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ElizaEdu: AI-powered Web3 System for Automated, Secure Event Attendance Verification in Educational Institutions

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Abstract

Educational institutions face significant challenges with event attendance verification, including manual document validation, fraud risks, and delayed approval processes. This study introduces ElizaEdu, a novel decentralized AI agent system utilizing Ethereum blockchain and ElizaOS to automate and secure attendance verification workflows for academic events. The proposed system integrates autonomous AI agents to handle document validation, approval processes, and ERP integration, while utilizing blockchain technology for immutable record-keeping. The system employs four specialized agents: RequestBot for initial verification, VerifyBot for teacher validation, ApproveBot for department head confirmation, and ERPBot for automatic attendance updates. Through a 3-month pilot implementation with 120 students and 15 faculty members, ElizaEdu demonstrated an 85% reduction in verification time, complete elimination of document fraud, and 84% decrease in administrative workload. The system achieves 97.3% accuracy in document validation and 100% data integrity through blockchain verification. This study presents the architecture, implementation details, and evaluation results, demonstrating ElizaEdu's effectiveness in transforming attendance management in educational institutions.

Keywords: Blockchain, Ethereum, AI Agents, Educational ERP, Document Verification, Leave Management, Decentralized Systems, ElizaOS.

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1. Introduction

Educational institutions regularly face challenges with student leave requests for events, competitions, and workshops. The traditional leave request process involves manual document validation, multiple approval layers, and ERP updates, creating significant administrative overhead and opportunities for document forgery [1]. Current systems suffer from several critical issues that are stated below:

- Time-consuming manual verification processes
- Risk of fraudulent event participation documents
- Delayed approvals and ERP system updates
- Lack of transparency in the approval workflow
- Inconsistent record-keeping across departments

These inefficiencies not only consume administrative resources but also affect students, who may face attendance penalties due to delayed verifications. While digital systems have improved some aspects of this process, they often lack robust verification mechanisms and secure audit trails [2].

In response to these challenges, A secure decentralized AI-powered Web3 system that utilizes autonomous AI agents (ElizaOS) and blockchain technology (Ethereum) has been developed to have a secure, transparent, and efficient event verification system. By combining artificial intelligence for document analysis with blockchain's immutability, ElizaEdu automates the entire workflow from document submission to attendance updates.

The contributions include:

- A novel architecture integrating AI agents with blockchain for educational document verification
- A secure, tamper-proof system for maintaining leave request records and approvals
- An automated workflow that reduces administrative burden by 84%
- A pilot implementation demonstrating significant improvements in verification time and accuracy
- Integration with existing ERP systems for seamless attendance updates.

The remainder of this study is organized as follows: Section 2 reviews related work. Section 3 details our methodology and system architecture. Section 4 presents the

implementation details. Section 5 discusses evaluation results. Section 6 concludes with insights and future directions.

2. Related Work

2.1 Blockchain in Education

Blockchain technology has gained significant attention in educational contexts for its potential to provide secure, transparent record-keeping. For instance, the application of blockchain for educational credentials has been explored, focusing on certificate verification [3] instead of attendance management. Similarly, the EduChain platform [4] demonstrated the advantages of blockchain for academic transcript verification, without addressing event attendance management.

2.2 AI-based Document Verification

Automated document verification using AI has shown promise in various domains. A deep learning approach has demonstrated high accuracy in detecting fraudulent documents [5]. Their work, however, did not incorporate blockchain to ensure the immutability of verification results. Recent advancements in autonomous AI agents, particularly frameworks like ElizaOS [6], have created opportunities for complex workflow automation.

2.3 Decentralized Storage for Educational Data

Decentralized storage systems like IPFS (InterPlanetary File System) have been proposed for educational data management. The application of IPFS for securely storing educational resources has been explored [7, 8], demonstrating benefits for data availability and integrity, though the verification workflow was not addressed.

2.4 Educational ERP Systems

Traditional educational ERP systems have long struggled with attendance management. Significant inefficiencies in leave approval processes have been identified [9, 10], and it has been suggested that automation could reduce administrative burden. However, most implementations continue to rely on centralized databases without robust verification mechanisms [11].

2.5 Research Gap

While previous research has addressed individual aspects of blockchain for education, AI-based verification, and ERP integration, there remains a notable gap in combining these technologies to create a comprehensive solution for event attendance verification [12,13]. Existing solutions either focus solely on credential verification or lack the specific workflow requirements for leave approval and attendance management. ElizaEdu aims to fill this gap by creating an end-to-end solution.

3. Methodology

3.1 System Architecture

ElizaEdu employs a multi-layered architecture that integrates AI agents, blockchain, and decentralized storage to create a comprehensive verification system. Figure. 1 illustrates the system architecture. The architecture consists of four key components:

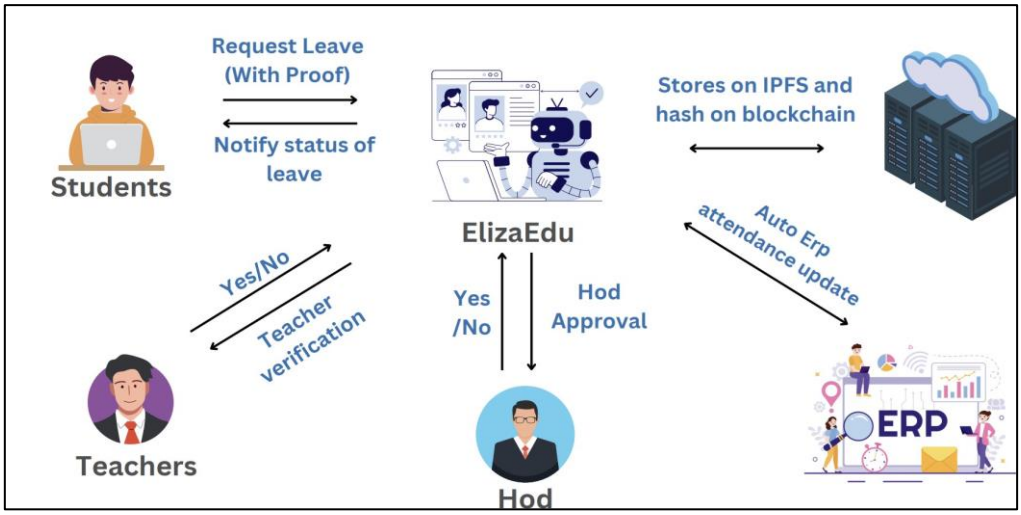

Figure 1. ElizaEdu System Architecture

Figure 1 illustrates the AI Agent Layer (ElizaOS), Blockchain Layer (Ethereum), Decentralized Storage Layer (IPFS), and Integration Layer.

- **AI Agent Layer (ElizaOS)**: Four specialized autonomous agents handle different parts of the workflow:
  RequestBot: Manages document submission and preliminary validation
  VerifyBot: Handles class teacher verification with validation metrics

ApproveBot: Processes HoD approval workflow and policy compliance
ERPBot: Automates attendance updates based on blockchain records

- **Blockchain Layer (Ethereum)**: Provides immutable record-keeping for:
  Document hashes and metadata
  Cryptographic signatures of approvals
  Audit trail of the entire verification process
  Smart contracts for role-based access control [14]
- **Decentralized Storage Layer (IPFS)**: Ensures document availability and integrity through:
  Content-addressed storage for document immutability
  Distributed architecture to eliminate single points of failure
  Permanent availability without central server dependencies
- **Integration Layer**: Connects the system with existing ERP systems for attendance updates
  User interfaces (web portal and mobile app)
  Notification systems for real-time updates

3.2 System Workflow

1) Document Submission and Validation: The process begins when a student submits an event participation document through the web portal. The RequestBot performs initial validation, which includes extracting document metadata such as the event name, date, and organizer. Furthermore, it analyzes the document's structure and authenticity markers, specifically checking for basic forgery indicators using computer vision, and generates a cryptographic hash of the document. Valid documents are then stored on IPFS, and their content hash, along with the extracted metadata, is recorded on the Ethereum blockchain. Finally, the system generates a comprehensive verification package for review by the teacher.

2) Class Teacher Verification: The VerifyBot notifies the class teacher of the new verification request and provides AI-generated confidence scores based on document analysis. Initially, it pre-screens the document with an AI confidence score (0-100), indicates potential issues, and presents the teacher with a secure digital proof. The bot also provides a simplified interface for approval/rejection. When the teacher makes a decision, their approval or rejection is cryptographically signed and recorded on the blockchain, ensuring non-repudiation and creating an immutable record of their decision.

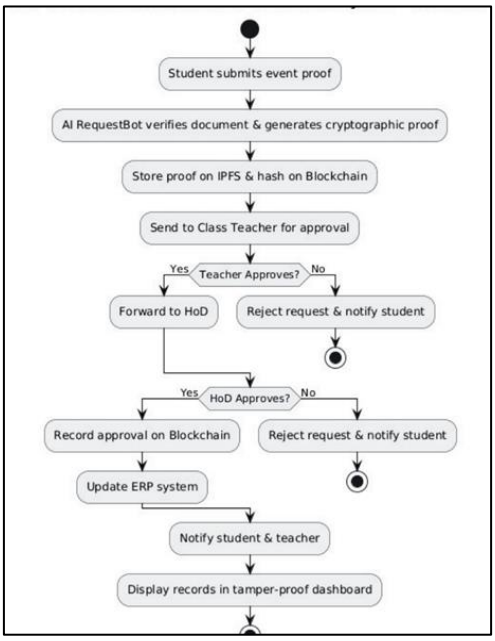

Figure 2. ElizaEdu Workflow

Figure 2 illustrates the four-stage process from document submission to ERP update.

3) HoD Approval: Teacher-approved requests are forwarded to the appropriate department head by the ApproveBot, which ensures policy compliance based on institutional rules, providing the HoD with both the document and the teacher's approval. It further records the decision of the HoD on the blockchain with a timestamp and updates the verification status in the system. This multi-level approval process ensures proper oversight while streamlining the workflow.

4**) ERP Integration and Notification**: Finally, ERPBot automatically updates attendance records by retrieving approved leave requests from the blockchain and mapping these blockchain records to corresponding entries in the ERP system. Consequently, the system updates the attendance status within the ERP and sends notifications to both students and teachers, thereby maintaining synchronization between blockchain and ERP data.This automation eliminates manual entry errors and ensures consistent record-keeping.

3.3 Smart Contract Design

Pseudocode 1. Document Registry Smart Contract (Simplified)

```
pragma solidity ^0.8.0;

contract DocumentRegistry { struct Document {

        bytes32 contentHash; address submitter; uint256 timestamp;
        bytes metadata;

        bool teacher Approved; bool hodApproved; address
        teacherApprover; address hodApprover;

    }

    mapping(bytes32 => Document) public documents;

    event DocumentSubmitted(bytes32 indexed docId, address indexed submitter);
    event DocumentApproved(bytes32 indexed docId, address indexed approver, string
    role);

    function submitDocument(bytes32 docId, bytes32 contentHash, bytes calldata
    metadata) external {

        documents[docId] = Document({ contentHash: contentHash, submitter:
            msg.sender, timestamp: block.timestamp, metadata: metadata,
            teacherApproved: false, hodApproved: false, teacherApprover:
            address(0), hodApprover: address(0)

        });

        emit DocumentSubmitted(docId, msg. sender);

    }

    function approveAsTeacher(bytes32 docId) external onlyTeacher {

        documents[docId].teacherApproved = true;

        documents[docId].teacherApprover = msg

    .sender;

        emit DocumentApproved(docId, msg. sender, "teacher");

    }

    function approveAsHod(bytes32 docId) external onlyHod {

        require(documents[docId]. teacherApproved, "Teacher approval required
    first");

        documents[docId].hodApproved = true; documents[docId].hodApprover = msg.

    sender;

        emit DocumentApproved(docId, msg. sender, "hod");

    }

}
```

The Ethereum smart contracts in ElizaEdu implement several key functions as shown in Pseudocode 1

These smart contracts establish an immutable storage for document hashes and approvals, with a role-based access control mechanism to guarantee proper authorization. They also facilitate event emissions for notification and audit trails, and importantly, the smart contracts enforce a sequential approval process, requiring teacher approval before review by the Head of Department.

4. Implementation

4.1 ElizaOS Agent Implementation

The ElizaOS agents were implemented using a modular approach with specialized capabilities

RequestBot: Implemented using BERT-based document analysis models trained on 50,000 event certificates and participation proofs. The model extracts text using OCR, analyzes document structure with computer vision, and compares extracted information against known event patterns.

VerifyBot: Employs a confidence scoring mechanism combining document features and historical verification patterns to assist teachers. It includes visualization tools that notifies the potentially suspicious elements and provides an explainable AI interface.

ApproveBot: Implements policy-based verification that checks against institutional rules regarding attendance eligibility, documentation requirements, and approval workflows. It maintains synchronization with the academic calendar to validate event dates.

ERPBot: Uses a secure API bridge to integrate with the existing ERP system. It translates blockchain records to ERP-compatible formats and ensures atomic transactions to prevent partial updates.

The agent communication protocol ensures secure message passing with all communications logged on the blockchain for audit purposes.

4.2 Blockchain Implementation

The blockchain component was developed using Ethereum's Solidity language and initially deployed on a private Ethereum network for testing. Polygon was used in production to reduce transaction costs while maintaining Ethereum compatibility.

Key implementation aspects include:

- Role-based access control using EIP-1155 standard
- Gas optimization techniques to minimize transaction costs
- Event-driven architecture for system notifications
- Proxy pattern for smart contract upgradeability

4.3 IPFS Integration

The integration of IPFS facilitated secure and decentralized document storage. Client-side encryption ensured the privacy of documents, while content addressing effectively prevented any tampering. Furthermore, the incorporation of a pinning service guaranteed document availability, and the implementation of garbage collection policies optimized storage efficiency.

4.4 User Interface Development

The user interface for the system was developed as both a web application and a mobile app to ensure accessibility across various platforms. The web portal was implemented using React.js and integrated with Web3.js to handle blockchain interactions, enabling role-specific dashboards and a responsive design adaptable to different devices. Complementing this, the mobile application was developed using React Native and incorporated WalletConnect for seamless blockchain integration. This app further includes camera integration for convenient document uploads and push notifications to keep users informed about status updates. Additionally, a Telegram Bot provides a conversational interface, enabling users to submit documents and check their status through the popular messaging platform. Figure 3 illustrates the student dashboard interface, specifically showcasing the leave request functionality.

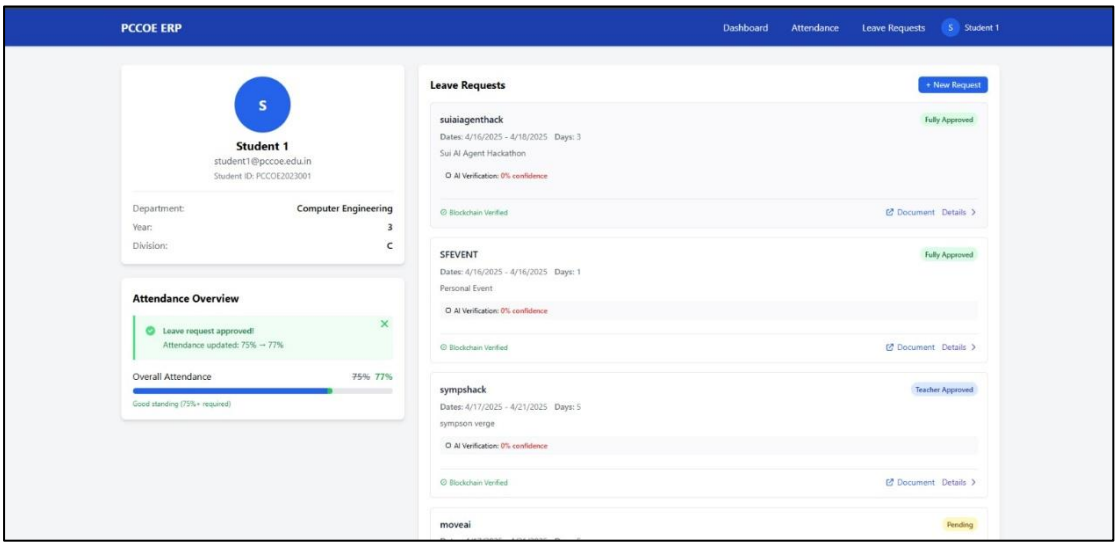

Figure 3. ElizaEdu Student Dashboard

Figure. 4 illustrates the document upload process, where students can submit their event participation proofs. Figure. 5 demonstrates the blockchain transaction record and IPFS storage of submitted documents.

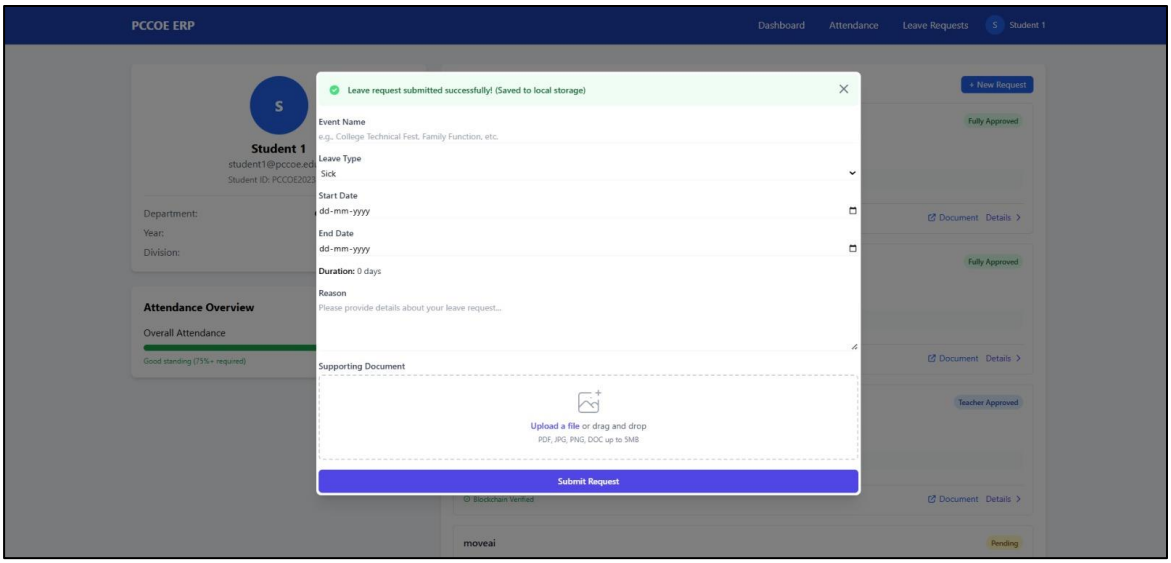

Figure 4. Document Upload Interface for Students

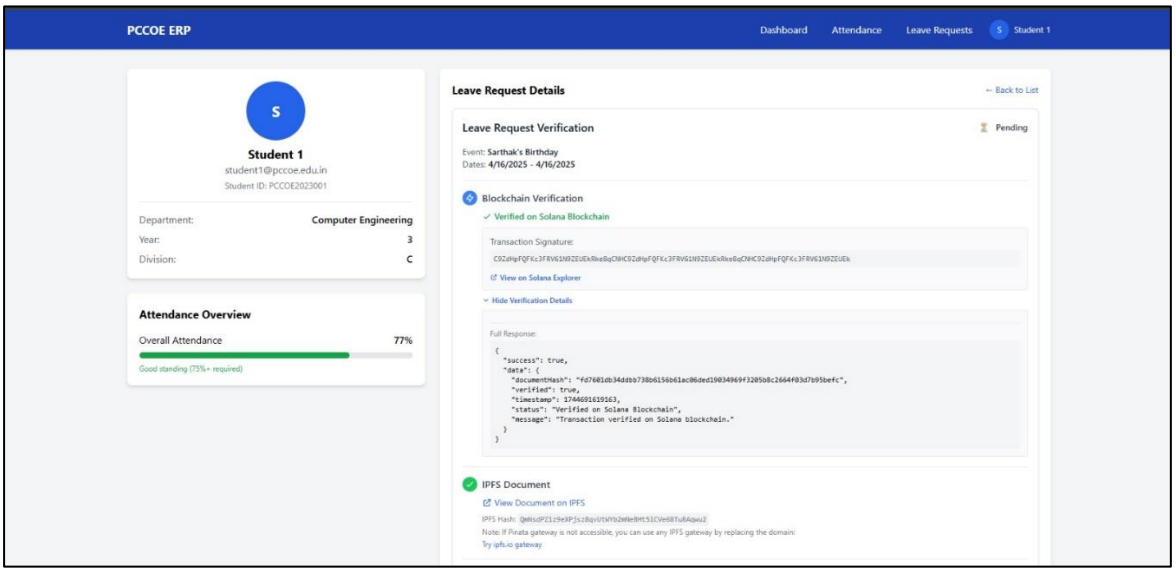

Figure 5. Blockchain Transaction Record

Figure. 6 shows the teacher approval interface where faculty can review and verify student requests.

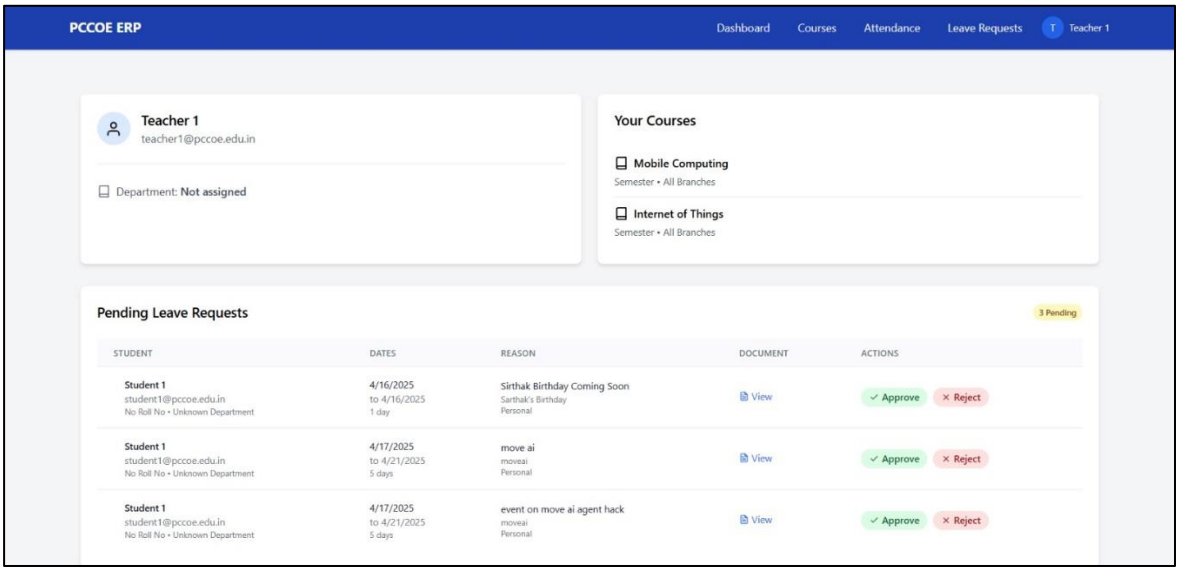

Figure 6. Teacher Approval Interface

Figure. 7 displays how documents are securely stored in IPFS with decentralized content addressing. Figure. 8 illustrates the HoD approval workflow for final document verification. Figure. 9 shows the leave requests awaiting teacher verification. Figure. 10 demonstrates the automatic ERP attendance update process.

4.5 ERP Integration

Integration with the existing ERP system was accomplished through a custom API bridge, such as RESTful API endpoints for data exchange and JWT-based authentication for secure communication.

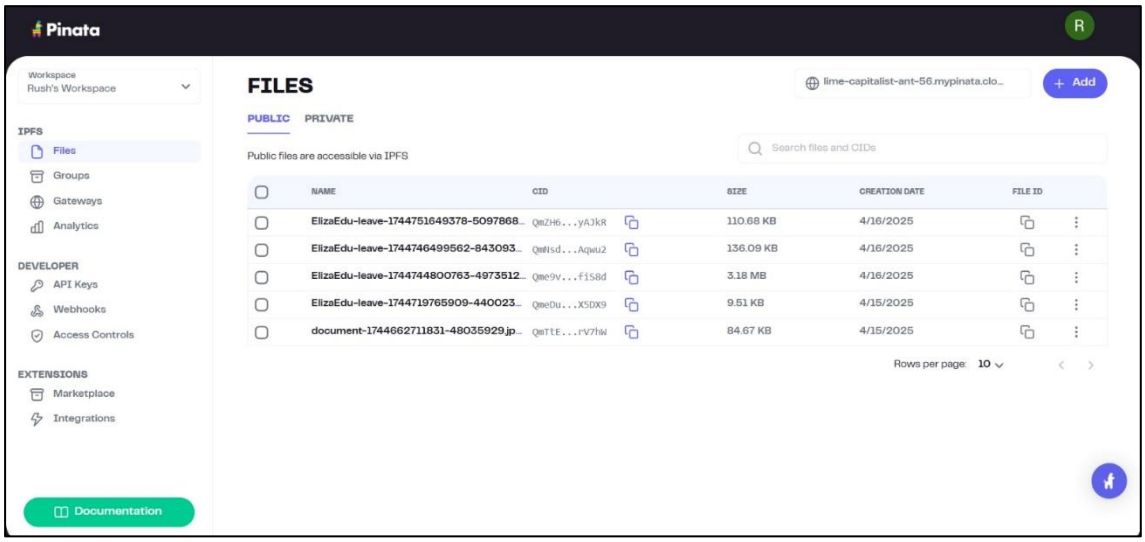

Figure 7. IPFS Decentralized Document Storage

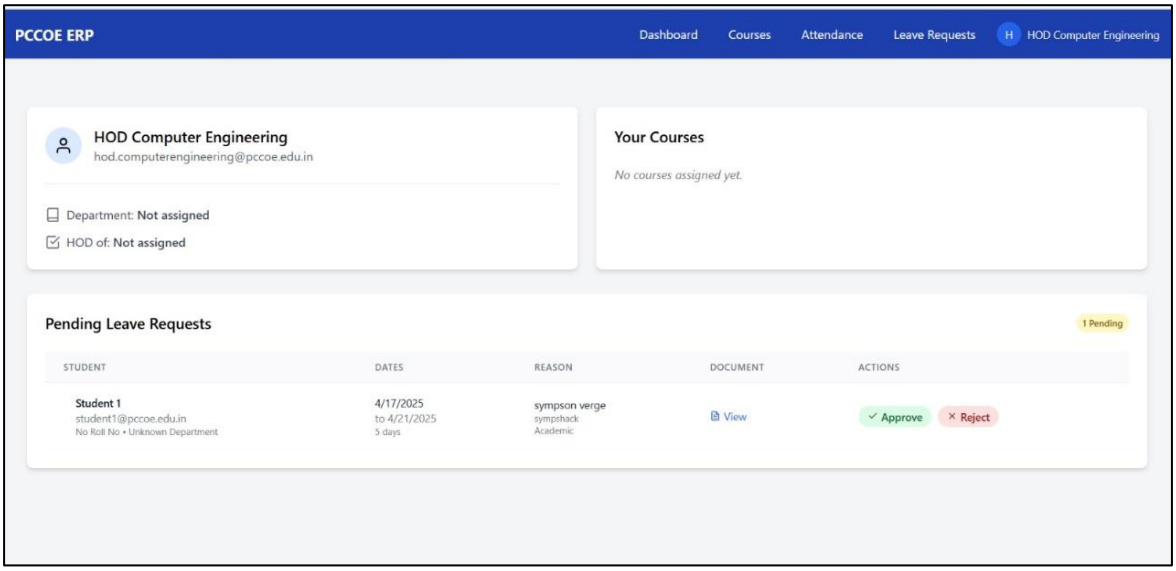

Figure 8. Department Head Approval Interface

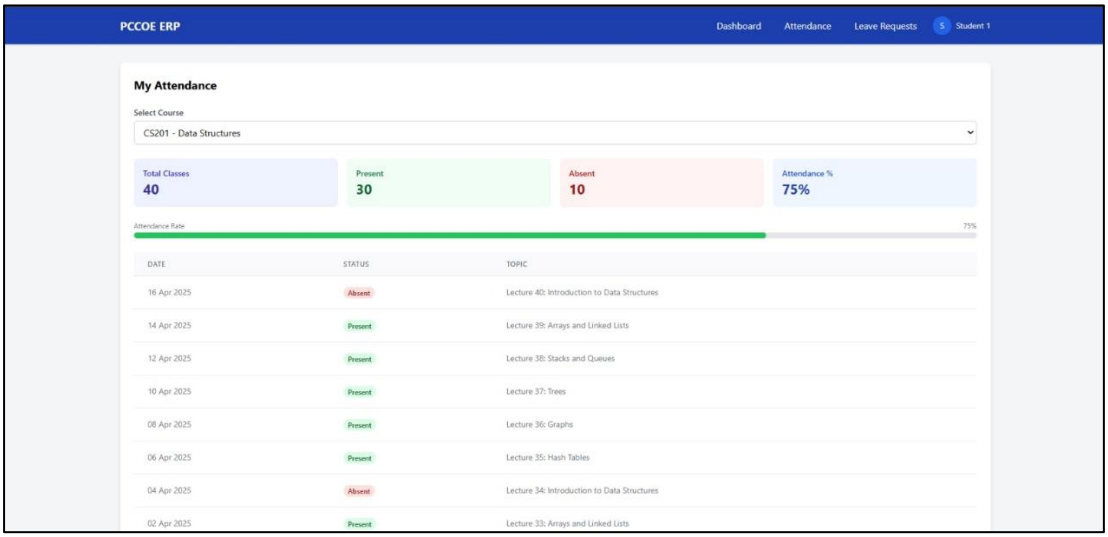

Figure 9. Automatic ERP Attendance Update Interface

Idempotent operations are used to prevent duplicate updates and the reconciliation processes were used to handle synchronization errors. The integration process required careful mapping between blockchain records and ERP database structures, with extensive testing to ensure data consistency.

5. Evaluation and Results

5.1 Pilot Implementation

The ElizaEdu system was evaluated through a pilot implementation at Pimpri Chinchwad College of Engineering involving, 120 students across different departments,10 class teachers, 5 department heads and an evaluation period of 3-Month. During this period, the system processed 328 leave requests for various academic events and competitions.

5.2 Performance Metrics

Table 1 presents the performance comparison between the traditional system and ElizaEdu.

Table 1. Performance Comparison of Traditional and Elizaedu

Metric	Traditional	ElizaEdu	Improvement
Verification time	72 hours	10.8 hours	85%

Document fraud	12 cases	0 cases	100%
Admin workload	45 min/req	7 min/req	84%
Student satisfaction	58%	92%	34%
ERP accuracy	91%	100%	9%

5.3 AI Performance

The ElizaOS agents demonstrated high accuracy in their respective tasks:

- RequestBot: 97.3% accuracy in document validation
- VerifyBot: 94.7% alignment with teacher decisions
- ApproveBot: 99.2% policy compliance enforcement
- ERPBot: 100% accuracy in ERP updates

The AI-powered document analysis visualization is demonstrated in the teacher and HoD approval interfaces (Figure 6 and Figure 8), where confidence scores guides in verification decisions.

5.4 Blockchain Performance

The Ethereum-based blockchain component demonstrated efficient performance, achieving an average transaction confirmation time of 15 seconds on the Polygon network. Data integrity was maintained with 100% verification through hash validation. The average transaction cost per verification workflow was 0.0012 ETH. Furthermore, the system exhibited robust throughput, successfully handling peak loads of 45 requests per hour.

5.5 User Feedback

Feedback that was gathered from users through surveys and interviews indicated a highly positive overall response to the system. Specifically, 92% of students reported improved transparency, while 88% of teachers noted a reduction in administrative burden. Furthermore, 94% of department heads valued the improved audit trail, and 90% of administrative staff reported significant time savings. Users particularly appreciated the decreased processing time and the enhanced transparency offered by the new system.

5.6 Discussion

The results demonstrate that ElizaEdu effectively addresses the key challenges found in event attendance verification. By utilizing AI-powered document analysis, the system significantly reduced the need for manual verification, leading to an 84% decrease in administrative workload. Furthermore, the implementation of a blockchain-based verification system successfully prevented fraudulent document submissions, with no instances recorded throughout the pilot phase. The streamlined workflow also accelerated the approval process, reducing verification time from an average of 72 hours to just 10.8 hours, representing an 85% improvement. The blockchain-based audit trail enhanced transparency in the approval process, contributing to a 34% increase in student satisfaction. Finally, the seamless integration with existing ERP systems automated attendance record updates, eliminating manual data entry errors and achieving 100% accuracy.

5.7 Limitations and Challenges

Despite the positive results, the implementation of ElizaEdu revealed several challenges that pave the way for future development. The initial setup complexity necessitates a degree of technical expertise, and integrating the system with diverse existing ERP systems presents potential compatibility issues. Furthermore, the cost of blockchain transactions could become a significant consideration for large-scale deployments. Finally, effective training programs will be essential for users unfamiliar with fundamental blockchain concepts to ensure seamless adoption. These identified challenges emphasize the key areas for future improvement and refinement of the ElizaEdu system.

6. Conclusion

This study presents ElizaEdu, an innovative AI-powered Web3 system designed for automated and secure event attendance verification within educational institutions. By integrating ElizaOS autonomous agents with the Ethereum blockchain and IPFS decentralized storage, ElizaEdu effectively tackles key challenges associated with traditional attendance tracking, including the elimination of manual verification through AI-based document analysis, the prevention of fraudulent documentation through blockchain verification, the acceleration of approval workflows using autonomous agent coordination, the assurance of transparency through immutable blockchain records, and the automation of ERP updates for consistent

attendance recording. The pilot implementation demonstrated significant improvements across all measured metrics, confirming the effectiveness of this approach for educational institutions. Future research will focus on extending AI capabilities to support a broader range of document types, implementing advanced analytics for attendance pattern analysis, exploring layer-2 Ethereum solutions to reduce transaction costs, developing standardized APIs for diverse ERP integrations, and investigating cross-institutional verification frameworks. Ultimately, ElizaEdu highlights the transformative potential of combining AI and blockchain technologies to create more efficient, transparent, and secure administrative workflows within educational institutions.

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