ScholarChain

A Blockchain Academic Records with AI Credential Verification

1. Abstract

ScholarChain is a blockchain-based academic record management system that addresses the weaknesses of conventional credential systems, where paper certificates can be forged, centralized databases are vulnerable, and manual verification causes delays. It encodes degrees, transcripts, and course records as digital assets within cryptographically linked blockchain blocks, using SHA-256 hashing to make any modification instantly detectable. Role-based access control ensures Registrars, Instructors, and Students have strictly separated permissions, preventing unauthorized changes. An integrated Google Gemini AI module analyses transcript data to generate performance summaries, skill assessments, and career recommendations. Together, these features make ScholarChain a secure, verifiable, and actionable academic advisory platform.

2. Keywords

Blockchain, Academic Records, Digital Credentials, Proof of Work, SHA-256, React, TypeScript, Vite, Web Crypto API, Excel Import, Google Gemini AI, Role-Based Access Control, Transcript Management, Credential Verification, Immutable Ledger, Cryptographic Hashing.

3. Synopsis

The ScholarChain project fills a critical gap in academic credential verification, allowing employers, graduate schools, and licensing bodies to validate records without contacting institutions. Paper certificates are easily forged, and centralized databases are vulnerable to failure and manipulation, especially in global labour markets. ScholarChain uses blockchain principles—cryptographic record linkage, Proof-of-Work, and hash-based tamper detection—to create a secure, self-contained credential ledger. Built with React and TypeScript, it supports registrars issuing credentials, instructors submitting course data, and students accessing verified records and generating shareable reports. The system leverages the Web Crypto API for SHA-256 hashing, bulk record import via the xlsx library, and Google Gemini AI for transcript analysis and career guidance. Together, these features form a robust, extensible proof-of-concept for secure, verifiable, and scalable academic record management.

4. Technologies Used

1. Frontend: React with TypeScript
- Uses React's declarative component model with TypeScript's type system.
- Builds a maintainable, role-sensitive interface with fewer runtime errors.

2. Build Tool: Vite
- Provides near-instant development server startup and fast hot module replacement.
- Generates highly optimised production bundles for better performance.

3. Cryptographic Engine: Web Crypto API
- Performs SHA-256 hashing for secure block linking.
- Browser-native API avoids third-party dependencies and ensures consistent hashes.

4. AI Integration: Google Gemini AI
- Analyses student transcripts to generate performance summaries.
- Provides skill assessments and personalised career pathway recommendations.

5. Data Import: xlsx Library
- Supports bulk import of Excel files containing student records.
- Allows registrars to process entire cohorts at once.

6. Consensus Mechanism: Proof-of-Work

- Requires solving a computational challenge before adding a new block.
- Ensures that tampering with the blockchain is extremely difficult.

5. Procedure

Step 1: User Authentication and Role Assignment
Users log in to ScholarChain using institutional credentials. The system enforces role-based access control, assigning users to one of three tiers: Registrar, Instructor, or Student. Role profiles determine the interface and restrict data visibility and actions, ensuring students cannot access others' records, instructors see only their courses, and only registrars can issue credentials or interact with the blockchain ledger.

Step 2: Academic Record Submission
Instructors submit student performance data via structured digital forms with mandatory fields and type validation. Registrars can upload bulk Excel files parsed by the xlsx library for high-volume submissions. All records undergo schema validation to confirm required fields—student ID, course code, grade, and academic period—are correctly formatted before blockchain inclusion.

Step 3: Proof-of-Work Block Mining
Once a record is ready, the system initiates the Proof-of-Work process. Using the Web Crypto API, it iteratively computes SHA-256 hashes with candidate nonce values until a valid hash meeting the difficulty criteria is found. The new block, containing record data, timestamp, nonce, and computed hash, is then appended immutably to the chain.

Step 4: Chain Integrity Verification and Tamper Detection
Authorized users or the system can verify chain integrity by recomputing hashes from the genesis block to the current tip, ensuring each block's stored hash matches the computed hash and its predecessor link is valid. Any discrepancy flags tampering, pinpointing the exact block where integrity is compromised.

Step 5: AI-Powered Transcript Analysis and Credential Sharing
Students and registrars can submit transcripts to the integrated Google Gemini AI, which generates insights on academic progress, skills, and career paths. Students can also create shareable credential verification reports, enabling third parties to confirm authenticity via blockchain hash validation.

6. Why It Is Best

ScholarChain stands out from paper-based and generic digital credential systems through cryptographic immutability, decentralised verification, role-based governance, and AI-powered academic insights. Its SHA-256 hash-chained ledger ensures any record tampering is instantly detectable, while Proof-of-Work makes retroactive chain modification computationally infeasible. Role-based access mirrors institutional hierarchies, enforcing strict data partitioning to protect sensitive academic records. Google Gemini AI transforms the system into an active advisory tool, providing personalised performance insights and career guidance. Bulk Excel import enables high-volume record onboarding, making ScholarChain a secure, practical, and institutionally relevant solution for modern credential management.

7. Conclusion

ScholarChain leverages blockchain to address academic credential challenges, featuring a SHA-256 hash-chained immutable ledger, Proof-of-Work consensus, role-based access control, structured and bulk record submission, real-time chain verification, and AI-powered transcript analysis via Google Gemini. Testing confirms tamper detection, strict permission enforcement, and accurate AI-driven insights. The prototype provides a foundation for a production-grade system with planned enhancements like public or permissioned blockchain migration, QR-code credential verification, integration with student information systems, digital signatures, and a mobile credential-sharing app. These improvements eliminate single points of failure, automate data flow, support privacy-preserving credential sharing, and position ScholarChain as a fully interoperable, production-ready platform for institutions of any size.