 1, pp. 11–20, 2024.
- [41] R. E. Tarigan, H. Agustian, R. Nurfaizi, A. R. A. Zahra *et al.*, "Harnessing big data for economic transformation in a digitalized world," *2024 3rd International Conference on Creative Communication and Innovative Technology (ICCIT)*, pp. 1–8, 2024.
- [42] D. A. Yusuf, R. W. Anugrah, M. A. Komara, D. Julianingsih, and E. Garcia, "Leveraging blockchain technology to strengthen cybersecurity in financial transactions: A comprehensive analysis," *CORISINTA*, vol. 1, no. 2, pp. 119–125, 2024.
- [43] C.-J. Wang and H.-Y. Hsieh, "Effect of deep learning approach on career self-efficacy: Using off-campus internships of hospitality college students as an example," *Sustainability*, vol. 14, no. 13, p. 7594, 2022.
- [44] M. Zhang, J. Cao, Y. Sahni, Q. Chen, S. Jiang, and L. Yang, "Blockchain-based collaborative edge intelligence for trustworthy and real-time video surveillance," *IEEE Transactions on Industrial Informatics*, vol. 19, no. 2, pp. 1623–1633, 2022.
- [45] L. S. Lutfiani, A. Birgithri, and Z. Queen, "Technological aspects in the era of digital transformation leading to the adoption of big data," *Startupreneur Business Digital (SABDA Journal)*, vol. 3, no. 1, pp. 43–53, 2024.
- [46] R. Rasmitadila, T. Prasetyo, H. D. Hasnin, W. R. R. Hayu, and F. Hamamy, "Student teacher's perception of the relevancy of theory and practice in inclusive classrooms based on internship experiences: External and internal support," *International Journal of Special Education*, vol. 39, no. 1, pp. 124–135, 2024.
- [47] Q. Aini, D. Manongga, U. Rahardja, I. Sembiring, and Y.-M. Li, "Understanding behavioral intention to use of air quality monitoring solutions with emphasis on technology readiness," *International Journal of Human-Computer Interaction*, pp. 1–21, 2024.
- [48] J.-h. Kim, B.-i. Seok, H.-j. Choi, S.-h. Jung, and J.-p. Yu, "Sustainable management activities: A study on the relations between technology commercialization capabilities, sustainable competitive advantage, and business performance," *Sustainability*, vol. 12, no. 19, p. 7913, 2020.