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LEVERAGING THE POWER OF BLOCKCHAIN TECHNOLOGY FOR BUILDING A RESILIENT STUDENT FEEDBACK SYSTEM

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Abstract
In today's educational landscape, student feedback plays a pivotal role in enhancing teaching and learning. Traditional feedback systems have their limitations, such as data security and transparency issues. The current research explores the integration of blockchain technology to create a robust and secure student feedback system. Blockchain's unique characteristics, including data integrity, transparency, and smart contracts, can significantly improve the feedback process. The research outlines the academic relevance of student feedback systems, key components for effective feedback, and the role of blockchain in building such a system. It also presents a conceptual model design, system architecture, and the smart contract functionality implemented in Solidity. The use of blockchain ensures the security, transparency, and efficiency of the feedback process, offering the potential for transformative improvements in education.
Keywords: Blockchain-based Feedback System, Educational Improvement, Privacy, Student Feedback, Transparency, User Experience.

Introduction
The practice of students providing feedback about teaching and learning, often referred to as student feedback or student evaluations of teaching (SET), has become an integral part of educational institutions worldwide. It involves students sharing their perspectives, opinions, and assessments of their learning experiences and the effectiveness of their instructors. This feedback process is typically conducted through surveys or questionnaires and offers valuable insights into the quality of education being delivered. The information collected through student feedback plays a vital role in shaping educational environments and improving the teaching and learning process. Students giving feedback about teaching and learning is a fundamental aspect of the educational process. It empowers students to actively contribute to the quality of education they receive, promotes continuous improvement in teaching methods and curriculum, and strengthens the overall educational experience for both students and instructors. This feedback loop is essential for creating responsive and effective educational systems.

A. Academic Relevance of Student Feedback System
Student academic feedback holds significant importance in education because it serves a multifaceted role in enhancing the learning experience. The significance of student feedback system can be attributed to the following factors:

- Enhances Teaching Effectiveness: Student feedback enables instructors to refine their teaching methods, making them more effective in meeting students' diverse learning needs.
- Improves Course Content and Delivery: Feedback helps educators fine-tune course materials and teaching techniques, ensuring they align with student comprehension and engagement levels.
- Fosters Student Engagement: Encouraging feedback empowers students to actively participate in their education, promoting a sense of ownership and responsibility for their learning.
- Tailors Support and Resources: Student input highlights areas where additional resources or support, such as tutoring or materials, may be needed, aiding institutions in resource allocation.
- Promotes Accountability and Transparency: Public availability of feedback results fosters accountability within institutions, fostering transparency and improvement.
- Enhances Student-Teacher Communication: Feedback encourages open communication between students and instructors, allowing concerns to be addressed constructively.

- Supports Evidence-Based Decision-Making: Collected data guides decisions about curriculum, faculty development, and resource allocation, grounded in real student experiences.
- Informs Accreditation and Quality Assurance: Student feedback is vital for assessing institutional commitment to continuous improvement and adherence to quality standards.
- Enhances the Learning Environment: Actively responding to feedback creates a positive and supportive learning environment, contributing to higher satisfaction and retention rates.
- Encourages Faculty Development: Faculty can use feedback for professional growth, identifying areas for improvement and refining their teaching skills. This feedback loop is pivotal in continuous educational improvement and student success.

B. Key Components of Feedback System

A feedback system where students provide feedback about teachers is essential for improving the quality of education and ensuring that educators are effective in their roles. Implementing a robust feedback system can be a valuable tool for promoting excellence in education and ensuring that both students and teachers have a voice in the improvement process. It should be seen as a collaborative effort aimed at enhancing the overall educational experience.To create an effective feedback system, several key components should be considered:

- Anonymity: It should be ensured that students can provide feedback anonymously. This encourages honesty and eliminates the fear of repercussions.
- Clear Objectives: The purpose and objectives of the feedback system should be clearly communicated to both students and teachers. The goal is to improve teaching and learning.
- Questionnaire or Survey: A structured questionnaire or survey should be designed that covers various aspects of teaching and the learning experience. Questions should be clear, concise, and focused on specific aspects of teaching performance.
- Open-Ended Questions: Open-ended questions should be included to allow students to provide detailed comments and suggestions beyond multiple-choice responses. These can provide valuable insights.
- Frequency: A regular schedule should be established for collecting feedback. It could be done at the end of each course, semester, or academic year. Regular feedback ensures that issues are addressed promptly.
- Online Platform: Online platform should be employed for collecting feedback to make it easy for students to submit their responses. Online systems can also streamline data collection and analysis.
- Accessibility: It should be ensured that the feedback system is accessible to all students, including those with disabilities or language barriers. Accommodations should be made as necessary.
- Privacy and Data Security: The privacy of both students and teachers should be protected by ensuring that data collected is securely stored and that results are kept confidential.
- Analysis and Reporting: A system should be in place for analyzing the feedback data and generating reports. These reports should be shared with teachers in a constructive and non-threatening manner.
- Action Plan: Teachers should be encouraged to create action plans based on feedback. This involves setting goals for improvement and implementing strategies to address identified issues.
- Professional Development: Professional development opportunities should be offered to teachers based on feedback results. This can help them improve their teaching skills and address specific areas of concern.
- Feedback Loop: A feedback loop should be established where teachers can respond to the feedback they receive and seek clarification or further input from students if needed.
- Follow-up: The progress should be monitored over time and the impact of feedback on teaching quality should be assessed regularly. Adjustments should be made to the feedback system as necessary.

- Transparency: Transparency should be maintained throughout the process. The usage of feed and the changes being made based on student input should be communicated
- Feedback Culture: A culture of feedback should be fostered within the educational institution and the students should be encouraged to see the value in providing constructive feedback and teachers to be open to receiving it.
- Continuous Improvement: Feedback system itself should be subject to continuous improvement. Hence feedback from students should be solicited on the feedback process to make necessary enhancements.

C. Role of Blockchain in Building Robust Feedback System

Incorporating blockchain into feedback systems can result in more robust, transparent, and secure processes. Blockchain technology has the potential to enhance and optimize feedback systems in various ways, contributing to the achievement of the goals and objectives outlined in the traditional feedback process. The role of blockchain in enabling these goals are listed below:

- Data Integrity and Security: Blockchain's decentralized and tamper-resistant ledger ensures the integrity and security of feedback data. Feedback data stored on a blockchain is resistant to unauthorized alterations, ensuring that the information remains accurate and trustworthy.
- Transparent and Immutable Record Keeping: Blockchain provides a transparent and immutable record of all feedback interactions. Each entry in the blockchain represents a specific feedback instance, making the entire process transparent and easily auditable.
- Ownership and Control: With blockchain, individuals can have ownership and control over their feedback data. They can grant or revoke access to their feedback information, allowing for greater privacy and data control.
- Identity Verification: Blockchain can enable secure identity verification, ensuring that feedback comes from verified sources. This can reduce the risk of fake or malicious feedback, enhancing the credibility of the feedback system.
- Smart Contracts for Automated Processes: Smart contracts, which are self-executing contracts with the terms of the agreement directly written into code, can automate various aspects of the feedback process. For example, they can trigger feedback requests, distribute feedback tokens or rewards, and facilitate the assessment and response process.
- Data Portability: Blockchain allows individuals to have portable feedback data that can be shared across different educational or professional platforms. This promotes data interoperability and ensures that feedback data can be used to its full potential.
- Enhanced Feedback Loop: Blockchain can streamline the feedback loop by automating actions and responses. For instance, when a student receives feedback from the student, a smart contract can trigger notifications for further discussions, creating a more efficient feedback cycle.
- Decentralized Verification: Verification of feedback can be decentralized through blockchain. Instead of relying on a single centralized authority, blockchain's distributed ledger can be used to verify the authenticity of feedback provided by multiple parties.
- Data Analytics and Insights: Blockchain can facilitate data analytics and insights by providing a comprehensive and secure dataset. Institutions and individuals can gain valuable insights into feedback trends and patterns, helping them make data-driven decisions for improvement.
- Trust and Credibility: The transparent and tamper-proof nature of blockchain enhances trust and credibility in the feedback system. This can lead to increased confidence in the feedback process, resulting in more meaningful and constructive feedback.
- Reduced Intermediaries: Blockchain reduces the need for intermediaries in the feedback process, cutting down administrative costs and potentially making feedback systems more cost-effective.

D. Mapping Feedback System Requirements with Characteristics of Blockchain

Table I. depicts the suitability of blockchain in implementation of feedback system revealing how blockchain characteristics are tailored for design of resilient and robust feedback system.

TABLE I. Mapping Feedback System requirements to the Blockchain characteristics

Feedback System Requirement	Blockchain Characteristic Tailored to the Need
Data integrity and Security	Immutable ledger
Transparent and immutable record keeping	Transparency and Immutability
Ownership and control	User controlled data
Anonymity	Public addresses, zero knowledge proofs
Automated processes	Smart contracts
Data portability and sharing	Decentralization
Unbiased evaluation	Decentralized trust and verification and reduced intermediaries.

Literature

In the realm of technology and education, several pioneering papers have illuminated the transformative potential of blockchain. In their paper Rehman et al. (Rahman et al., 2020) introduce a cutting-edge solution to the challenges of obtaining honest stakeholder feedback in the digital age. The advent of blockchain technology has revolutionized security and transparency across various sectors, and this paper explores its application in feedback systems. Traditional feedback collection often encounters obstacles related to safety, bias, and nepotism, exacerbated by trust issues in database systems. The authors propose a digital feedback system that ensures user anonymity, encouraging candid feedback without fear of repercussions. This system not only preserves user trust but also provides valuable insights into the collective sentiments within an organization. Beyond data collection, this innovation has the potential to be a game-changer in the corporate world, transforming the way organizations utilize feedback for growth and development. By harnessing blockchain technology, this system offers a secure, transparent, and trustworthy means of understanding organizational perceptions, fostering a culture of openness and improvement. Smith et al.'s proposal holds the promise of reshaping feedback processes and enhancing transparency in corporate environments. The development of a Course Feedback System that harnesses blockchain technology for the secure, tamper-resistant, and efficient collection and management of student feedback was carried out (Chandratre & Garg, 2019). This innovative approach not only enhances transparency but also empowers professors with the tools to create custom surveys, further contributing to the improvement and evaluation of courses in an educational setting. The research carried out offers a comprehensive exploration of blockchain technology, starting with a detailed examination of blockchain architecture (Zheng et al., 2017). It delves into a comparative analysis of various consensus algorithms commonly employed in different blockchain implementations. Additionally, the paper highlights key technical challenges and provides a succinct overview of recent advancements in the field (Kosba et al., 2016). The application of blockchain technology in the education sector is explored to create a decentralized and highly trusted ledger for Student Information Systems (SIS) (Mohammed Ali et al., 2022). It addresses issues in traditional systems such as centralized record-keeping and dependency on single cloud providers or locally hosted databases. The proposed models focus on ensuring data availability, enabling students to access their information at any time, while maintaining records for students, faculty, course registrations, and grades. These models eliminate the need for super administrators and centralized storage, enhancing data integrity and facilitating the issuance of genuine certificates in an electronic community. The blockchain technology is advocated to address the shortcomings in traditional education systems, particularly in Student Information Systems (SIS). They highlight the advantages of a decentralized, reliable, and highly trusted ledger, emphasizing attributes like security, immutability, and independence from educational institutions. The paper introduces three blockchain-based models designed to create a fully functional SIS, enabling the secure management of student and faculty records, course registrations, and grades, while eliminating the vulnerabilities associated with super administrators and centralized data storage. The proposed models aim to foster an electronic community where authentic certificates can be easily issued and shared without reliance on centralized administration (Karat & Kannimoola, 2023) (Alammary et al., 2019) (Morsidi et al., 2021) (Shree et al., 2020).

A. Research Gaps

An exhaustive literature review identifies key areas for further research in blockchain-based student feedback systems, including scalability, usability, privacy, cost, security, INCENTIVES, educational impact, and overcoming adoption barriers. Addressing these issues can advance the effectiveness and efficiency of such systems in education. The existing research endeavours to tackle several of these challenges by implementing a decentralized application that enhances the user experience through a multi-tier application architecture. To address privacy, cost, and security concerns, a local blockchain is employed, utilizing synthetic ethers for transactions. Furthermore, fungible tokens, adhering to the ERC-20 standard, are minted to incentivize faculty members with exceptional feedback records, promoting their active engagement in the system.

III. CONCEPTUAL MODEL DESIGN

A. SYSTEM REQUIREMENT SPECIFICATION AND BLOCKCHAIN TOOLS EMPLOYED

- Each student should be uniquely identified by public address in his MetaMask wallet. All the stake holders will be performing the transactions using their corresponding MetaMask wallet.
- Authorization through modifiers: Implement access control to restrict certain functions, such as deploying contract or retrieving sensitive information, to authorized parties only employing the modifiers supported by Solidity.
- Time Constraints: Time constraints should be enforced for feedback submission to ensure that feedback is submitted within a specified window (For example, within a semester or a certain number of days after the end of the semester).
- Minimum Feedback Requirements: Minimum requirements should be set for feedback submission, such as requiring students to provide ratings for all questions.
- User Notification: The users should be notified of important events or changes in the contract, such as the closure of the feedback submission window or contract upgrades.

B. System Roles

The system is operable with the users of diverse roles depicted in Table II. The role name along with the task permitted to the user in that role is listed.

TABLE II. System roles

Role Name	Task Permitted
Admin	Deploys the contract with the parameters conforming to target and deadline parameters. Deploys DateTimeConverter smart contract Adds director to the system Adds coordinators to the system Adds faculty members to the system Assigns courses to different faculties Generates feedback questions and stores on the blockchain.
Director	Configures and sets up the feedback system which includes defining parameters, setting up user roles, and configuring access controls. Access to All Feedback Data Generate comprehensive reports and analytics based on the feedback data to assess the performance of faculty and the overall quality of education Extends the deadline if the feedback target is not met within the stipulated time period. Prepares action plan based on feedback responses Mints ERC-20 Feedback tokens.

	Rewards the faculties with excellent feedback report.
Faculty	Views own feedback report Respond to feedback by providing comments or action plans to address concerns or suggestions raised by students.
Coordinator	Registers the students of his own class Views no. of student registrations of the own class Views no. of feedbacks provided by the students of his class. Views/modifies class information
Student	Provides feedback for all the courses of the current semester. Authenticates with the system using his public address to preserve anonymity to prevent any potential bias or fear of retaliation.

C. SYSTEM ARCHITECTURE

The multi layered architecture employed for system implementation is depicted in Fig. 1. The decentralized application employs a well-structured architecture featuring a 3-tier framework extended with additional layers to enhance integrity and security. At the Presentation Layer, a React-based frontend provides the user interface for interacting with the decentralized application (DApp). The Application Layer encompasses Middleware components for added functionality, Web3.js for blockchain interaction, and custom business logic within the DApp Logic. The API Layer manages interactions with the blockchain, serves frontend data, and handles user authentication, while the Blockchain Layer utilizes smart contracts (Solidity) on the Ethereum Mainnet for production and Ganache for local development and testing. The Infrastructure Layer comprises Ethereum nodes and IPFS for distributed storage, and the Security and Identity Layer incorporates MetaMask for user wallet and account management. This multi-layered architecture ensures robustness, scalability, and security in the decentralized application ecosystem.

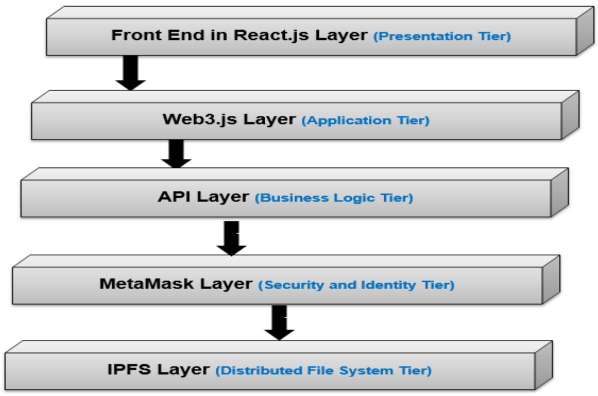

Fig. 1. Multi Layered System Architecture

D. SYSTEM WORKFLOW

A typical workflow and sequence of tasks performed by the system are depicted in Fig. 2.
Here's a description of the system flow for the blockchain-based feedback system:

- Contract Deployment by Admin: The system begins with the Admin deploying the contract, establishing the foundation for the feedback system.
- Creating roles and inserting Feedback Questions: Following contract deployment, the Admin adds director, faculty members, class coordinators and inserts feedback questions onto the blockchain, setting the stage for feedback collection.
- Student Registration: Coordinator registers his class students within the system without any payment requirement.
- Registration Monitoring: The Coordinator monitors and ensures that all students enrolled in their respective courses complete their registration with the system.
- Feedback Collection: Students give the feedback within the specified deadline.

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- Feedback Tracking: The Coordinator keeps track of registered students who have submitted feedback, with a focus on meeting the target of at least 70% student participation, as established by the system's objectives.
- Faculty Feedback Access: Faculty members have the capability to access and view the average feedback provided by students across all the courses they teach. Furthermore, faculty members have the opportunity to provide responses to address any challenges encountered in content delivery as highlighted in the feedback.
- Director's View: The Director can access the average feedback data for any faculty member concerning a specific course. Prepare an action plan based on the feedback responses received from different faculty members. Additionally, the director acknowledges and rewards faculty members who receive exceptional feedback reports, recognizing their outstanding performance.
- Report Generation: The system generates reports pinpointing areas for improvement, highlighting faculty names, and assessing feedback ratings below 2.5 on a 5-point scale (ratings below 2.5 signify less than 50% satisfaction). If the target feedback is not achieved within the stipulated time period the director has the privilege to extend the deadline.
- Faculty Response: Faculty members can provide explanations in response to the generated reports, offering their insights into the feedback received. These responses are viewable by users in the Director role.
- Faculty Reward: Faculty members who consistently receive excellent feedback, defined as scoring above 4 points in all questions across all the courses they teach, will be automatically rewarded. This reward will be in the form of the transfer of 1 ERC20 token to their wallet.

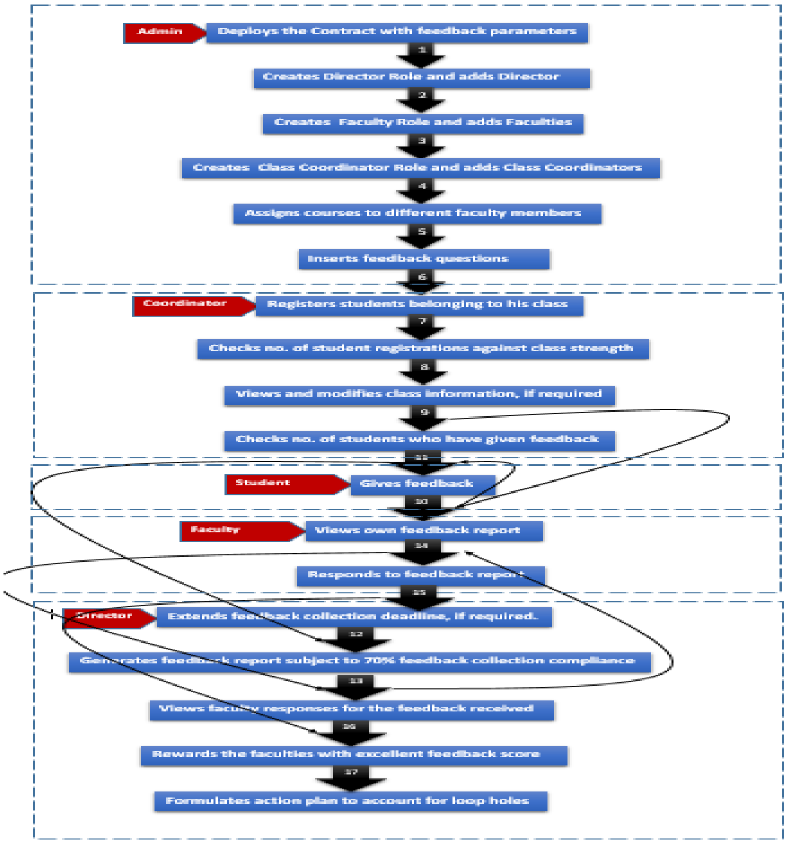

Fig. 2. System Workflow and Sequence of Tasks

E. MODEL IMPLEMENTATION

The interaction between the different components of feedback system is shown in Fig. 3.

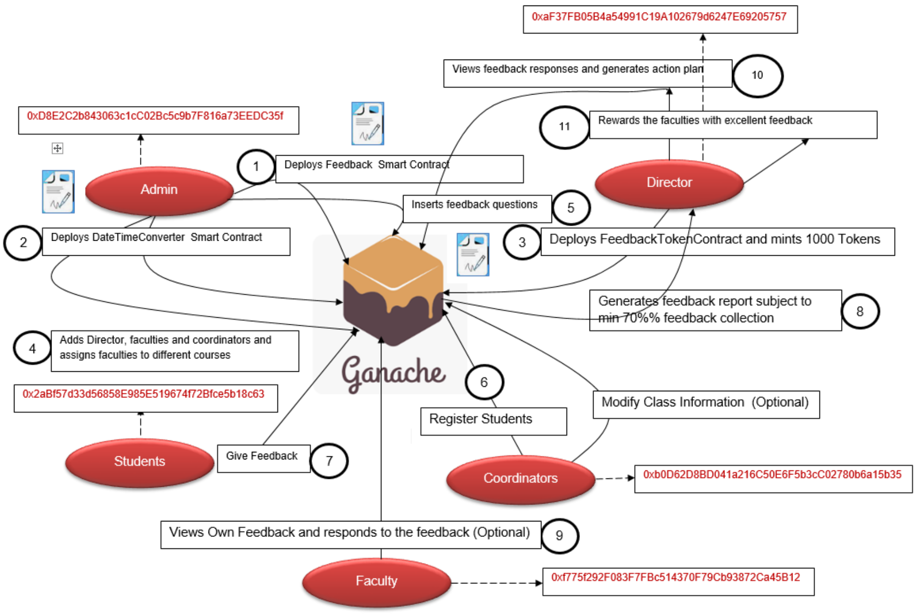

Fig. 3. Interaction between the different components of feedback system.

F. SOLIDITY DATA STRUCTURE SELECTION

Solidity data structures employed in model implementation are depicted in Table III.

TABLE III. SOLIDITY DATA STRUCTURES EMPLOYED IN MODEL IMPLEMENTATION

Data Structure	Purpose
address	In blockchain every user is identified by unique ethereum public address. For storing the addresses of admin, director, faculty, coordinator and student.
Structure	For storing faculty information, class information, feedback information, feedback responses, etc.
mapping	Mappings address to relevant structures.

The consolidated smart contract structure with different data structures and the smart contract functions affecting the data structures is depicted in Fig. 4.

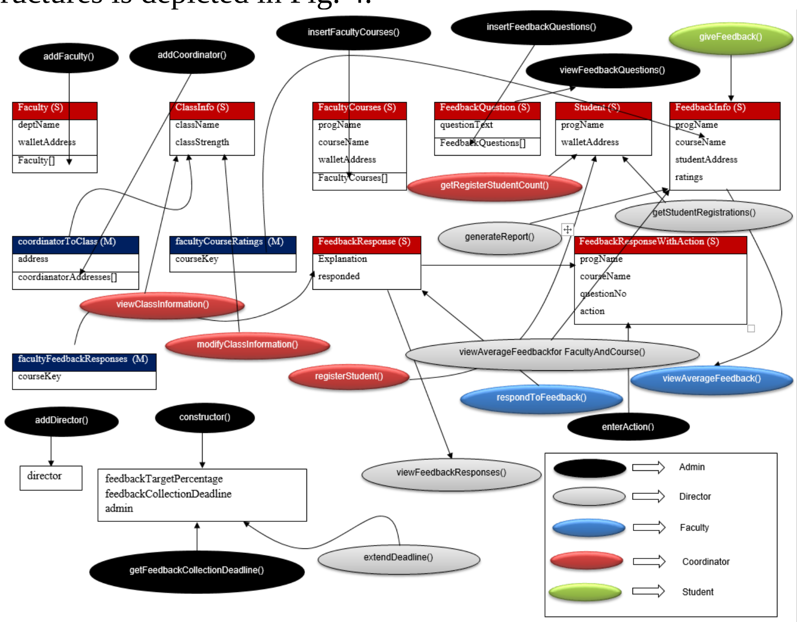

Fig. 4. Consolidated Smart Contract Structure

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IV. EXPERIMENTAL RESULT AND FUTURE SCOPE

A. Model Implementation in Remix IDE

Fig. 5. depicts implementation of the above conceptual model in Solidity and testing in Remix IDE.

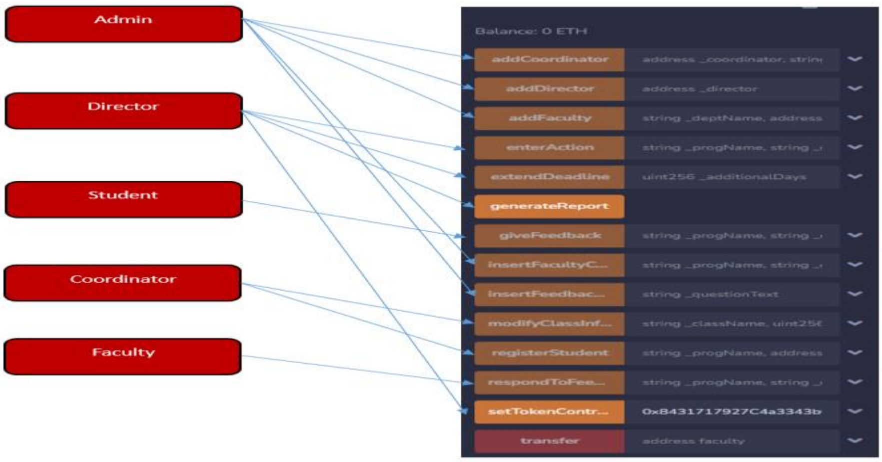

Fig. 5. Mapping System Roles to System Tasks Accessible to the Role

Different parameters employed in model testing are depicted in Table IV

TABLE IV. SOLIDITY RUNTIME PARAMETERS EMPLOYED IN MODEL TESTING

Parameter	Description
Solidity Compiler	0.8.1
Runtime	EVM

The conceptual model presented above is implemented in Solidity and tested in Remix IDE by deploying on two different test networks Ganache and LineaGoreli.

Fig. 6. shows the smart contracts implemented in Solidity for converting Unix time to human readable date time format, ERC-20 token creation and feedback collection.

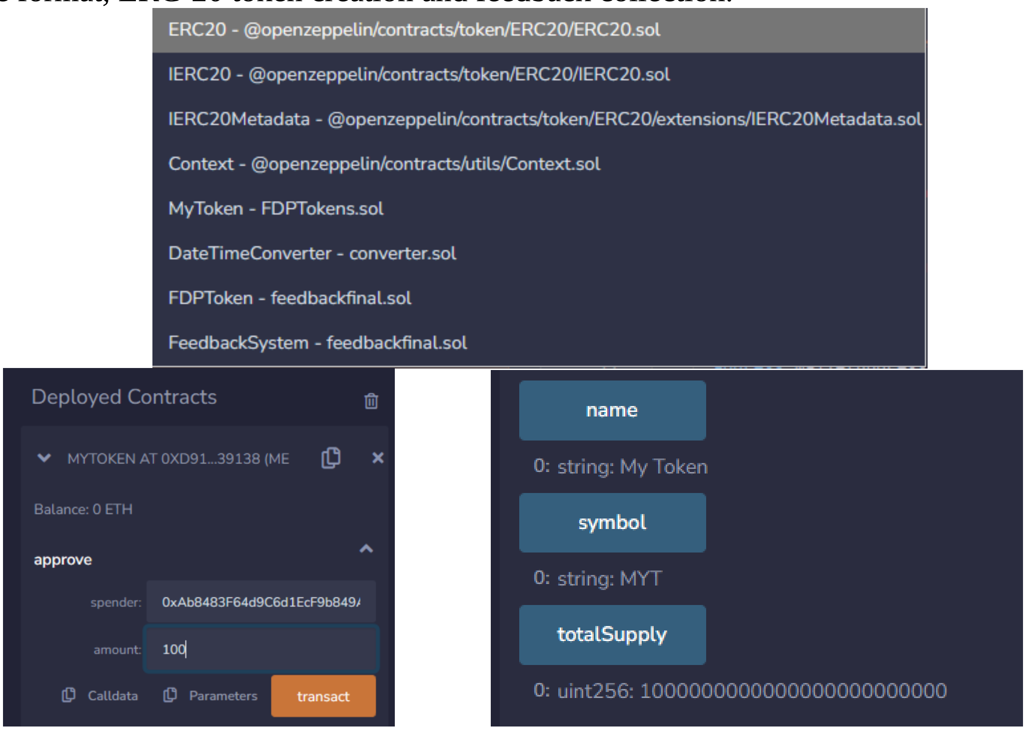

Fig. 6. Smart Contracts Implemented in Solidity

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Fig. 7. shows deployment of feedback collection smart contract by specifying the contract parameters at the time of deployment.

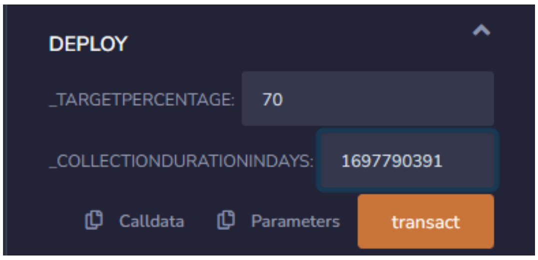

Fig. 7. Deployment of feedback collection smart contract in Remix IDE

Epoch converter is used for converting the feedback deadline into human readable format as depicted in Fig. 8.

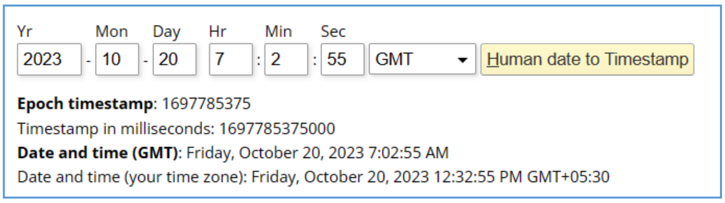

Fig. 8. Epoch Converter for Converting Feedback Deadline into Human Readable Format

B. Creating System Roles

Wallet Addresses of different roles operable in the system is depicted in Table V.

TABLE V. WALLET ADDRESSES OF DIFFERENT ROLES OPERABLE IN THE SYSTEM.

User Address	Role Name
0xD8E2C2b843063c1cC02Bc5c9b7F816a73EEDC35f	Admin
0xaF37FB05B4a54991C19A102679d6247E69205757	Director
0xb0D62D8BD041a216C50E6F5b3cC02780b6a15b35	Coordinator
0xf775f292F083F7FBc514370F79Cb93872Ca45B12	Faculty
0x2aBf57d33d56858E985E519674f72Bfce5b18c63	Student

Fig. 9. shows the deployment of feedback smart contract on Ganache.

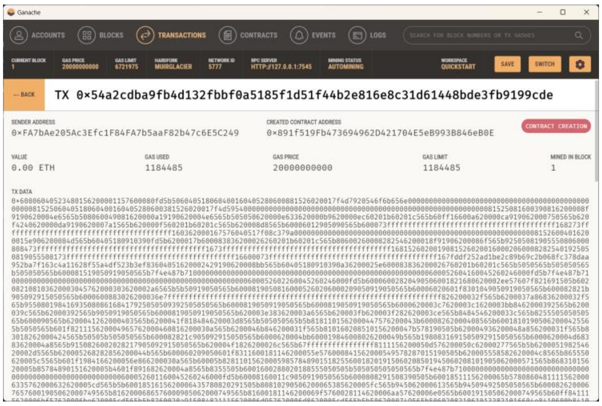

Fig. 9. Deployment of feedback smart contract on Ganache

The frontend of the feedback system is implemented in React.js. Fig shows the admin interface. The user authentication is handled through MetaMask accounts corresponding to the user. When the admin

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connects to the system using his metamask account, the functions permissible to admin are displayed as shown in Fig. 10.

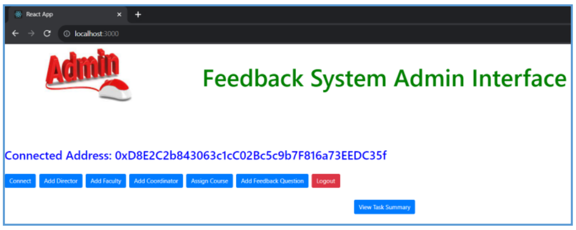

Fig. 10. Admin Interface of Feedback System Using React.js

Fig. 11. shows adding director to the feedback system

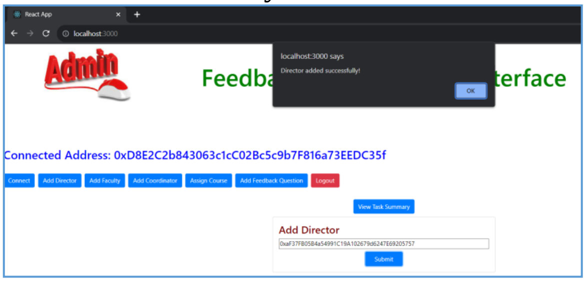

Fig. 11. Adding Director to the System

The ‘View Task Summary’ button offers a consolidated overview of the various tasks carried out by the administrator, marking the initiation of the feedback system. This allows for a comprehensive view of the administrative activities as shown in Fig. 12.

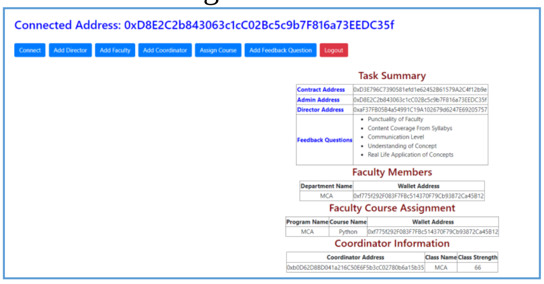

Fig. 12. Consolidated View to Admin Tasks

Fig 13(a) – Fig13(b) show the transaction details of smart contract deployment in LineaGoreli test network

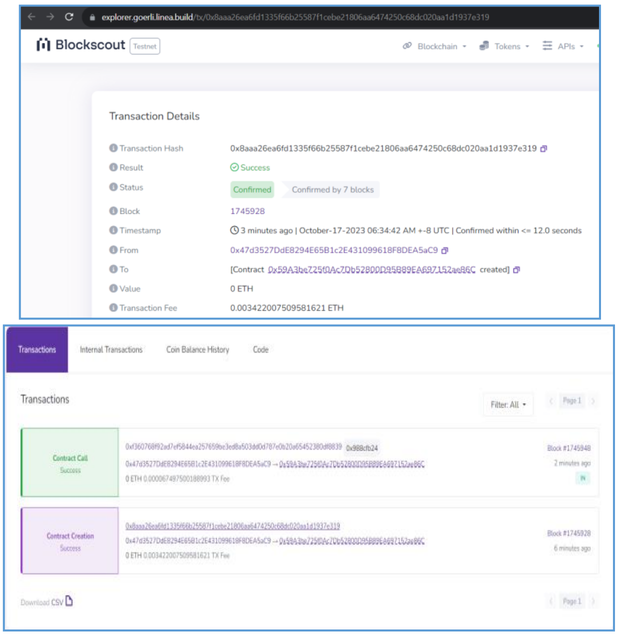

Fig 13(a) – Fig13(c) Smart contract deployment on LineaGoreli test network

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C. Retrieving the ERC-20 Tokens in Faculty Wallet

MyToken contract Address is 0x891f519Fb473694962D421704E5eB993B846eB0E. For retrieving the ERC-20 token sent by the director as a reward towards excellent feedback records, the faculty logs into the MetaMask wallet by specifying the pass phrase, clicks on the 'Token' option and uses 'Import Token' link for importing the ERC-20 tokens in his MetaMask.

On specifying the token address shared by the director with the faculty and clicking in 'Next' button, the available token balance is shown in MetaMask which can be imported into the wallet by clicking on 'Import' button as shown in Fig 14.

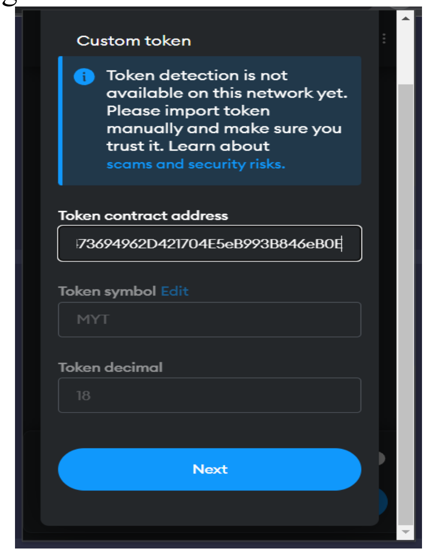

Fig. 14. Importing ERC-20 Tokens by Faculty

On specifying the token address shared by the director with the faculty and clicking. The available ERC-20 tokens will be deposited in the MetaMask wallet of the faculty as shown in Fig. 15.

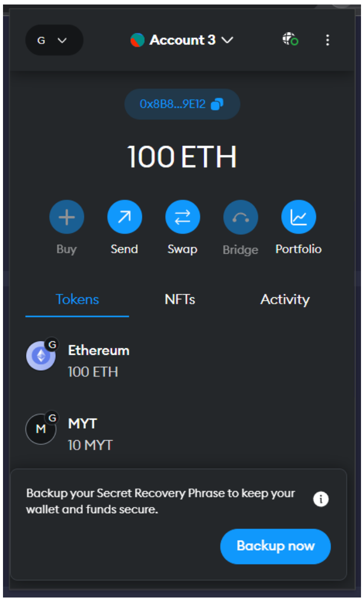

Fig. 15. Balance of ERC- 20 Tokens in Faculty Wallet

Fig 16(a) and 16(b) show the ERC-20 token balance of faculty and director, respectively.

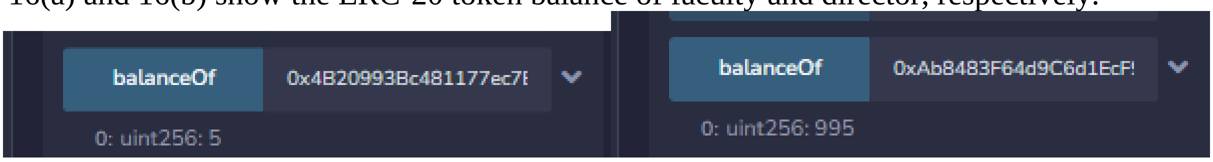

Fig. 16(a) – 16(b) ERC-20 Token Balance of Faculty and Director

V. CONCLUSION AND SCOPE FOR FUTURE WORK

The implementation of a blockchain-based student feedback system represents a significant step forward in enhancing the educational feedback process. This paper has highlighted the importance of student feedback in improving teaching quality, learning experiences, and overall educational environments. By integrating blockchain technology into this system, we've achieved data integrity, security, transparency, and smart contract automation. The decentralized nature of blockchain ensures the trustworthiness of the feedback data, while smart contracts facilitate seamless feedback collection, analysis, and response. This innovative approach empowers students to provide feedback anonymously, fosters accountability and transparency within educational institutions, and promotes student-teacher communication. It also allows faculty members to respond to feedback constructively, fostering a culture of continuous improvement.

Future research and development in the realm of blockchain-based student feedback systems should prioritize addressing critical areas. These include enhancing scalability for handling substantial feedback data volumes efficiently, improving user experience to ensure ease of interaction for students and faculty, devising advanced privacy solutions for safeguarding user data while preserving blockchain transparency, conducting in-depth cost and resource analysis for system maintenance, further investigating security vulnerabilities specific to educational blockchains, exploring innovative tokenization and incentives to encourage greater student participation, assessing the real-world educational impact of these systems, and tackling challenges hindering blockchain adoption within educational institutions. This ongoing work promises more effective and transparent educational feedback processes, contributing to the continued advancement of educational quality and experiences.

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