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A secure and adaptive examination revaluation framework using blockchain and subject-aware AI evaluation

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Abstract

The growth of digital technologies has led to an increasing need for safe, open and effective processes for managing examination records and revaluation processes. Conventional examination evaluation systems are mostly manual, which leads to delays, human error, lack of transparency, as well as an administrative overhead. Students have to wait for extended durations to gain access to the results of revaluation or verified answer scripts which discourages confidence in the revaluation process. To overcome these issues, this paper proposes "A Secure and Adaptive Examination Revaluation Framework Using Blockchain and Subject-Aware AI Evaluation." The proposed framework uses a private blockchain to securely store the finalised examination records and ensure data integrity, authenticity and prevent unauthorized modifications. Following result declaration, students will be able to submit their answer scripts digitally and submit an application for revaluation through a secure web-based platform, allowing for more efficient and faster processing. The framework supports typed and hand-written answer scripts due to the use of Optical Character Recognition (OCR) techniques to extract text. A subject-aware, rule-based AI evaluation module is used to analyse the extracted content using predefined academic rubrics and domain-specific keywords for generating the question-wise suggested marks in an explainable and consistent manner. To ensure that fairness and accountability is ensured, an evaluation produced by AI generators is reviewed by authorized academic personnel via multi-level approval workflow before being finalized. By combining blockchain technology with subject-aware AI-assisted evaluation, the proposed framework ensures less human workload, faster processing of revaluation and improves the transparency and trust of examination systems. The unalterable nature of record storage using blockchain technology enhances the trust of students, faculty members and examination authorities, paving the way for the adaptation of the framework in modern-day educational institutions.

Keywords: Blockchain Technology; Examination Revaluation Framework; Subject-Aware AI Evaluation; Optical Character Recognition; Rule-Based Scoring; Secure Academic Records; Tamper-Proof Storage

1. Introduction

Examination systems are important to evaluate academic performance and progress of students in educational institutions. However, in many universities and colleges, the processes involved in examination evaluation, result processing, answering script processing, recounting, and revaluation processes are still based on traditional methods or partially digitized methods. These systems are to a large extent reliant on manual verification and centralized data storage, often leading to delayed processing, human errors and poor transparency. As a result, students have to wait for several weeks for getting copies of their evaluated answer scripts or revised marks after applying for recounting or revaluation. In addition to inefficiency, data security is a major concern with existing systems of examination management. Examination records kept in centralized database are prone to unauthorized access, data manipulation,

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and accidental data loss. Since examination results have a direct impact on the academic progression and future career opportunities of students, the integrity, authenticity and confidentiality of these records is of critical importance.

Any issue with examination data can cause disputes, lost trust and administrative complications. Emerging technologies, like blockchain and artificial intelligence (AI), promise to be able to solve these challenges. Blockchain technology provides a decentralized and tamper-proof data storage mechanism, which allows examination records to be stored in a secure, transparent, and tamper-proof way. Once records are committed to the blockchain, unauthorized modifications will be computationally infeasible and thus data integrity will be ensured along with trust over the long term. On the other hand, AI techniques can help in automating evaluation related tasks such as recounting, revaluation, thus reducing the amount of manual workload and providing consistency and accuracy to the evaluation process. Inspired by these developments, this paper proposes a Secure and Adaptive Examination Revaluation Framework Using Blockchain and Subject-Aware AI Evaluation.

The proposed system provides students to securely access their answer scripts after declaration of results and apply for recounting or revaluation through a digital platform free of any procedural delays. An evaluation mechanism that determines the possible discrepancies or underrated responses in the answer scripts using predefined rules and rubrics and predefined academic keywords is applied to the answer scripts using AI-assisted and rule-based evaluation mechanism. To maintain fair play and transparency of responsibility, the final decision-making authority is left with the hands of authorized academic personnel through a structured decision approval workflow. By incorporating blockchain technology, subject aware AI evaluation and process automation, the proposed framework seeks to improve the efficiency, security and transparency of examination record management and revaluation processes. The system reduces administrative overhead, minimizes human error, and builds trust among students, faculty members and examination authorities, thus making it suitable for adoption in modern educational institutions.

2. Literature Survey

A proper literature survey was carried out to analyse the current examination management systems and also to analyse the application of emerging technologies like Blockchain and Artificial Intelligence in educational environments. The onus of this review is to identify the limitations of traditional examination process and examine the recent research efforts to improve security, transparency and efficiency in examination evaluation and revaluation process. Several researches have been elaborated to show disadvantages of conventional examination systems, in which result processing, answer script processing and revaluation are carried out manually or are handled in centralized databases. These approaches tend to be plagued by long processing times, lack of transparency and also prone to human errors. Researchers have reported that students are usually given restricted access to assessed answer scripts leading to dissatisfaction and disputes on fairness in evaluating. Furthermore, the centralization of examination records means that sensitive academic data is at risk of unauthorized access, data manipulation, and accidental data loss, which affects the credibility of academic assessment systems. Blockchain technology has become a highly promising solution for secure and tamper-proof data management. Introduced initially by Nakamoto as a decentralized ledger system, blockchain has now been adopted in various domains that call for high data integrity. Recent studies have shown the effectiveness of blockchain in academic certificate, examination, and education certificate management. By using cryptographic hashing, block linking and distributed storage mechanisms, blockchain enables the immutability of data and storage traceability. These characteristics make blockchain especially suitable for dealing with sensitive examination records of which authenticity and trust are important requirements. Artificial intelligence has also received a lot of attention in the field of automated assessment and evaluation. Several researches have been conducted in this area of evaluating answers using AI-based techniques such as keyword matching, rule-based scoring mechanisms, and natural language processing approaches. Such systems are reported to reduce the workload of examiners and improve consistency of marking. However, current studies highlight the need to keep human involvement in the final evaluation process in order to prevent biased decisions and promote fairness academically, particularly with subjective evaluations.

Optical Character Recognition (OCR) techniques have been extensively studied for digitization of handwritten answer scripts and converting the same into machine-readable text. Research results have found that combining OCR and automated evaluation techniques can greatly enhance the processing time of answer scripts. Nevertheless, accuracy of OCR based systems depends on various factors such as handwriting quality, document clarity, scanning resolution, etc., which requires other validation and preprocessing steps.

Based on the reviewed literature, it is clear that although blockchain-based systems have good security and transparency and AI-assisted evaluation systems are available, with advantages in terms of efficiency, not much research has been conducted on the integration of both technologies into a unified examination revaluation system. In

addition to this, there is a noticeable scarcity of subject-aware and rule-based evaluation systems that let administrators define and dynamically control criteria that determine evaluation. Addressing these gaps, the proposed system is a combination of Blockchain Based immutable storage of records and AI assisted rule-based reevaluation, which will be a secure, transparent and efficient solution for modern examination management.

3. Existing System

This section explains the limitations that are facing the current examination management system and proposed blockchain-based examination reevaluation framework with the help of artificial intelligence and secure record storage to overcome the challenges.

3.1. Existing Examination System

In conventional examination system, result processing, answer script processing, recounting and reevaluation is mostly done either through manual or semi-digital approach. After the announcement of results, students, who apply for recounting or reevaluation, have to wait for a few days or weeks to get updated results. Answer scripts are usually kept either as hard copy documents or in centralized databases, a process that is both time consuming and inefficient while retrieving the answer scripts. The current system places huge importance on human examiners to do the evaluation and the re-evaluation, which brings about the possibility of human errors, inconsistency in marking and possible bias. Moreover, the centralizing examination storage raises sensitive academic data with the threat of unauthorized data access, data manipulation and accidental data loss. Transparency in the reevaluation process is limited in so far as the students do not generally have direct access to their evaluated answer scripts and detailed justification for revised marks.

The current system is characterized by a number of important weaknesses that impact the efficiency and reliability of this system. A long time to process the results and reevaluate them is one of the greatest issues, which causes delays to students. Manual labour is also a major part of the system which can have a high probability of causing human error and inefficiencies in the operations. Moreover, both evaluation and reevaluation procedures are not transparent, so it is hard to check the correctness and impartiality of the stakeholders. The integrity of sensitive academic records is also endangered by the risk of data security breaches and possible cyber-attacks. Besides this, the system is inefficient on the whole due to unexpected delays in receiving scripts of answers and reevaluation outcomes.

3.2. Work Plan: Reevaluation of Examination Proposed

To overcome the drawbacks of the current system, this paper proposes the application of a Secure and Adaptive Examination Reevaluation Framework Using Blockchain and Subject-Aware AI Evaluation. The proposed system brings a digitally driven solution to managing examination record and to reevaluation workflow and make it secure and transparent. In the proposed framework, finalized examination records are securely stored on a private blockchain, ensuring data integrity, immutability, and resistance to unauthorized modification. Students are provided with a secure platform to digitally upload their answer scripts and apply for recounting or reevaluation immediately after result declaration, thereby eliminating procedural delays. Uploaded answer scripts in both typed and handwritten forms are processed using Optical Character Recognition (OCR) and text extraction to convert the answer scripts to machine-readable text format. A subject-wise, rule-based artificial intelligence (AI) evaluation module analyses the extracted content based on predefined academic rubrics and subject-specific keywords and produces question-wise suggested marks. This way, it is consistent, explainable and aligned with academic standards.

In order to ensure fairness and accountability the proposed system employs a human-in-the-loop evaluation model in which authorized administrators and chief examiners will review the AI-based evaluations, prior to final approval. Once approved, the finalized examination records are stored on the blockchain, making it possible to safely verify the results and retrieve the results and answer scripts instantly.

3.3. Advantages of Proposed System

- Shorter time of reevaluation processing with the help of AI.
- Better transparency through the provision of access to answer scripts online.
- Improved data protection with a blockchain based immutable storage.
- Less manual work on the part of examiners.
- Greater confidence in the system of examination owing to tamper proof records.
- Quickening of result verification and retrieval.

3.4. Comparison Between Existing System and Proposed System

A comparative analysis of the existing system and the proposed framework is summarized as under.

Table 1 Comparison between existing system and proposed system

Feature	Existing System	Proposed System
Evaluation Method	Fully manual	AI-assisted with human approval
Data Storage	Centralized database	Blockchain-based storage
Reevaluation Time	Several days or weeks	Reduced processing time
Transparency	Low	High
Data Security	Moderate	Very High
Answer Script Access	Delayed	Instant

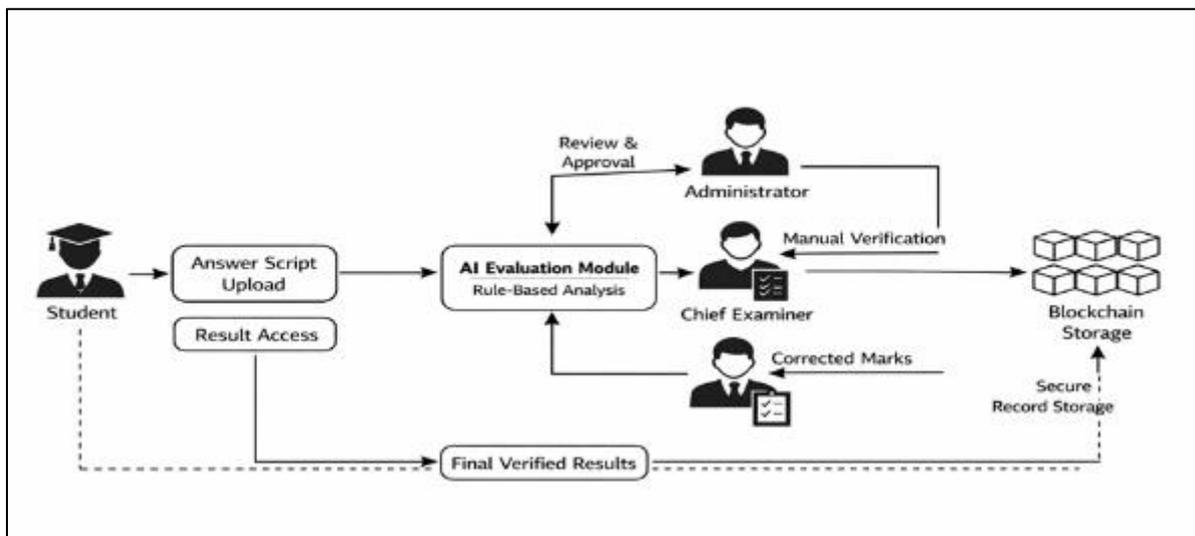


Figure 1 Overall system architecture of the proposed examination reevaluation framework.

4. Methodology

The proposed methodology establishes a structured and secure workflow for the design and implementation of a blockchain-based examination record management and AI assisted reevaluation system. The methodology is concerned with three main goals - secure handling of examination records, automatic assistance in evaluation and open reevaluation with human supervision. The overall process is designed to ensure accuracy and efficiency and the integrity of data in every stage of the examination lifecycle. The overall architecture of the proposed framework is illustrated in Figure 1.

4.1. Overall System Workflow

The proposed system enforces an organized workflow that is sequential and delivered to provide efficiency, transparency, and the safety of the examination evaluation process. The working process starts with the announcement of the examination results by the authorized examination authority. The students then post their answer scripts through the system digitally. Optical Character Recognition (OCR) is the method used to process these scripts so as to extract and preprocess textual data. Artificial intelligence mechanisms such as rule-based mechanisms are used to help in the analysis and alteration of answers based on evaluation rules that are predefined. The scripts are then refined and passed through authorized administrators and the chief examiners to ensure the accuracy and conformity to the standards of the examination. Finally, when approved, the completed examination records are stored safely with the help of blockchain technology that allows keeping the data intact, unchanged, and inaccessible to manipulation. Lastly, the system allows students to have immediate access to their verified results in a transparent manner with access to

corresponding answer scripts. This systematic workflow ensures improved efficiency, consistency of evaluation, and secure record management whilst retaining transparency throughout the reevaluation process. The workflow of the proposed examination reevaluation system is presented in Figure 2.

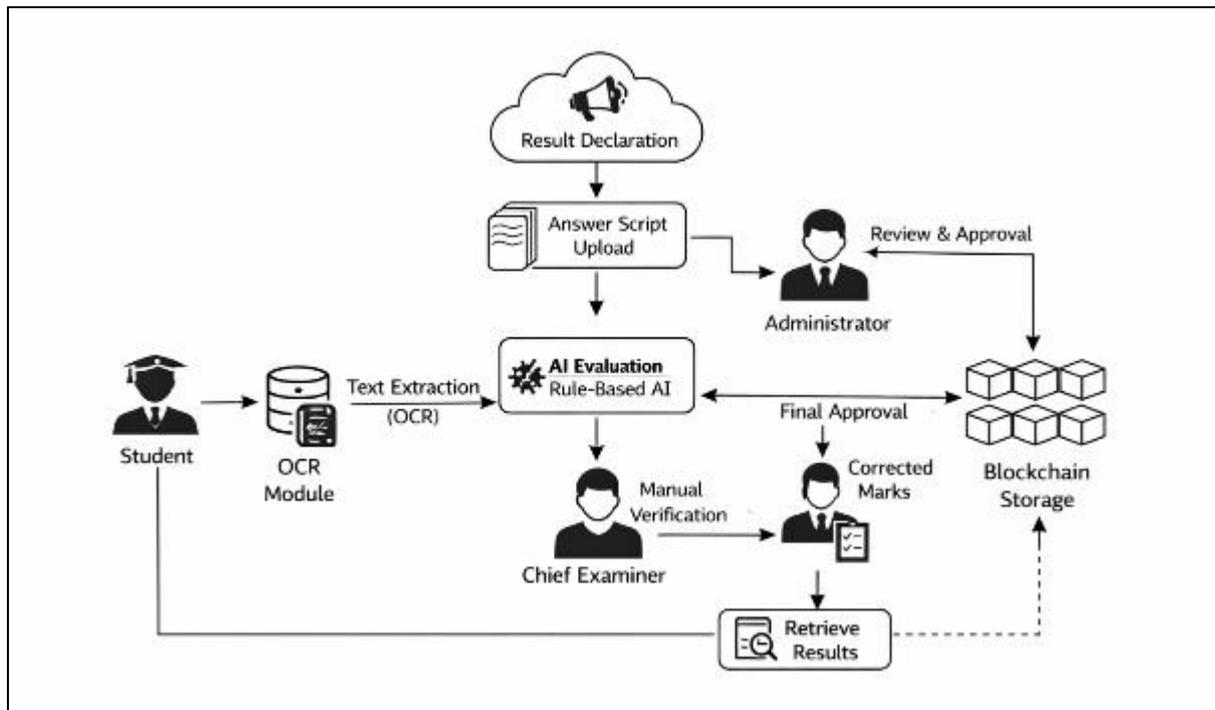


Figure 2 Overall workflow of the proposed examination reevaluation framework.

4.2. Processing of the Answers with a Web-Based Answer Script

After declaration of results, an assigned time limit is given to the students to upload their answer scripts in PDF format using a secure web interface. The system supports both typed answer scripts and scanned handwritten documents. For typed PDFs, direct text extraction is used, while for scanned answer scripts, Optical Character Recognition (OCR) is used to convert from the handwritten text to machine readable text.

The extracted text goes for preprocessing procedures such as noise removal, formatting normalization, and removal of irrelevant characters. These steps are necessary to increase the accuracy of further evaluation and ensure uniform representations of answers in different input formats.

4.3. Rule-Based Evaluation with the Help of AI

The evaluation of answer scripts is done using subject-aware, rule-based AI evaluation module. The evaluation rules are predefined and are configurable by administrators and contain various parameters like subject-specific keywords, definition marks, explanation marks, maximum allowable scores to each question, etc.

The textual content extracted is analysed against these predefined rubrics to come up with suggested marks question-wise. This rule-based approach helps in consistency and explainability in evaluation and prevents the unpredictability of the black box learning models. The role of the AI module is to act as an assisting tool to point out possible discrepancies, undervalued answers or missing evaluation elements, rather than replacing the human brain in judgment. The structure of the rule-based AI evaluation mechanism is illustrated in Figure 3.

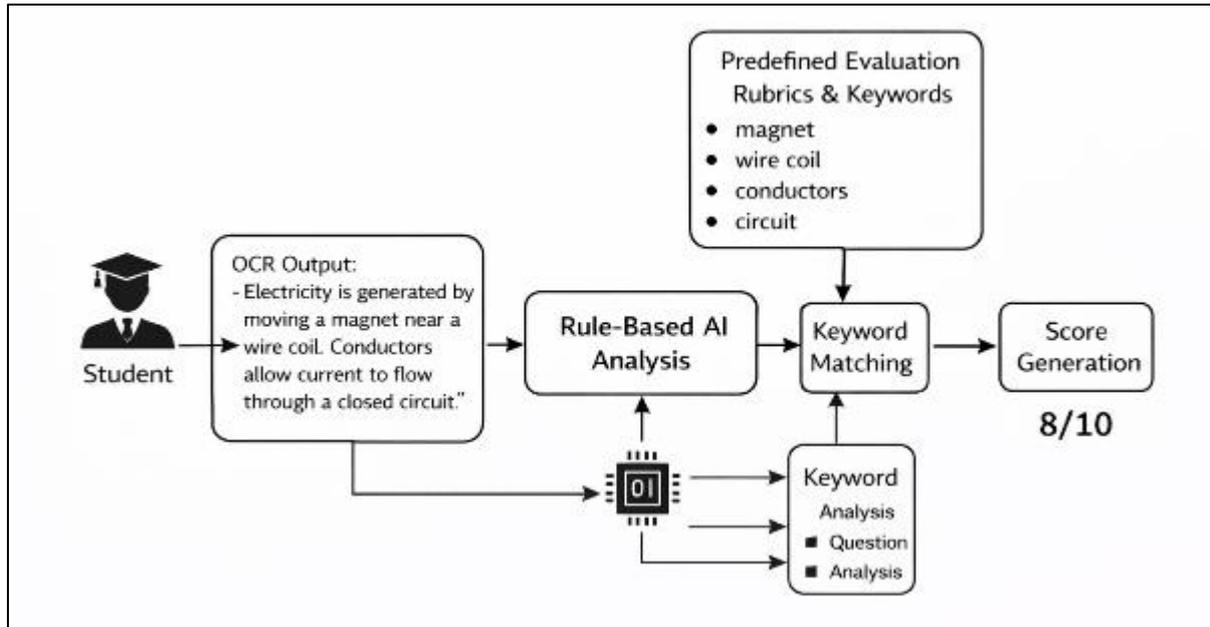


Figure 3 AI-assisted rule-based answer script evaluation model.

4.4. Review & Authorization by Administrators and Chief Examiners

To ensure fairness and accountability, the proposed system has a human in the loop evaluation mechanism. The AI-generated suggested marks are reviewed by the authorized administrators and assigned chief examiners using dedicated dashboards. Examiners can ascertain the evaluated answers, review AI proposal and make necessary corrections based upon the academic judgment. Final marks confirmed only after they are approved by the concerned authorities. This multi-level review mechanism helps increase the trust in the evaluation process and ensures that academic standards are followed. The role-based approval workflow used in the reevaluation process is illustrated in Figure 4.

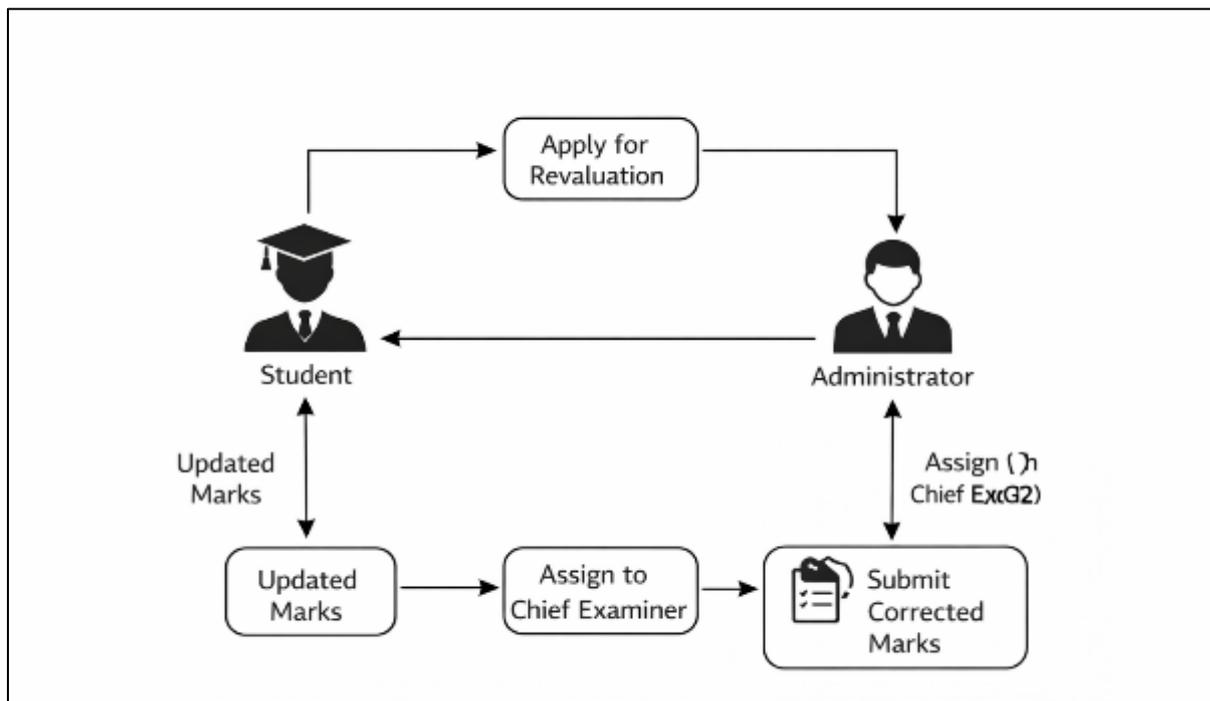


Figure 4 Role-based revaluation workflow involving students, administrators, and chief examiners.

4.5. Blockchain-Based Storage of Examination Records

Once the results of the evaluation are approved, the finalized examination records are securely stored in a private blockchain network. Each block contains primary information e.g., student identifier, subject code, final approved marks and the cryptographic hash of the corresponding answer script. The system uses cryptographic hashing techniques to connect each block to the previous block in order to ensure immutability and to prevent unauthorized modifications. In order to optimally utilize the storage space, full answer scripts are not directly stored on the blockchain, but the hash of the script is recorded to maintain data integrity while saving storage space. The blockchain storage mechanism used to secure examination records is shown in Figure 5.

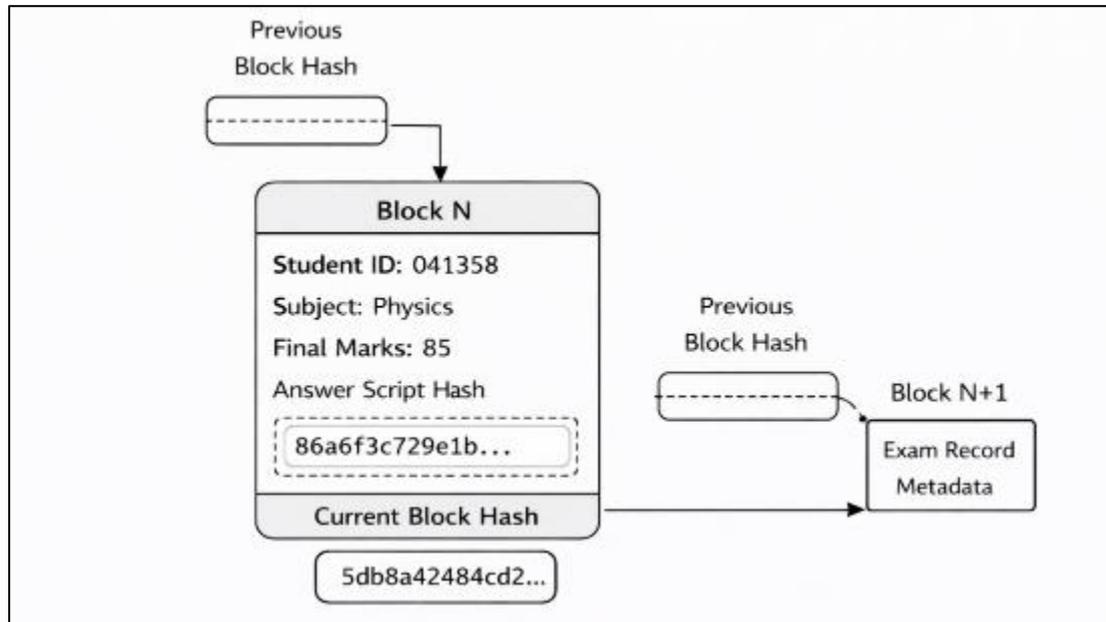


Figure 5 Blockchain-based storage structure for examination records.

4.6. Verification and Retrieval of Result Instantaneously

The students can access their final results and their verified answer scripts securely through the system in a matter of few seconds. When retrieving, the system generates blockchain integrity verification to ensure that examination records have not been changed. This verification mechanism is responsible for the transparency, auditability, and trust of the results published. The hybrid combination of blockchain-based verification and instant access makes the examination reevaluation process far more reliable and lessens the overall user experience.

4.6.1. Algorithms:

Algorithm 1: Rule-Based AI Assisted Answer Script Evaluation

Input: Answer Script PDF, Subject-wise Evaluation Rules

Output: AI-Suggested Marks (Question-wise)

- **Step 1:** Initialize Evaluation Rule Base

Load predefined rubrics including keywords, synonym sets, definition marks, and explanation marks for each question.

- **Step 2:** Upload Answer Script

Accept answer script in PDF format (typed or scanned) from the student.

- **Step 3:** Text Extraction

If PDF is text-based, extract text directly.

Else, convert PDF pages to images and apply OCR to extract text.

- **Step 4:** Text Preprocessing

Normalize extracted text by removing noise, special characters, and formatting inconsistencies.

- **Step 5:** Question Segmentation

Split the extracted text into question-wise answer segments using pattern matching and question identifiers.

- **Step 6:** For each Question Answer do
 - **Step 6.1:** Retrieve corresponding evaluation rubric.
 - **Step 6.2:** Perform keyword matching and synonym matching.
 - **Step 6.3:** Evaluate definition correctness and explanation completeness.
 - **Step 6.4:** Assign partial or full marks based on rule satisfaction.

End for

- **Step 7:** Generate Question-wise Suggested Marks

Aggregate scores for all questions.

- **Step 8:** Return AI-Suggested Marks

Algorithm 2: Human-in-the-Loop Revaluation Approval Process

Input:

AI-Suggested Marks, Answer Script PDF

Output:

Final Approved Marks

- **Step 1:** Forward AI-Suggested Marks to Administrator.
- **Step 2:** Administrator reviews AI-Suggested Marks.
- **Step 3:** Administrator assigns revaluation request to Chief Examiner.
- **Step 4:** Chief Examiner accesses answer script and AI suggestions.
- **Step 5:** Chief Examiner manually verifies answers.
- **Step 6:** Chief Examiner submits corrected marks.
- **Step 7:** Administrator reviews Chief Examiner's submission.
- **Step 8:** Administrator approves final marks.
- **Step 9:** Return Final Approved Marks.

Algorithm 3: Blockchain-Based Examination Record Storage

Input:

Final Approved Marks, Answer Script

Output:

Immutable Examination Record

- **Step 1:** Generate cryptographic hash of the answer script using SHA-256.
- **Step 2:** Create examination record containing: Student ID, Subject Code, Final Marks, Script Hash.
- **Step 3:** Generate new blockchain block.
- **Step 4:** Link new block with previous block hash.
- **Step 5:** Append block to private blockchain.
- **Step 6:** Store blockchain reference for verification.
- **Step 7:** Return confirmation of secure storage.

Algorithm 4: Secure Result Retrieval and Verification**Input:**

Student Request

Output:

Verified Result and Answer Script

- **Step 1:** Authenticate student access request.
- **Step 2:** Retrieve examination record from blockchain.
- **Step 3:** Verify block hash integrity.
- **Step 4:** If hash verification is successful, allow access.
- **Step 5:** Display final marks and verified answer script.
- **Step 6:** End retrieval process.

5. Experiments and Results

This section describes the experimental setup, tests conducted, and performance analysis of the developed system to determine the effectiveness of the proposed system, its accuracy, security and transparency.

5.1. Experiments Conducted

To prove the functionality and effectiveness of the proposed system, some experiments were done. In the beginning, the students were given the opportunity to submit their answer scripts using a web-based interface in PDF format, both scanned and typed. The system was also able to process files of different sizes and types without data loss, and this is indicative of a strong input processing. The scripts submitted were then taken through the Optical Character Recognition (OCR) software to digitize the scanned data into readable machine code and the resulting text was compared with the accuracy and readability and this test proved the efficiency of the OCR module. The extracted text was then assessed through a rule-based AI assessment system that was subject-conscious and implemented predetermined rubrics and keyword-matching methods to come up with question-specific proposed marks to achieve consistency and fairness in the assessment. The results of the AI-based generation were examined with the assistance of authorized administrators via a system dashboard, and the marks could be verified, corrected, and approved, which confirmed the effectiveness of the human-in-the-loop system. Once the examination records were finalized, they were locked away on a private blockchain with cryptographic hash values and any efforts to make changes to the stored data caused a mismatch in hash values, which proved the indisputability and the inability to alter data in blockchain storage. Lastly, the system allowed students to get their confirmed results and answer scripts in real-time, where blockchain integrity checks checked authenticity and prevented unjustified alterations.

5.2. Results Obtained

The results derived from the experiments prove the effectiveness of the proposed framework: The system was able to process and analyse the uploaded answer scripts quickly with a minimum delay. OCR-based text extraction was highly accurate for most answer scripts to enhance the efficiency of automation. AI-assisted evaluation helped to reduce the time taken for manual correction and provide consistency to scores. Administrative validation eliminated errors in final results and increased evaluation reliability. Storage-based on Blockchain technology ensured high levels of data security and data record integrity. Instant retrieval of the result increased the transparency and improved student satisfaction.

Table 2 Experimental Results

Parameter	Observed Value
OCR Accuracy	~90–92%
Evaluation Time	Reduced
Result Retrieval Time	Instant

5.3. Performance Analysis

The performance of the proposed system was analysed using important evaluation parameters as summarised as below.

Table 3 Performance Analysis

Parameter	Observation
Evaluation Time	Reduced
Accuracy	High
Security	Tamper-proof
Transparency	Improved

5.4. Discussion of Experimental Results

The experimental results demonstrate that the combination of OCR, AI-assisted rule-based evaluation and blockchain technology enhances the efficiency and reliability of examination revaluation systems to a great extent. The decrease in evaluation time and manual workload is an example of how bringing automation into the mix helps to demonstrate the practical benefits of automation while the inclusion of some human review ensures fairness and academic integrity. Blockchain-based storage of records further ensures higher trust by preventing any unauthorized modification of data.

6. Experimental & Results outputs

The functional interface of the student module is illustrated in Figure 6.

6.1. Student Module

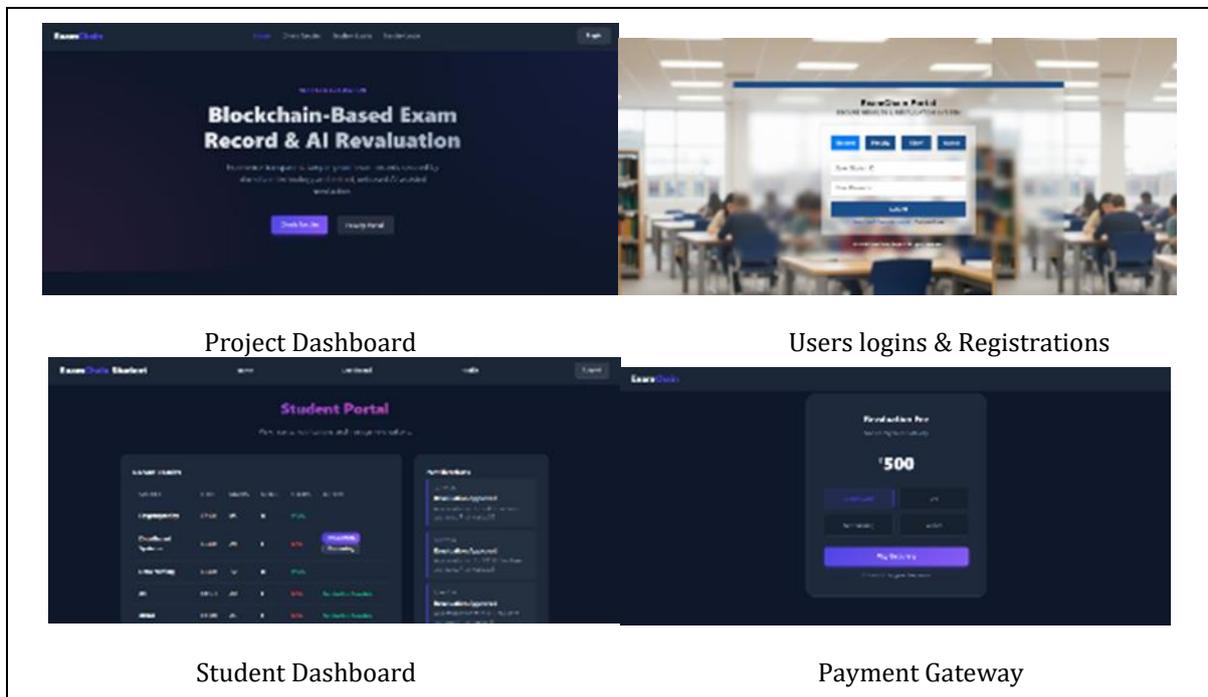


Figure 6 Student module interface showing dashboard, login, and payment gateway features.

6.2. Admin Management Module

The administrator dashboard used for managing evaluation processes is shown in Figure 7.

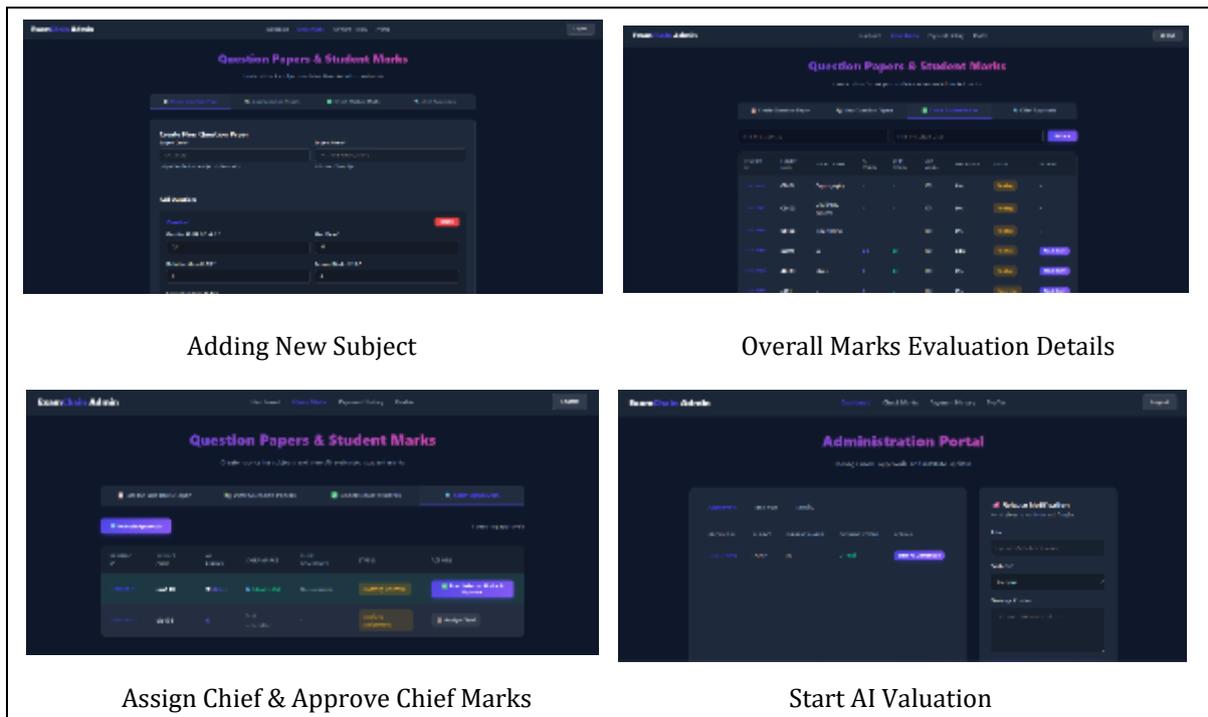


Figure 7. Administrator management module for subject management and AI evaluation control.

6.3. Chief Evaluation Module

The chief examiner module used for final evaluation approval is illustrated in Figure 8.

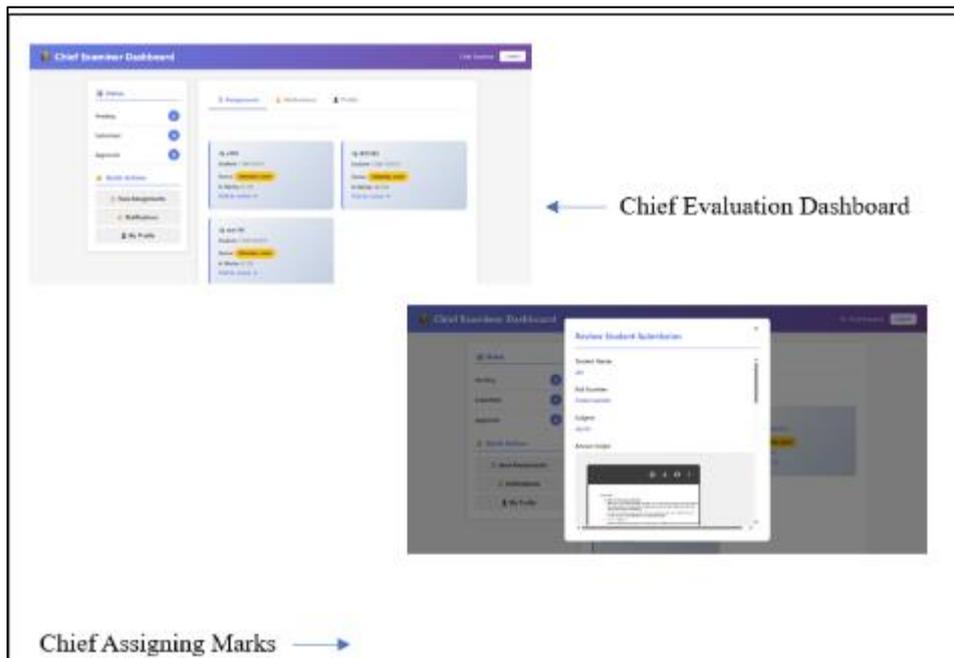


Figure 8 Chief examiner evaluation interface for reviewing AI-generated marks.

7. Conclusion

The paper provided a secure and dynamic examination reevaluation framework that incorporates blockchain technology and subject-conscious AI-assisted evaluation to address the shortcomings of traditional examination systems. The

suggested system uses OCR to process answer scripts automatically and enables rule-based AI scoring and provides a mechanism of fairness by giving a human-in-the-loop approval system. Storage ensured by blockchain ensures a tamper-proof record management approach, enhancing transparency, trust, and security during examination. It has been shown that through experimental results, the system not only saves on evaluation time, but also it is more accurate and the answer scripts and results are more accessible. In general, the proposed framework provides an effective and reliable solution for modern examination management systems and can support future large-scale digital academic infrastructures.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Statement of Ethical Approval

This research does not involve human participants or animals. Therefore, ethical approval was not required.

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